FRAMINGHAM HEART STUDY
GENERATION 3
ECHOCARDIOGRAPHY MANUAL

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Table of Contents

Introduction to Performing Echocardiography in GEN 3

Echocardiography is the investigation of choice for the noninvasive assessment of cardiac structure and function. It provides important knowledge of the prevalence, predictors, and prognosis of cardiac disease.

The echocardiography scanning time is approximately 25 minutes. Participant is already in the room, set up with electrodes, placed on his side on the bed, as part of one of five tests being performed in the noninvasive cardiovascular testing station.

Equipment

2 Scanning Rooms each one containing the following:

- Chattanooga Group, Inc. Triton Electric Hi-Lo Treatment Table, Model #200
- Height adjustable sonographer chair
- Philips Medical Systems Agilent Sonos 5500 Ultrasound System, Model # M2424A
- Sonos 5500 Monitor, Model # DR5815
- Panasonic SVHS VCR Model # AG-MD835
- Laptop computer for some specific 2-D and PW Doppler flow acquisition; Cardiovascular Engineering, Inc., Holliston, Massachusetts
- Acquisition software provided by Gary Mitchell, MD, Cardiovascular Engineering, Holliston, MA.

Echo Storage Server:

- Micron Netframe Server, Model #3550, Serial #ECHK 2200575
- Micron PC COM 15" Monitor, Model #500Ez, Serial #LTN 28011F00018377
- Micron Standard keyboard, Model #SK-1688, Serial #C0201132105

First Digisonics Echo Reading Station:

- Micron PC COM Monitor, Model #910Ex, Serial #SSAM08020200001600
- Micron PC Client Pro Work Station, Model #D850GB-ODY, Serial #3076624-0001
- Micron Standard Keyboard, Model #SK-1688, Serial #C0109226475
- HP Laser Jet 2200d Printer, Model #C7058A, Serial #GRH07192
- Sony SVHS HiFi Videocassette Recorder, Model #SVO-9500MD, Serial #26312
- Sony MODisk Unit, Model #RMO-S551 5.2GB, Serial #751388
- Sony VCR Remote Control Unit, Model #SVRM-100A, Serial #110532
- Sony 15" Monitor, Model #GVM-1311Q
- Digisonics DigiView System Software for Echo measurements, Digisoncis, Inc. Houston, Texas

Second Digisonics Echo Reading Station:

- Micron PC COM Monitor, Model 910Ex, Serial #SSAM08020200001333
- Micron PC Client Pro Work Station, Model #D845GRG-ODY, Serial #3202705-0001
- Micron Standard Keyboard, Model SK-1688, Serial #C0204060060
- Sony SVHS HiFi Videocassette Recorder, Model #SVO-9500MD, Serial #47912

- Sony VCR Remote Control Unit, Model #SVRM-100A, Serial #110855
- Digisonics DigiView System Software for Echo measurements, Digisoncis, Inc. Houston, Texas

Supplies

- Transducer gel
- ECG electrodes
- S-VHS Video Cassette Tapes
- CD disks, for storing 2-D images and PW Doppler signals
- Sony MOD Magnetic Optical Disks, 5.2 GB, Model #EDM-5200B, for storing 2-D loops and M-mode and Doppler frames of Echo images.

Examination & Data Cleaning Documentation Materials

- Participant and Sonographer Worksheets
- Participant ID tape labels
- Log book
- Log-In sheets

Miscellaneous

- Standard pillow - for participant
- Blanket – for participant
- Towels – for wiping gel off participant
- Latex Exam Gloves – for sonographer, optional (If participant is allergic to latex, sonographer will scan without gloves.)

Performing the Echocardiography Test

A succinct **Echocardiography Scanning protocol** is provided in the appendix. Below we will give a brief description of performing the Echocardiography test in a standard fashion at the Framingham Heart Study Clinic.

Initial Test Set Up

In the waiting room the participant reads a set of instructions about the **Echocardiography Test** (see appendix) and signs an informed consent form before arriving at the noninvasive cardiovascular testing station. If not, have the participant read the instructions and sign the consent form before proceeding.

The sonographer fills out the **FHS Echocardiography Sonographer worksheet** (see appendix). The reverse side of this form is used after the test for qualitative and quantitative interpretation of the echocardiography test (see appendix).

Acquisition
Enter the participant initials and ID#, exam #, and sonographer ID # in Gary Mitchell's acquisition computer. Also enter the participant ID# and name and sonographer ID# on the Agilent Sonos 5500 Ultrasound System (in text below referred to as "Sonos 5500").

Labeling storage media & log in sheet
The sonographer should also enter exam date, room #, sonographer ID#, SVHS #, CD #, and miscellaneous information regarding data management, on the **FHS Generation 3 Exam 1 Log Book Sheet For Tonometry, Brachial, and Echo tests Log-In Sheet** in the Log Book (see appendix). Put participant ID# and name label on the SVHS cassette tape jacket as well as on 2 CD's.

Participant Set-up

- Place 4 electrodes on participant's chest.
  1. White - below right clavicle
  2. Green - right rib cage
  3. Black - below left clavicle
  4. Red - left rib cage
- Ask the participant to lay on his/her left side with left arm on the pillow.
- Start echo test following the scanning protocol (see appendix).

The Ultrasound Scan

The following standard Echocardiography directions should be followed for the standard Echocardiography test. Before proceeding with the scanning, briefly explain to the participant

that he will not be able to watch his heart during the test. However, at the end of the test, he will be shown his heart in motion on the monitor.

Apical 5—Chamber [A5C] View[a]

- Cover transducer's matching layer with ultrasound gel and place transducer in 5th intercostal space of participant's chest.
- Angle transducer anteriorly to visualize LVOT, Aortic root and aortic valve in widest excursion. LV endocardium should be clearly visible.
- Place CW Doppler in LVOT and obtain flow with highest velocity and valve clicks. If there is aortic stenosis, interrogate the LVOT and aortic valve accordingly to the description in the Digisonics Reading Protocol (see chapter in this Manual).
- Tape images and flow on Sonos 5500.
- Switch CW to PW. Place PW sample volume in LVOT approx. 0.5 cm from the aortic valve. Record the flow on Sonos 5500 and on G. Mitchell's computer. If the flow velocity is higher than 120 cm/sec switch to high PRF. Do not move baseline (it would make flow analysis difficult).
- Obtain carotid tonometry and save on G. Mitchell's computer.
- **Ask the participant if they are comfortable. If not readjust transducer.**

Parasternal Long Axis [PLA] View

- Move transducer from the apex to the third or fourth intercostal space left from the sternum so that the orientation point is directed toward right shoulder and ultrasound beam is parallel to the imaginary line connecting right shoulder with the left flank.
- Start taping on Sonos 5500 at depth 20 cm optimal long axis of LV, so the anterior septum is not at an angle and all cardiac structures in this view are clearly visible.
- Decrease depth, get the biggest possible image without loosing LV posterior wall and acquire one loop on Sonos 5500. Clear definition of RV, Aortic Root, AV, LA, MV and LV.
- Zoom on LVOT, show clear insertion of AV cusps. Save 5 beats on G. Mitchell's computer and record on Sonos 5500.
- Narrow the sector, press color Doppler and tape flow trough MV and AV paying attention to regurgitation.

RV Inflow

- Move transducer left from the sternum as far as possible and tilt inferomedially so a long axis of the RV and RA is obtained. Show anterior and posterior leaflets of TV.
- Tape color flow across TV, paying attention to any regurgitant jet.

Parasternal Short Axis [PSA] View

- Rotate transducer about 90 degrees from PLAX so ultrasound beam is perpendicular to long axis of LV and obtain short axis.
- Start from the base of the heart showing: Aortic root, 3 aortic valve cusps- right, left and none, LA with clear posterior wall definition (be aware of sidelobing simulating false posterior wall – see figures 1a and 1b).

- Acquire 2 M-Mode frames of Aortic Root, AV and LA. Emphasize box-like opening of aortic valve cusps.
- Tape color Doppler on Sonos 5500 to see AI or TR, if time.
- Tape the sweep from the base of the heart to the apex showing LV wall motion and thickening. On your sweep back from the apex to the base, stop at MV and acquire one M-mode frame of MV.
- Tilt the transducer inferiorly and obtain cross section of the LV at the papillary muscle level. Zoom on the LV and acquire one loop with clear boundaries of endocardium and epicardium.
- Place M-mode cursor across LV and acquire 3 frames with 3 beats each, still in the Zoom mode. (See figures 2a, 2b and 2c.)

Apical 4-Chamber [A4C] View

- Move the transducer to the apical position and obtain 4-chamber view.
- Start taping at depth 20 cm. Decrease depth to get biggest image possible and acquire one loop on Sonos 5500.
- Tape color Doppler flow across MV, AV, TV. Confirm regurgitation existing in other views.
- Press presets on Sonos 5500 for PV flow. Place PW sample volume in the right pulmonary vein and obtain flow. Save Pulmonary vein flow for about 20 seconds on G. Mitchell's computer and acquire one frame on Sonos 5500.
- Switch back to FHS Echo presets. Place PW at MV leaflet tips and obtain highest E and A wave velocities of MV inflow. Save about 20 sec of the flow on G. Mitchell's computer and acquire one frame on Sonos 5500.
- Decrease depth, narrow the sector and obtain long axis of the LV from the apex to the mitral valve annulus. Acquire one loop on Sonos 5500.
- Increase the depth and put M-mode cursor at MV annulus. Acquire one frame on Sonos 5500.
- Press presets on Sonos 5500 for DTI. Place PW sample volume at MV annulus and acquire recordings on G. Mitchell's computer. Acquire one frame on Sonos 5500.

Apical 2-Chamber [A2C] View

- Rotate transducer from apical 4-chamber to apical 2-chamber view (about 90 degrees counterclockwise or until right sided cardiac structures disappear).
- Tape 5 beats showing wall motion and endocardium thickening of LV.
- Tape color Doppler across MV, confirming any regurgitation seen in previous flows.
- Decrease the depth showing anterior and posterior walls of LV from the apex to the MV annulus. Acquire one loop on Sonos 5500.

Apical 3-Chamber [A3C] View (Also called **ALA=Apical Long Axis view)**

- Rotate transducer even more counterclockwise until you see AV and ascending aorta, LA, MV and LV. Acquire one loop on Sonos 5500.
- Increase depth to show LA. Tape color Doppler flow across AV and MV.
- Wipe gel off the participant's chest. Ask him/her to lie supine for the last images from the subcostal region.

Subcostal View

- Begin subcostal examination by placing the transducer in the midline or slightly to the participant's right side. Direct ultrasound beam superiorly and leftward toward left clavicle. Tape subcostal 4-chamber view on Sonos 5500, with special emphasis on RV free wall.
- Tape color Doppler.
- Rotate transducer to subcostal short axis. Tape a few beats showing IVC and short axis of LV from the base to the apex.

Finish the echo test, wiping the gel off the participant. Thank the participant for participation, patience and cooperation. Proceed to the last test, the Brachial Reactivity Test. [b]

Before proceeding to the Brachial test, briefly show the participant the images on the loops on the screen and explain in simple words the different views.

Settings for Echo PW and Tissue Doppler

The following settings for Echo PW and tissue Doppler should be used during the standard Echocardiography test:

Pulmonary vein PW

Filter:	300 Hz
Gain:	65%
Focus:	Down
Sweep:	50

Mitral Valve PW

Filter:	300 HZ up to 400 HZ
Gain:	60%
Scale:	80 cm/sec
Sweep:	50

LVOT PW

Filter	300 HZ – 400 HZ
Gain:	65% Avoid high PRF
Scale:	120 cm/sec (marked 120 cm/sec but actually shows up to 180 cm/sec)
Sweep:	50

Tissue Doppler

Filter	50 HZ
Gain:	55%
Scale	20 cm/sec
Sweep:	50

Policy regarding how "hard to press" to obtain measurable ultrasound images

Our policy on 'pressing hard' with the ultrasound transducer on the participant's chest, particularly the obese, states that we will tolerate worse images and will not press to the point of discomfort, if a participant complains during the test.

Policy regarding the length of time of the scan

Since we are limited by a time constraint in the Clinic, we have also made it a policy not to spend more than 25-30 minutes of scanning time on each participant, even if it is difficult to perform the echocardiography test on the participant, due to obesity, heavy smoking history, COPD, prior chest surgery, etc.

In the event that a participant has an abnormal echocardiogram [e.g. aortic or mitral stenosis], that requires more scanning time, the sonographer should inquire with the clinic staff if they may take an extra 5 and maximum of 10 additional minutes. If the clinic staff is concerned about work flow, and requests that the test not be extended, the sonographer may add additional images at the end of clinic, if the participant is willing to wait.

Echo Reading & Interpretation Protocol

- The ECG shouldn't overlie M-mode septal images.
- Make sure that the posterior wall of structures is contained on the frame so that back wall can be measured.
- The septum in the PLA view should be parallel with the top of the screen [a number of the septums are angled, which when rotated into the PSSA will make for an oblong/eggy LV short axis.
- Please make the LV short axis as round as possible.
- Please be mindful not to snub the apex in the apical 4 chamber focused view. This would spoil the LV length and LV fractional shortening measurements.

Reading Protocol Steps

- Click on ERS32 icon
- Click on new study icon
- Select original study
- Enter first 3 characters of person's name or ID#
- Open study
- Create new study from existing study [far left page icon on power bar]. Make sure "New Study From Existing Patient" is selected.
- Check ID
- Alter interpretation date if necessary – (Interpretation date is automatically displayed).
- Enter Interpreter ID#
- Enter Sonographer ID#
- Hit OK
- Read icon [yellow circle]
- Click on images, fhs-digiserv Y-drive
- Click on images folder
- Enter first 3 digits of ID in file name
- Click on participant ID that you are measuring
- Select folder which is labeled with the date that study was initially acquired (virgin study)
- Highlight all .dcm files, then press open, which will read the clips into local hard drive (hold shift key, highlight first and last .dcm)
- While loading digital images, read analogue SVHS tape and scrutinize for details such as,. Pericardial Effusion or where to measure posterior wall of LA on M-mode. (Follow measurement tips below)

Measurement tips for analogue tape

- Perform **qualitative reading** off the analogue tape.
- Note abnormalities in left margin as one reads.
- Make quick rough hand-held caliper measurements of LA, AV, LV wall thickness & internal dimensions.
- These measurements are for guidance only.
- LVWT you can measure in PLAX or PSAX. LVID in PSAX only.
- **Verify that M-Modes are appropriate by carefully observing the 2-D images:**
  - LV is not too eggy and/or not too apical.

- LA is contained inside the frame.
- MV is not too eggy, etc.
- As soon as digital images have been loaded, look at them and make rough measurements before going to Digisonocs measurement protocol.

- After the entire analogue tape has been reviewed, code qualitative abnormalities;
  - Put the symbol of a square, □, on left margin for sections to be coded after measurements are made
  - **Don't forget to check LV wall motion in each view**
  - Don't forget to code right heart abnormalities
  - Code technical quality of 2D study, CW AV, Color Doppler
- Don't make on-line 2D measurements except for:
  - RVH, RVE, MV thickness, if necessary or
  - if M-Mode of a structure is unmeasurable and you need guidance for coding sheet

Digisonics "Tricks" to think about before measuring

1. **How many beats?**
   - Measure at least 3 beats if they are technically adequate, and the inter-beat differences are due to biologic (e.g. respiratory) variation.
   - If third beat is technically inferior and the given frame is the best available one (see below), measure only two beats. It is better to have two good accurate measurements than to have the results skewed by a third unreliable estimate.
   - All 3 beats should be from the same frame
   - If rhythm is atrial fibrillation/flutter, measure at least 4 complexes; you may need to measure more than one frame; try to measure adjacent complexes
2. **Extra-systoles?**
   - Look at the cardiac rhythm on screen. Avoid measuring premature beats or beat immediately following a premature beat.
3. **Which frame?**
   - Choose the frame that best defines the leading edges of the structure being measured
   - Scan the M-mode frames prior to reading 2-D study, focusing specifically on clarity of leading edges. Make a note on the possible frames you would select for measurement. Make a mental note of presence of multiple linear structures that could represent the leading edge.
   - Clarity of leading edges for LV diastolic measurements is a more important consideration compared to clarity of the systolic phase of the cardiac cycle.
   - Try to measure aortic root and aortic cusp separation on the same frame
   - If two frames are identical in terms of quality, select the first frame as a convention
4. **Measuring, general**
   - Which order are cardiac structures measured in? Begin with Ao Root, Ao cusp separation, LA in systole, LA in diastole, M-mode of Mitral Valve annular descent, E-point to septal separation (EPSS), and lastly LV dimensions.
   - Which order of beats: Of three beats on the chosen frame, measure the best looking beat first. If all three beats look alike, start measurements of beats from left to right
   - "leading edge to leading edge" for LA/Ao Root & LV
   - inner to inner for E-point septal separation (EPSS) and aortic cusp separation.
   - Make sure that each **M-mode measurement reflects reality**. Is it close to your 2-D impression of the cardiac structure (based on either eye balling or on online measurement of the screen with an external caliper?
   - Think about reproducibility...If you are guessing don't measure.
   - Remember to calibrate before measuring structures on frames captured from the tape

every time the depth is changed, e.g. MV leaflet displacement; Highlight "measure," highlight "2-D," highlight "scale." Then touch two points on screen 6cm apart. After first measurements click RMB. Repeat for next two measurements.

- Score from overall wall motion. If overall wall motion is abnormal and you paint the walls yellow for hypo or brown for akinetic, you need to paint the rest of the walls to get the correct score.

5. **Cursor placement?**
   - What if the leading edge is thickened? (e.g.. calcified aortic root), the measurement cursor is "buried" into the leading edge
   - While reading the 2-D study, keep in mind the importance of assessing which of the possible linear structures most likely represents the leading edge of the structure that will be measured on M-Mode. This judgment is based on excluding the possibility of ventricular trabeculae, chordae tendinae, "side-lobe artifacts," posterior effusions, and other miscellaneous structures that could obscure/mimic the leading edge.
   - Look carefully at the M-mode for incomplete or partial **dropout** in lines that may well represent the true leading edge.
   - It is permissible to **extrapolate** and drop the measurement cursor to an imaginary leading edge which corresponds in position to an adjacent beat if no leading edge is discernible in a particular beat @ the appropriate time of placement and the beat is otherwise technically adequate for measurement (e.g. isolated dropout in the leading edge of LVPW in one beat alone)
   - Remember to **bracket** your cursor placement - place the cursor above, below then exactly where you want to place it.
6. **Measuring the LV**
   - Check for the presence of an "eggy" appearance in the 2-D short axis-view of the ventricle (from which the M-mode is derived). If the ratio of length/ breadth of the ventricle is >1.3, do not make LVID measurements. You can still code the left ID & WT as normal or abnormal depending on the 2-D impression.
   - Check that the cursor placement is at the tips of the papillary muscles, i.e. that the cursor is not too apical & that the RV is still present as more than a sliver.
   - Check that you are not measuring RV moderator band, papillary muscle or pericardial effusion.
   - If you skip measurements make sure the Digisonics hasn't borrowed numbers from elsewhere.
7. **Measuring the LA, EPSS, aorta**
   - Beware of side lobes creating false posterior **LA** walls
   - If **Ao** heavily calcified bury leading LA edge
   - **EPSS** Place cursor on the same side of the E-point of the mitral tracing as the peak downward excursion of the septum; an "inner edge to inner edge" technique is used. We extrapolate to point of maximum downward excursion of the septum.
   - Measure the **aortic root cusp** separation in early systole using an "inner edge to inner edge" technique (i.e. trailing edge to leading edge)
8. **Qualitative Coding**
   - Try to confirm presence of mild or borderline findings in more than one view
   - e.g. MAC, aortic calcification or trivial regurgitation in more than one view
   - If you aren't sure about MAC, aortic calcification, MV thickening, etc. code it as probably normal
   - If you really don't know if something is normal or not, code it as unknown
   - Look @ specific definitions on posted coding sheet.
9. **Coding Quality**

- For CW AV, code it as fair if only imaging CW used, &/or only from one view; code good quality if non-imaging CW probe and > 1 view are recorded of adequate quality
- **Good** means highly accurate (reflects reality) & excellent reproducibility
- **Fair** means basic questions are answered correctly, reproducibility reasonable
- **Poor** means reproducibility poor, some ability to comment on questions
- **Inadequate** means accuracy and reproducibility unacceptable

- **Click on "Measure" to start measuring Digisonics Dicom images and follow protocol using the Dicom Images Table.**

Dicom Images Table

Measure	Units of Measure	Mandatory	Elective	Comment
Score – Wall Motion		Every subject		If all normal click Overall Wall Motion • Overall wall motion is normal • If global pattern click overall wall motion & appropriate category. • If Regional wall motion abnormality • Click on appropriate statement and then click on appropriate segment **Don't forget to click on Score from Overall Wall Motion!!! Ventricle should be colored.**
MM: Ao/LA Protocol • Aortic Root diameter • Aortic cusp separation • LA_{es} • LA_{ed}	**(cm)**	3	Total 6 + average	• All measurements are leading edge to leading edge except **aortic cusp separation**, which is inner edge to inner edge. • LAd anterior point should be in same place as AoR posterior point
MM: MVEPSS mitral valve • **NOT** Mitral Valve Protocol • Click: Mitral Valve EPSS	(cm)	3	Total 3 + average	• EPSS – inner edge to inner edge – extrapolate to most posterior point of septum and most anterior point of MV • 2 points do NOT have to be perpendicular • Do not measure EPSS when measurement appears to be incorrect due to "eggy" LV etc
MM: Mitral Valve Annular Descent • Click on M-Mode, then Mitral Valve, then MV Annular Descent		3		• Measure 3 times • Systole is the smallest internal diameter
MM: LV/RV Protocol • IVS_{ed} • $LVID_{ed}$ • $LVPW_{ed}$ • IVS_{es} • $LVID_{es}$ • $LVPW_{es}$	**(cm)**	3 • If <3 measure anyhow	Total 6 + average	• Take time to select best frame • Note frame on sheet • Don't forget to touch R wave between cycles • Fractional Shortening should be greater than 28%
2D PSA Ice Pick Protocol • IVS_{ed} • $LVID_{ed}$ • $LVPW_{ed}$ • $LVID_{es}$ • Computer calculates mean LVWT & LVFS	**(cm)**	2	2	• Called **Parasternal Long Axis** on Report. • Measure twice in the **PSSA view** • Diastole is usually frame 1 • Systole is the smallest internal diameter • DON'T FORGET! DO **NOT** measure RV septal wall and posterior LV epicardium • Skip LA in diastole and click on Next. • Skip LA in systole and click on Next.

DigiSonics Measurement Echocardiography Protocol and Tricks

Measure	Units of Measure	Mandatory	Elective	Comment
2D SAX Protocol • Trace epicardium$_{ed}$ • Trace endocardium$_{ed}$ • Trace epicardium$_{es}$ • Trace endocardium$_{es}$ • Leave arrow on 2-D image & right-click for diastole • Computer calculates	**(cm/cm^2)**	2	2	• Called **Parasternal Short Axis** (PSSA) on report • Measure twice in PSSA • Diastole @ onset QRS • Systole is the smallest internal diameter • Measure clockwise • Start where endocardium/epicardium is clearest.
2D LV Diastolic Dimension • Click on 2-D, then LV Protocol, then LV diastolic dimensions • LV length$_{ed,}$ measure twice	**(cm)**	2	2	• Called **Left Ventricle** (LV) on report • Measure in magnified view of LV in Apical 4CH, or in full Apical 4CH view, whichever image is superior. • Watch in "real time" for apical endocardium • Diastole @ onset QRS • Proximal point at MV annulus level, distal point at apical endocardium; right mouse button, repeat X 2
2D LV 2Chamber View • Select enlarged 4-chamber view loop • Measure 2 beats in diastole & systole • Select the first beat • Trace endocardium in diastole Press RMB • Touch the tip of the papillary muscle • Trace endocardium in systole Press RMB • Touch lateral and medial border of MV Annulus. • Repeat measurement for the second beat • Press "average" then go to the report to check measurements.		•	Total 4 + average	• Called **Two Chamber View** on report • Measure in magnified view of LV in Apical 4CH, or in full Apical 4CH view, whichever image is superior. • Choose view that has best endocardial definition

Optional Dicom Image Measurements			
Doppler AS Aortic Valve area by continuity (cm^2)	Optional suspect AS	3	• **AV area by continuity equation** • Calculation method [TVI vs.diam]: **Both** • Select area method: **diameters** • Enter orifice area: **Measure** off PLA digital image, about 5 frames into systole; place 2 points for $LVOT_{ed}$, then measure another $LVOT_{ed}$ hit average • RMB to continue • Trace LVOT TVI – make sure to calibrate • **Scale** – for Doppler. Touch 2 points 100 cm/sec apart & touch 1 sec. **Note that scale is often different than on old HP.** • Trace LVOT TVI, **then RMB** • Trace another, then RMB • Trace another, then RMB • Hit **Average** • Enter Doppler angle – 0 • Trace AV TVI, then click RMB • **Scale = Doppler scale** Touch 2 points 100 cm/sec apart & touch 1 sec. • **Trace AV TVI, RMB** • **Another AV TVI, RMB** • **Another AV TVI, RMB** • **Average, then RMB** • **Review report**
Doppler MS (m/sec)	Optional suspect MS	3	• Only if MS is suspected or Doppler project* • Need to figure out about ½ placement • Need to make 2 D MV area
2D MV Area (Cm^2)	Optional suspect MS	3	• Measure 4 off the video tape • Be sure to CALIBRATE
2D MV Leaflet Thickness (cm)	Optional suspect MVP	3	Measure under major dimension
2D MV Superior Displacement		3	• Measure under minor dimension • Measure in PLA dicom image (no calibration needed) • Measure at maximum MV Leaflets displacement into LA • Draw an imaginary line connecting hinge points of MV leaflets insertion. • Put first dot on imaginary line and second dot on the leading edge of MV leaflet at the point of maximum MV leaflet displacement.

* LV Dimensions - Normal Range: $LVID_{ed}$: 3.5-5.8cm; $LVID_{es}$: 2.2-4.0cm; Frac. Short.: 25%-43%

** Apical 4-Chamber View - Normal Range: Major $LVID_{ed}$: 6.9-10.3cm;

While measuring, **click on report after each measurement package is completed** and review measurements as follows:

➔ Consistency, are they within 10% of each other

➔ Number of measurements correct?

➔ Range, are they within reasonable range?

➔ Logic, do they make sense with your 2D impression.

To delete measurements

- Go to Data Entry menu, click on Edit Measurement Grid. By and large it is easier and safer to delete the entire measurement.
- If you want to delete just one out of three measurements, it can be done. After deleting the measurement in the Edit Measurement Grid, you want to make a new measurement. Go back to the Protocol you were in. Then click on one of the measurements that you have already made in the Protocol Measurement Tree. This will allow you to start measuring again.

Quick Measurements are not saved – to make quick measurements

- On digital images, right click on image; select 2D; make measurements.
- On the SVHS tape images right click on the screen, select scale, then select 2-D vs. MM vs. Doppler to calibrate, and then measure the image. You have to recalibrate each time.
- You can convert analogue SVHS images into a DICOM image. Details to follow.

Miscellaneous tips

- "Start over" command is equivalent to getting rid of all prior measurements;

Change measurement name

- Click on Configure: click on 'trees'; right click on item; rename item.

How to change personal information, i.e. name and ID on a study

- Open up an image from "Images Folder" from the erroneous study to check that time on image coincides with the right time that the study was done in Clinic.
- Open ERS32 program.
- Look for erroneous study (i.e. no ID#, no name) by time and date.
- Go to "Data Entry" menu and select "Study Information".
- Enter Pt. ID# and name in appropriate field.
- Click OK.
- Close ERS32 program.
- In "Images Folder", erroneous study folder will be renamed with new ID# and new name.

Backing up daily virgin studies to MOD (Magnetic Optical Disk)

- Back up Echo studies daily from Digisonics on 2 virgin copies.
- Label MOD virgin copies as follows:
  - 5/2004 = May, 2004
    A = side 1
    B = side 2
    6/2004= June, 2004
    A = side 1
    B = side 2
    When number of studies exceed MOD capacity, store data on Overflow MOD disk for that year.
  - **Double click on Images Folder Icon on blue screen.**
  - Put MOD in Sony E:drive – Side 1 up (A), arrow pointing in.
  - Open a new MOD, label it correctly: Echo, GEN 3, Exam 1, etc.(see above).
  - Begin by formatting MOD:
  - Double click on My Computer Icon on blue screen.
  - Message dialogue box will say: "This disk is not formatted. Do you want to format it?
  - Press Yes.
  - On screen, leave as is:

- Capacity: 2.40 GB
- File system: FAT
- Allocation Unit Size: Default allocation size
- Volume label: Leave blank
- Format options: Check Quick Format
- Click OK
- Message dialogue box will issue warning and ask you to format the disk.
- Click OK.
- Now you can start backing up daily Echo studies:
- Look at list of studies in Images Folder on Y:drive.
- Click on "Created" to get dates in order.
- Highlight each study performed that day by looking at Echo log book sheets from both rooms 108 & 110.
- Double click to open each study.
- Check that images have been successfully transferred by opening each folder from that day.
- Double click on random image, i.e. a Jpg file or a Video clip.
- When done checking each study, highlight all studies from that day by left-clicking on the studies. Each study will be about 30 MB.
- Left-click on box with highlighted studies and drag them to the E:drive (which should be open and on the screen).
- Copying will start. Copying takes about 8 minutes for 7-8 studies.
- When done, immediately copy on virgin Copy 2 as well. (This is the copy which will be stored off-site.)
- Check off in special MOD Back-up Echo studies in white binder by entering MOD number. Person who is storing MODs should also initial it.
- Check on E:drive that studies were copied.

ASK EMELIA IF SHE WOULD LIKE TO
Enter MD Overread table
OR PRIORITY MD OVERREAD

Appendix Item 1

FHS Vascular Function Tests – Handout for Participant

The Framingham Study's Noninvasive Cardiovascular Testing Station

In the cardiovascular testing station you will receive five tests that noninvasively examine your heart and blood vessels' structure and function. None of the tests involve radiation. You will receive the following tests:

1. Blood pressure

- The sonographers will carefully measure your blood pressure while listening with headphones.

2. Arterial tonometry

- The sonographer will hold a flat pressure-sensing device (the tonometer) against the superficial pulses in your arm, leg and neck for approximately a minute at each of these four sites. This approach allows us to assess blood vessel stiffness. **Details of the test are provided on the reverse side.**
- At the very end of all 4 tests, the sonographers will measure the distances between the 4 sites where the recordings were taken.

3. Echocardiogram

- The sonographer will hold an ultrasound transducer at several points over your left chest. The echocardiogram uses sound waves to take a picture of your heart. The test measures the heart's size and function.

4. Brachial ultrasound

- The sonographer will hold an ultrasound transducer over your left arm artery (brachial) and measure the size and the flow in the artery at baseline. Then the sonographer will inflate a blood pressure cuff over your lower arm for 5 minutes. After the cuff is released the sonographer will take a picture of the size and blood flow in the artery for two minutes after the cuff is released. The test measures the ability of the brachial artery to get bigger (dilate) when exposed to increased blood flow; this ability is a measure of the health of the blood vessel lining. The test may cause temporary numbness and tingling. Rarely subjects develop painless red spots, which disappear in a few days. **Details of the test are provided on the reverse side.**

5. Fingertip Pulse Test

- While the technician is performing the ultrasound test, s/he will also measure your pulse at one fingertip on each hand. If you have a known latex allergy, s/he will not apply the fingertip device.

- **If you have a <u>very abnormal</u> echocardiogram test the results will be sent to your physician.** Since the test is performed in a research context, and read without any knowledge of your symptoms or history, the results would need to be interpreted by your doctor in the context of your clinical history.

- **The Brachial ultrasound and arterial tonometry are solely used for research purposes. They are not used in clinical practice or to guide medical decisions. For this reason we will not be sending the results to your physician.**

If at any point during the testing you are uncomfortable and would like to terminate the tests, please tell the technicians.

<u>The Arterial Pressure Waveform Test (tonometry)</u>

The Framingham Study's Noninvasive Cardiovascular Testing Station

The Arterial Pressure Waveform Test (tonometry)

How is the test performed?

- Measurements are made by gently pressing the tip of flat pressure sensing device (the tonometer) against the superficial pulses in the arm, leg and neck for approximately a minute at each of four sites. This device records the pressure waveform that is associated with each pulse or heartbeat.
- Next, the distance from the base of the neck to each of the pulse sites is measured.
- You will be asked to lie quietly during this phase of the testing. There should be no discomfort. This test has been performed safely in thousands of patients.
- At a later date, using a computerized analysis, we will examine the shape of the pressure waveforms and calculate the speed at which pressure waves travel through the large arteries.

Why are we doing this test?

- The arterial pressure waveform test is a noninvasive method to evaluate the stiffness of the large arteries.
- This test will allow us to evaluate the relationship between cardiac risk factors, arterial stiffening and the development of cardiovascular disease.

The Brachial Artery Vascular Reactivity Ultrasound Test

For this test you will be asked to do the following:

- Have an ultrasound picture taken of the artery located in your upper arm.
- Have a blood pressure cuff inflated on your lower right arm for 5 minutes.
  When the cuff is inflated your arm may feel like it is going to sleep or numb.
- After the cuff is released we will take pictures of your artery for 2 more minutes.
  When the cuff is released your arm may feel pins & needles, warm or cold.
- At a later date we will make computer measurements of the amount that your artery expands after the cuff was released. The changes are very small, so we cannot tell you the results while we are doing the study.
- ***To get the best information it is very important that you not move when we are taking the ultrasound pictures.***
- This noninvasive test has been performed in thousands of research participants safely.
- Approximately 0.5% of participants develop painless red spots on the arm after the test, which resolve on their own within a few days. This is harmless, but if it occurs please call the sonographer (508-935-3445 or 508-935-3406) so we can track the frequency & the time to resolution.

Why are we doing this test?

- This test is designed to look at the function of the blood vessel lining.
- We are doing the test to understand if the results relate to risk factors for heart disease and to understand if the results will help predict the development of heart disease and stroke.

Thank you for your support of the research at The Framingham Study.

If you have further questions about the noninvasive tests please contact Dr. Emelia Benjamin by leaving a message at 508-935-3445 or 617-638-8968 or Dr. Ramachandran S. Vasan at 508-935-3450.

Appendix Item 2

FHS Echocardiography Ultrasonographer Worksheet

|7|0|2|1|6| FORM NUMBER OMB NO=0925-0216

FHS ECHOCARDIOGRAPHER ULTRASONOGRAPHER WORKSHEET

Study Date___/___/___ **Study type 0 1 2** (0=exam, 1=repeat study, 2=other) **EXAM** __ __

Data entry date___/___/___ ; ___/___/___ **Data entry ID** _____1st _____2nd

ECHO done? ☐ **Yes=1** ☐ **No=0** **Room #** **108** **110**

Tech ID __ __ **Height (inches)** ___ ___ **Sex M F**

Video MOD #_____if no video MOD, code 0 **SVHS #**_____if no SVHS#, code 0 **SVHS location**_____

STUDY QUALITY

OD	Good	Fair	Poor	Inadequate
M-mode Ao/LA	☐ =1	☐ =2	☐ =3	☐ =4
M-mode LV	☐ =1	☐ =2	☐ =3	☐ =4
PW mitral inflow	☐ =1	☐ =2	☐ =3	☐ =4
SVHS				
2-D study	☐ =1	☐ =2	☐ =3	☐ =4
CW AV	☐ =1	☐ =2	☐ =3	☐ =4
Color Doppler	☐ =1	☐ =2	☐ =3	☐ =4
Overall study quality	☐ =1	☐ =2	☐ =3	☐ =4

Comments:_____

_____

_____

_____

☐ Priority MD overread:

- ☐ Severe AS
- ☐ Thrombus
- ☐ Large pericardial effusion
- ☐ Other_____
- Called Dr._____
- ☐ Severe MS
- ☐ Vegetation
- ☐ Mod-severe _____regurgitation
- ☐ Mass
- ☐ Significant LV dysfunction≤30 % LVEF
  will call MD if Pt. not known to have cardiomyopathy or prior MI
- ☐ Ventricular wall thickness≥15 mm
- Date/time:_____

☐ MD overread, other:

- ☐ > Mild LAE
- ☐ Any LVH
- ☐ MS
- ☐ AS
- ☐ > Mild _____regurgitation
- ☐ Other_____
- ☐ > Mild AoR dil.
- ☐ Any LVE
- ☐ > Mild MAC
- ☐ Bicuspid AV
- ☐ RA/RV abnormality
- ☐ LV WMA
- ☐ Any MVP
- ☐ Valve prosthesis
- ☐ LVEF

☐ Requested by:

☐_____ ☐ For Dr._____ Date: _____

Reader__ __ __ **Reading 1 2** **Date interpreted___/___/___** (mo/day/yr)

OMB NO=0925-0216

LA enlargement	☐ **0=no**	☐ **1=borderln.**	☐ **2=mild**	☐ **3=moderate**	☐ **4=severe**	☐ **9=unknown**
Other LA comment						

Mitral Valve	☐ **0=normal**	☐ **1=prob nl**	☐ **2=abnormal**		☐ **4=prosth.**	☐ **9=unknown**
MV thickening	☐ 0=no	☐ 1=minimal	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
MS	☐ 0=normal	☐ 1=possible	☐ 2=likely			☐ 9=unknown
MAC	☐ 0=no	☐ 1=minimal	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
MVP	☐ 0=no	☐ 1=min sup disp	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
Other MV comment						

Aortic Valve	☐ **0=normal**	☐ **1=prob nl**	☐ **2=abnormal**		☐ **4=prosth.**	☐ **9=unknown**
AV thickening	☐ 0=no	☐ 1=minimal	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
AV cusp excursion	☐ 0=normal	☐ 1=minimal	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
Bicuspid AoV	☐ 0=no	☐ 1=yes	☐ 2=maybe			☐ 9=unknown
Aortic Root	☐ **0=normal**	☐ **1=prob nl**	☐ **2=abnormal**			☐ **9=unknown**
Aortic root dilation	☐ 0=no		☐ 2=present			☐ 9=unknown
Aortic root calcium	☐ 0=no	☐ 1=minimal	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
Other AV/AR comment						

LV Structure	☐ **0=normal**	☐ **1=prob nl**	☐ **2=abnormal**			☐ **9=unknown**
LV enlargement	☐ 0=no	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
LVWT concentric	☐ 0=no	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
LVWT other	☐ 0=no	☐ 1=DUSK	☐ 2=ASH	☐ 3=ISH	☐ 4=oth_____	☐ 9=unknown

LV Regional WMA	☐ **0=normal**	☐ **1=prob nl**	☐ **2=abnormal**			☐ **9=unknown**
Septum	☐ 0=normal	☐ 1=paradoxic	☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown
Anterior	☐ 0=normal		☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown
Anterior/Anterolateral	☐ 0=normal		☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown
Posterior	☐ 0=normal		☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown
Inferior	☐ 0=normal		☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown
Apex	☐ 0=normal		☐ 2=hypokinetic	☐ 3=akinetic	☐ 4=dyskinetic	☐ 9=unknown

LV Systolic Function	☐ **0=normal**	☐ **1=prob nl**	☐ **2=regional**		☐ **4=global**	☐ **9=unknown**
LV ejection fraction	☐ 0=normal	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
						LVEF ___%
Other LV comment						

Right Heart/Pericardium	☐ **0=normal**	☐ **1= prob nl**	☐ **2=abnormal**			☐ **9=unknown**
RA enlargement	☐ 0=no	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
RV enlargement	☐ 0=no	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
RV hypertrophy	☐ 0=no	☐ 1=borderline	☐ 2=mild	☐ 3=moderate	☐ 4=severe	☐ 9=unknown
Pericardial fluid	☐ 0=no/syst.		☐ 2=small	☐ 3=medium	☐ 4=large	☐ 9=unknown
Other right /pericardium						

Valve Regurgitation	☐ **0=none**		☐ **2=present**			☐ **9=unknown**
Mitral	☐ 0=none	☐ 1=trace	☐ 2=mild	☐ 3=moderate	☐ 4=m-s ☐ 5=sev	☐ 9=unknown
Aortic	☐ 0=none	☐ 1=trace	☐ 2=mild	☐ 3=moderate	☐ 4=m-s ☐ 5=sev	☐ 9=unknown
Tricuspid	☐ 0=none	☐ 1=trace	☐ 2=mild	☐ 3=moderate	☐ 4=m-s ☐ 5=sev	☐ 9=unknown
Mitral Stenosis	☐ **0=none**	☐ **1=trivial**	☐ **2=mild**	☐ **3=moderate**	☐ **4=severe**	☐ **9=unknown**
Aortic Stenosis	☐ **0=none**	☐ **1=trivial**	☐ **2=mild**	☐ **3=moderate**	☐ **4=severe**	☐ **9=unknown**
Other Doppler comment						

Comments:_____

_____

Clinical correlation is suggested ☐ **0=not applicable** ☐ **1=yes**

Appendix Item 3

Generation 3 Exam 1 Log Book Sheet for Tonometry, Brachial & Echo Tests

GENERATION 3 EXAM 1 LOG BOOK SHEET FOR TONOMETRY, BRACHIAL AND ECHO TESTS

|7|0|2|1|7| FORM NUMBER OMB NO=0925-0216

Date of Clinic Visit ____ - ____ - _____ **Room #** **108** **110**
Mo Day Yr

TONOMETRY

Test done?	**yes** (test was done, even if all 4 pulses could not be acquired and recorded)	**no** (test was not attempted or done)	**If no, why: Circle all that apply**
30 49 88 717 __	**Sonographer ID#**		1. Subject refusal 2. Subject discomfort 3. Time constraint 4. Equipment problem, specify _____ 7. Other, specify _____
|__|__|__|-|__|__|__|	**Video CD#**		
___/____/____	**TONOMETRY test date** if different from Clinic Date above.		

ECHO

Test done?	**yes** (test was done, even if recorded on video only)	**yes, partial** (i.e. only apical OR only parasternal images were acquired)	**no** (test was not attempted or done)	**If no or partial, why: Circle all that apply**
30 49 88 717 __	**Sonographer ID#**			1. Subject refusal 2. Subject discomfort 3. Time constraint 4. Equipment problem, specify _____ 7. Other, specify _____
|__|__|__|-|__|__|__|	**SVHS#**			
___/____/____	**ECHO test date** if different from Clinic Date above.			
MD overread required:	**yes**		**no**	

BRACHIAL

Test done?	**yes** (test was done, even if problems with Baseline, Doppler, and/or Deflation)	**no** (test was not attempted or done)	**If no, why: Circle all that apply**
30 49 88 717 __	**Sonographer ID#**		1. Subject refusal 2. Subject discomfort 3. Time constraint 4. Equipment problem, specify _____ 5. test contraindication 7. Other, specify _____
|__|__|__|-|__|__|__|	**Video CD#**		
___/____/____	**BRACHIAL test date** if different from Clinic Date above.		

PAT

Test done?	**yes** (test was done, even if problems with data)	**no** (test was not attempted or done)	**If no, why: Circle all that apply**
30 49 88 717 __	**Sonographer ID#**		1. Subject refusal 2. Subject discomfort 3. Time constraint 4. Equipment problem, specify _____ 5. test contraindication 7. Other, specify _____ 8. Latex allergy
|__|__|__|-|__|__|__|	**Video CD#**		
___/____/____	**PAT test date** if different from Clinic Date above.		

Appendix Item 4

FHS Echo Protocol

FHS ECHO PROTOCOL – Gen 3				
Set up	***Connect ECG, tall R wave; Enter Subject ID, last name, first name; Sonographer ID; On sheet code tape # & location start +MOD#***			
VIEW	**DATA SOUGHT**	**Loop/Disk**	**Priority**	**EMPHASIS**
A5C	2-D LV Wall motion, CW AoV		Medium	
	PW LVOT	**GM save**	**High**	Cursor in LVOT ~ .5 cm from AV
Tonometry	**Carotid**	**GM save**	**High**	
PLA	2-D – start 20 cm - ↓ depth		Med	Chamber size & fxn, valve & AoR
	2-D LVOT - magnify	**GM save**	**High**	LVOT diameter
	2-D LV, RV, LA & Ao; MV & AV	**2D 1 loop**	**High**	LV wall motion & thickness; MV/AV
	Color flow: AV/MV		Med	
RV inflow*	*2-D & Color flow TV*		*Low*	*If short on time – abandon*
PSA	2-D of AV, LA		**High**	AV opening & # leaflets
	M-mode full screen of AV&LA- narrow sector, ↓ depth	**MM 2 frames**	**HIGH**	Clear boundaries
	2-D sweep: LV (pap → apex → pap) narrow sector, ↓ depth		**High**	LV wall motion
	2-D of MV			
	M-mode full screen of MV	**MM 1 frame**	Med	Clear boundaries Epicardial +
	2-D LV PSA below MV tips magnify narrow sector, ↓ depth	**2D 1 loop**	**HIGH**	Endocardial definition
	M-mode LV same level – magnify	**MM 3 frames**	**HIGH**	Ensure Clear boundaries.
Apical 4	**2-D all 4 chambers – start 20 cm - ↓ depth**	**2D 1 loop**	**High**	Chamber size & function: RV & LV
	Color flow: MV, TV & AV		Med	Regurgitant flows
	#PW Pulmonary veins – speed @ 50	**GM save & PWI frame**	Med	Diastolic function – spend only 30 sec
	PW MV tips inflow: speed @ 50	**GM save & PW 1 frame**	**High**	Cursor @ leaflet tips (max velocity)
	2-D LV & MV annulus - narrow sector, ↓ depth	**2D 1 loop**	Med	Endocardial definition
	M-mode MV annulus @ 50	**MM 1 frame**	Med	Diastolic function
	#Tissue Doppler PW of the MV annulus - speed @ 50	**GM save & PW 1 frame**	Med	Diastolic function
Apical 2	**2-D LA&LV - narrow sector ↓ depth**	**2D 1 loop**	**High**	LV wall motion, endocardial definition
	Color flow: MV		Med	Regurgitant flow
Apical long	Color flow: MV & AV		Med	Regurgitant flows
	2-D LA/ LV /Ao narrow sector ↓ depth	**2D 1 loop**	Med	LV wall motion, endocardial definition
Subcostal*	*2-D (valves/chambers (RV):see wall thickness*		*Low*	*Focus if study TLS; RVWT*
Check that desired images are saved in loops; 6 loops+10 frames=16 pages File, Save; -Paper work *Delete if short on time #preset				

Appendix Item 5

Distribution & Categorization of Echocardiographic Measurements in Relation to Reference Limits

Distribution and Categorization of Echocardiographic Measurements in Relation to Reference Limits

The Framingham Heart Study: Formulation of a Height- and Sex-Specific Classification and Its Prospective Validation

Ramachandran S. Vasan, MD; Martin G. Larson, ScD; Daniel Levy, MD; Jane C. Evans, MPH; Emelia J. Benjamin, MD, ScM

Background Despite widespread categorization of echocardiographic measurements, there are no standardized guidelines for partitioning values exceeding reference limits.

Methods and Results We used regression analyses to develop sex- and height-specific reference limits for cardiac M-mode measurements (left ventricular [LV] mass, LV wall thickness, and LV and left atrial dimensions) in a healthy reference sample (n=1099) from the Framingham Heart Study. We then examined the distribution of measurements in a broad sample (n=4957) and classified the measurements according to increasing deviation from the height- and sex-specific reference limits and the 95th, 98th, and 99th percentile values for the broad sample (categories 0 through 4, respectively). To validate the categorization scheme, we used multivariable proportional-hazards regression to assess the relations of LV mass and LV wall thickness categories to risk of cardiovascular events and the relations of left atrial size to risk of atrial fibrillation. During a mean follow-up period of 7.7 years, 587 subjects developed new cardiovascular disease events, and 166 subjects developed new-onset atrial fibrillation. After adjustment for known risk factors, there was a 1.2- and 1.3-fold risk of cardiovascular disease events per category of LV wall thickness and LV mass, respectively, and a 1.6-fold risk of atrial fibrillation per category of left atrial size.

Conclusions Using a large community-based study sample, we propose a classification scheme that provides a standardized and validated framework for partitioning echocardiographic measurements. If adopted, the categorization scheme should promote uniformity in describing measurements among echocardiographic laboratories and enhance the comprehensibility of measurements to clinicians. (***Circulation.* 1997;96: 1863-1873.**)

Key Words • echocardiography • cardiovascular diseases • ventricles • atrium • follow-up studies

Reference values, often referred to as the "upper limits of normal," have been proposed for echocardiographic dimensions of cardiac chambers.[1-10] The current practice in echocardiographic laboratories across the world is to categorize echocardiographic measurements as normal or into mild, moderate, or severe degrees of abnormality. For instance, the expressions "moderate concentric left ventricular hypertrophy" and "severe left atrial enlargement" are used widely to describe quantitative abnormalities of these cardiac structures. Despite the widespread use of such descriptive terms, there are no standardized guidelines in the echocardiographic literature regarding cut points for partitioning values exceeding reference limits. Furthermore, the current clinical practice of categorizing values exceeding reference limits is highly variable between and within institutions, neither height- nor sex-specific, and inadequately substantiated by scientific data.

The choice of cut points for classifying echocardiographic values (or any other quantitative clinical measurement) on an ordinal scale should be based on the distribution of these observations in relation to reference limits in a randomly selected noninstitutionalized sample of the general population.[11] Such a classification system may be useful for descriptive purposes, for prognostication, and for the prevention and treatment of diseases.[12] Previous publications from the Framingham Heart Study have evaluated the relations of echocardiographic variables as continuous measures to cardiovascular disease events. The objectives of the present investigation were twofold: (1) to develop a classification system of echocardiographic values exceeding reference limits in a community-based study sample and (2) to prospectively examine the utility of our categorization approach for predicting clinically important events during follow-up.

Methods

Study Sample

The selection criteria and study design of the FHS (both original and offspring study cohorts) have been detailed exten-

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From the National Heart, Lung, and Blood Institute's Framingham (Mass) Heart Study (all authors); the Divisions of Cardiology and Clinical Epidemiology, Beth Israel Hospital, Harvard Medical School, Boston, Mass (D.L.); the Cardiology Section (E.J.B.) and Department of Preventive Medicine and Epidemiology (R.S.V., M.G.L., D.L., E.J.B.), Boston (Mass) University School of Medicine; and the National Heart, Lung, and Blood Institute, Bethesda, Md (D.L.).

Correspondence to Emelia J. Benjamin. MD, ScM, Framingham Heart Study, 5 Thurber St, Framingham, MA 01701.

E-mail emelia@fram.nhlbi.nih.gov

TABLE 1. Clinical and Echocardiographic Characteristics of Study Samples

	Reference Sample		Broad Sample	
	Men (n=387)	Women (n=712)	Men (n=2223)	Women (n=2734)
Clinical features				
Age, y (range)	35.7±6.1 (20-45)	36.1±5.5 (21-45)	49.8±13.9 (18-90)	51.6±15.0 (17-90)
Height, m	1.77±0.06	1.63±0.06	1.75±0.07	1.60±0.07
Weight, kg	74.0±6.9	58.9±6.1	81.1±12.0	64.1±12.3
Body surface area, m^2	1.91±0.11	1.63±0.10	1.96±0.16	1.66±0.15
Systolic blood pressure, mm Hg	116.9±9.3	109.6±10.3	128.8±17.2	125.0±20.6
Diastolic blood pressure, mm Hg	74.7±7.0	71.0±7.5	80.3±9.3	75.6±9.6
Coronary disease, %	...	...	8.3	5.3
Hypertension, %	...	...	35.0	31.6
Valve disease, %	...	...	2.8	3.1
Heart failure, %	...	...	0.8	1.0
AF, %	...	...	2.2	1.2
Diabetes mellitus, %	...	...	4.6	3.3
Echocardiographic features				
LV mass, g	173.9±39.7	114.5±23.5	202.1±61.8	135.9±44.3
Ventricular wall thickness, mm	18.1±2.0	15.5±1.5	19.8±3.0	17.4±3.0
LA dimension, mm	37.5±3.6	32.9±3.2	40.4±5.1	36.0±5.3
LV end-diastolic dimension, mm	50.9±3.5	46.1±3.1	51.1±4.4	45.7±4.0

Plus-minus values indicate mean±SD.

ing the covariates were included for the proportional-hazards analyses.

Choice of Statistical Models

We investigated whether the risk of adverse events differed among categories of echocardiographic variables using the several multivariable statistical models: models incorporating clinical variables only; multicategory models, in which risk of adverse outcome in each category was compared with that associated with category 0; trend models, in which we investigated whether there was a stepwise increase in risk of adverse outcome from one category to the next higher one; and threshold models, in which we tested whether there was a particular category above which there was increased risk of adverse outcomes (eg, risk of adverse events in subjects in categories 0 and 1 versus risk in subjects in categories 2, 3, and 4).

To explore the impact of sex on the risks associated with the echocardiographic categories, we performed secondary analyses incorporating interaction terms. All analyses were performed with the SAS System (SAS Institute Inc) procedures REG[35] and PHREG[36] on a SUNsparc 2 workstation; a two-sided value of $P<.05$ assessed statistical significance.

Results

Study Sample

The characteristics of the study subjects are summarized in Table 1. Compared with the reference sample, subjects in the broad sample were older, heavier, and had higher blood pressure, body mass index, and mean values for the echocardiographic measurements studied. In the broad sample, the prevalence of cardiovascular disease was as follows: hypertension, 33.1%; coronary disease, 6.7%; congestive heart failure, 0.9%; and AF, 1.7%. These conditions were grounds for exclusion from the reference sample.

Classification of Values Exceeding Reference Limits

In general, we noted a significant relation between height and echocardiographic variables in both sexes. The distributions of the ratio of observed to sex- and height-predicted values were examined for each echocardiographic variable; the Figure displays the distribution of this ratio for LA dimension, LV mass, LV wall thickness, and LV end-diastolic dimension. Approximately one quarter of men and one third of women exceeded reference limits for LV wall thickness, LV mass, and LA dimension. Eleven percent of men and 9% of women exceeded reference limits for LV end-diastolic dimension. Tables 2 and 3 provide the sex- and height-specific cut points for the five proposed categories of each echocardiographic variable derived from the percentiles of the ratio of observed to sex- and height-predicted values in the reference (category 0) and broad (categories 1 through 4) samples.

Relation of Category of Echocardiographic Variable to Clinical Outcome

Unadjusted Event Rates According to Category of Variable

Three subjects were lost to follow-up. During follow-up of the remaining 4954 subjects (mean age, 7.7 years; range, 0.4 to 11 years), 587 subjects experienced a new cardiovascular event; 55 of these new events were fatal. There were 166 subjects with new-onset AF among the 4872 subjects free of AF at baseline. Crude rates for new events increased across categories of LV mass, LV wall thickness, and LA size (Tables 4 through 6). Among men and women with a measurement of LV mass or LV wall thickness suggestive of extreme deviation from reference limits (category 4), >60% developed new cardiovascular disease events on follow-up; in comparison, <10% of the subjects in category 0 experienced a new event. Categories of LV mass or LV wall thickness between these two extremes (categories 1 through 3) had intermediate rates of new cardiovascular disease events. For categories of LA dimension, AF rates rose in stepwise fashion; >60% of subjects in category 4 developed AF, compared with 2% of subjects in category 0.

Multivariable Analyses

Irrespective of the choice of the statistical model, a significant risk gradient for adverse events was evident across the categories of LV mass, LV wall thickness, and LA dimensions for both sexes after adjustment for other

TABLE 2. Cut Points for Categorization of Echocardiographic LA Size, LV Mass, Wall Thickness, and LV Diameter in Women

Height		Category				
in	cm	0	1	2	3	4
			Left atrium, mm			
54	137	≤36.6	36.7-43.0	43.1-47.2	47.3-49.6	>49.6
55	140	≤36.8	36.9-43.3	43.4-47.5	47.6-49.9	>49.9
56	142	≤37.0	37.1-43.5	43.6-47.7	47.8-50.2	>50.2
57	145	≤37.2	37.3-43.7	43.8-48.0	48.1-50.4	>50.4
58	147	≤37.4	37.5-44.0	44.1-48.2	48.2-50.7	>50.7
59	150	≤37.6	37.7-44.2	44.3-48.5	48.6-51.0	>51.0
60	152	≤37.8	37.9-44.4	44.5-48.8	48.9-51.2	>51.2
61	155	≤38.0	38.1-44.7	44.8-49.0	49.1-51.5	>51.5
62	157	≤38.1	38.2-44.9	45.0-49.2	49.3-51.8	>51.8
63	160	≤38.3	38.4-45.1	45.2-49.5	49.6-52.0	>52.0
64	163	≤38.5	38.6-45.3	45.4-49.7	49.8-52.3	>52.3
65	165	≤38.7	38.8-45.5	45.6-50.0	50.1-52.5	>52.5
66	168	≤38.9	39.0-45.8	45.9-50.2	50.3-52.8	>52.8
67	170	≤39.1	39.2-46.0	46.1-50.4	50.5-53.0	>53.0
68	173	≤39.2	39.3-46.2	46.3-50.7	50.8-53.2	>53.2
69	175	≤39.4	39.5-46.4	46.5-50.9	51.0-53.5	>53.5
70	178	≤39.6	39.7-46.6	46.7-51.1	51.2-53.7	>53.7
71	180	≤39.8	39.9-46.8	46.9-51.3	51.4-53.9	>53.9
72	183	≤39.9	40.0-47.0	47.1-51.6	51.7-54.2	>54.2
			LV mass, g			
54	137	≤116	117-159	160-189	190-233	>233
55	140	≤119	120-163	164-194	195-240	>240
56	142	≤123	124-168	169-200	201-247	>247
57	145	≤126	127-173	174-205	206-254	>254
58	147	≤130	131-178	179-211	212-261	>261
59	150	≤133	134-183	184-217	218-268	>268
60	152	≤137	138-188	189-223	224-275	>275
61	155	≤141	142-193	194-229	230-282	>282
62	157	≤144	145-198	199-235	236-290	>290
63	160	≤148	149-203	204-241	242-297	>297
64	163	≤152	153-208	209-247	248-305	>305
65	165	≤155	156-213	214-253	254-312	>312
66	168	≤159	160-218	219-259	260-320	>320
67	170	≤163	164-223	224-266	267-328	>328
68	173	≤167	168-229	230-272	273-336	>336
69	175	≤171	172-234	235-278	279-344	>344
70	178	≤175	176-240	241-285	286-352	>353
71	180	≤179	180-245	246-291	292-360	>360
72	183	≤183	184-251	252-298	299-368	>368
			LV wall thickness, mm			
54	137	≤16.9	17.0-21.4	21.5-24.7	24.8-27.4	>27.4
55	140	≤17.0	17.1-21.6	21.7-24.9	25.0-27.6	>27.6
56	142	≤17.1	17.2-21.8	21.9-25.1	25.2-27.8	>27.8
57	145	≤17.2	17.3-21.9	22.0-25.3	25.4-28.0	>28.0
58	147	≤17.4	17.5-22.1	22.2-25.5	25.6-28.2	>28.2
59	150	≤17.5	17.6-22.2	22.3-25.6	25.7-28.4	>28.4
60	152	≤17.6	17.7-22.4	22.5-25.8	25.9-28.6	>28.6
61	155	≤17.7	17.8-22.5	22.6-26.0	26.1-28.8	>28.8
62	157	≤17.8	17.9-22.7	22.8-26.2	26.3-29.0	>29.0
63	160	≤18.0	18.1-22.8	22.9-26.3	26.4-29.2	>29.2
64	163	≤18.1	18.2-23.0	23.1-26.5	26.6-29.4	>29.4
65	165	≤18.2	18.3-23.1	23.2-26.7	26.8-29.6	>29.6
66	168	≤18.3	18.4-23.3	23.4-26.9	27.0-29.8	>29.8
67	170	≤18.4	18.5-23.4	23.5-27.0	27.1-29.9	>29.9
68	173	≤18.5	18.6-23.6	23.7-27.2	27.3-30.1	>30.1
69	175	≤18.6	18.7-23.7	23.8-27.4	27.5-30.3	>30.3
70	178	≤18.8	18.9-23.9	24.0-27.5	27.6-30.5	>30.5
71	180	≤18.9	19.0-24.0	24.1-27.7	27.8-30.7	>30.7
72	183	≤19.0	19.1-24.1	24.2-27.8	27.9-30.8	>30.8

RS indicates reference sample; BS, broad sample. Categories are 0, value≤95th percentile RS; 1, 95th percentile RS<value≤95th percentile BS; 2, 95th percentile BS<value≤98th percentile BS; 3, 98th percentile BS<value≤99th percentile BS; and 4, value>99th percentile BS. For women in category 0, the RS 95th percentile values correspond to the following percentiles of the broad sample: For LA size, 71%; for LV mass 72%, for LV wall thickness 64%, for LV internal diameter end diastole 91%, for LV diameter end systole 93%.

TABLE 3. Cut Points for Categorization of Echocardiographic LA Size, LV Mass, Wall Thickness, and LV Diameter in Men

Height		Category				
in	cm	0	1	2	3	4
			Left atrium, mm			
60	152	≤42.4	42.5-47.7	47.8-51.7	51.8-53.9	>53.9
61	155	≤42.5	42.6-47.9	48.0-51.9	52.0-54.1	>54.1
62	157	≤42.7	42.8-48.1	48.2-52.1	52.2-54.3	>54.3
63	160	≤42.8	42.9-48.3	48.4-52.3	52.4-54.5	>54.5
64	163	≤43.0	43.1-48.4	48.5-52.5	52.6-54.7	>54.7
65	165	≤43.1	43.2-48.6	48.7-52.6	52.7-54.9	>54.9
66	168	≤43.3	43.4-48.8	48.9-52.8	52.9-55.1	>55.1
67	170	≤43.4	43.5-48.9	49.0-53.0	53.1-55.3	>55.3
68	173	≤43.6	43.7-49.1	49.2-53.2	53.3-55.5	>55.5
69	175	≤43.7	43.8-49.3	49.4-53.4	53.5-55.6	>55.6
70	178	≤43.9	44.0-49.4	49.5-53.5	53.6-55.8	>55.8
71	180	≤44.0	44.1-49.6	49.7-53.7	53.8-56.0	>56.0
72	183	≤44.2	44.3-49.7	49.8-53.9	54.0-56.2	>56.2
73	185	≤44.3	44.4-49.9	50.0-54.0	54.1-56.4	>56.4
74	188	≤44.4	44.5-50.0	50.1-54.2	54.3-56.5	>56.5
75	190	≤44.6	44.7-50.2	50.3-54.4	54.5-56.7	>56.7
76	193	≤44.7	44.8-50.3	50.4-54.5	54.6-56.9	>56.9
77	196	≤44.8	44.9-50.5	50.6-54.7	54.8-57.0	>57.0
78	198	≤45.0	45.1-50.6	50.7-54.8	54.9-57.2	>57.2
			LV mass, g			
60	152	≤170	171-221	222-264	265-295	>295
61	155	≤175	176-228	229-272	273-305	>305
62	157	≤181	182-235	236-281	282-314	>314
63	160	≤186	187-242	243-289	290-324	>324
64	163	≤192	193-249	250-298	299-334	>334
65	165	≤198	199-257	258-307	308-344	>344
66	168	≤204	205-264	265-316	317-354	>354
67	170	≤210	211-272	273-325	326-364	>364
68	173	≤216	217-280	281-335	336-375	>375
69	175	≤222	223-288	289-344	345-385	>385
70	178	≤228	229-296	297-354	355-396	>396
71	180	≤234	235-304	305-363	364-407	>407
72	183	≤240	241-312	313-373	374-418	>418
73	185	≤247	248-320	321-383	384-429	>429
74	188	≤253	254-329	330-393	394-440	>440
75	190	≤260	261-337	338-403	404-451	>451
76	193	≤266	267-346	347-413	414-463	>463
77	196	≤273	274-355	356-424	425-475	>475
78	198	≤280	281-363	364-434	435-486	>486
			LV wall thickness, mm			
60	152	≤18.8	18.9-22.9	23.0-25.2	25.3-27.0	>27.0
61	155	≤19.1	19.2-23.2	23.3-25.6	25.7-27.4	>27.4
62	157	≤19.3	19.4-23.5	23.6-25.9	26.0-27.8	>27.8
63	160	≤19.6	19.7-23.8	23.9-26.3	26.4-28.1	>28.1
64	163	≤19.8	19.9-24.1	24.2-26.6	26.7-28.5	>28.5
65	165	≤20.1	20.2-24.4	24.5-27.0	27.1-28.9	>28.9
66	168	≤20.4	20.5-24.8	24.9-27.3	27.4-29.3	>29.3
67	170	≤20.6	20.7-25.1	25.2-27.7	27.8-29.6	>29.6
68	173	≤20.9	21.0-25.4	25.5-28.0	28.1-30.0	>30.0
69	175	≤21.1	21.2-25.7	25.8-28.3	28.4-30.4	>30.4
70	178	≤21.4	21.5-26.0	26.1-28.7	28.8-30.7	>30.7
71	180	≤21.6	21.7-26.3	26.4-29.0	29.1-31.1	>31.1
72	183	≤21.9	22.0-26.6	26.7-29.4	29.5-31.5	>31.5
73	185	≤22.2	22.3-26.9	27.0-29.7	29.8-31.8	>31.8
74	188	≤22.4	22.5-27.2	27.3-30.1	30.2-32.2	>32.2
75	190	≤22.7	22.8-27.5	27.6-30.4	30.5-32.6	>32.6
76	193	≤22.9	23.0-27.8	27.9-30.7	30.8-32.9	>32.9
77	196	≤23.2	23.3-28.2	28.3-31.1	31.2-33.3	>33.3
78	198	≤23.4	23.5-28.5	28.6-31.4	31.5-33.6	>33.6

Abbreviations and categories as in Table 2. For men in category 0, the RS 95th percentile values correspond to the following percentiles of the broad sample: For LA size, 78%; for LV mass, 77%; for LV wall thickness, 74%; for LV internal end-diastolic diameter, 89%; and for LV end-systolc internal diameter, 93%.

TABLE 4. Relations of Categories of LV Mass to Incidence of New Cardiovascular Disease Events: Results of Cox Proportional-Hazards Models

	Men			Women			Hazards Ratio (95% CI)†	
Proposed Category	No. in Category	No. of Events on Follow-up	Rate per 1000 Person-Years*	No. in Category	No. of Events on Follow-up	Rate per 1000 Person-Years*	Trend Models	5-Category Models
Value ≤95 percentile reference sample (category 0)	1707	189	15.1	1955	107	7.2	1.0 (Reference)	1.0 (Reference)
95 percentile reference sample<value≤95 percentile broad sample (category 1)	403	89	32.3	640	96	20.7	1.32 (1.20-1.44)	1.27 (1.03-1.56)
95 percentile broad sample<value≤98 percentile broad sample (category 2)	67	29	71.1	82	23	45.3	1.73 (1.44-2.08)	1.75 (1.26-2.45)
98 percentile broad sample<value≤99 percentile broad sample (category 3)	22	10	92.7	27	8	51.9	2.28 (1.74-3.00)	2.05 (1.20-3.49)
Value >99 percentile broad sample (category 4)	23	19	181.7	28	17	149.0	3.00 (2.09-4.32)	3.10 (2.08-4.63)

*Based on 587 new cardiovascular events among 4954 subjects in the broad sample. Cardiovascular events include coronary disease (angina, myocardial infarction, coronary insufficiency, and sudden cardiac death), heart failure, stroke, transient ischemic attacks, and intermittent claudication.

†Hazards ratio adjusted for age, sex, hypertension, diastolic blood pressure, pulse pressure, smoking, total cholesterol/HDL cholesterol, diabetes mellitus, and previous cardiovascular disease. These proportional-hazards analyses are based on 555 subjects with new cardiovascular events among 4775 subjects with complete information regarding covariates.

graphic reference limits[1-10] have been based on percentile estimates drawn from cross-sectional samples of smaller numbers of healthy subjects. Previous investigations from the FHS[19,50] and elsewhere[1-10] have not subdivided the values exceeding reference limits for practical use by clinicians.

The exclusion of subjects without satisfactory echocardiograms (who are generally sicker) may have resulted in the lowering of thresholds for abnormal values. The use of M-mode measurements presents other potential limitations. Cardiac disease may result in distorted LV geometry with the possibility of underestimating or overestimating LV mass.[51] Furthermore, M-mode technology (transducer sensitivity, etc) has changed over the past two decades because the echocardiograms were performed. In addition, categories based on M-mode measurements may not be generalizable to two-dimensional echocardiographic measurements. Nonetheless, previous investigations have found reasonable agreement between measurements made by the two techniques.[6,52] Finally, it is possible for a patient to shift between categories simply on the basis of limitations in the reproducibility of echocardiographic measurements.[53]

Because the generation and validation of our classification are based on ambulatory subjects, its prognostic relevance in hospitalized subjects is unknown. A related potential limitation is that in addition to age, the cut points are largely dependent on the prevalent pattern and severity of cardiac disease in the study participants. For instance, cut points for varying degrees of LV hypertrophy and LV dilatation obtained from our study sample may differ substantially from those obtained from subjects in hypertension and heart failure clinics, respectively. Nonetheless, it is heartening to note that the prevalence of cardiovascular disease in our study sample was consistent with that observed in the general US population.[54] Furthermore, although we have demonstrated significant prognostic value of this categorization scheme, the therapeutic implications of our classification, if any, are unknown. Last, given the largely white racial composition of the Framingham sample, readers should exercise caution in extrapolating the study results to other racial groups.

TABLE 5. Relations of Categories of LV Wall Thickness to Incidence of New Cardiovascular Disease Events: Results of Cox Proportional-Hazards Models

	Men			Women			Hazards Ratio (95% CI)†	
Proposed Category	No. in Category	No. of Events on Follow-up	Rate per 1000 Person-Years*	No. in Category	No. of Events on Follow-up	Rate per 1000 Person-Years*	Trend Model	5-Category Model
Value ≤95 percentile reference sample (category 0)	1633	184	15.4	1745	69	5.1	1.0 (Reference)	1.0 (Reference)
95 percentile reference sample<value≤95 percentile broad sample (category 1)	474	101	31.2	850	137	22.5	1.18 (1.08-1.30)	1.27 (1.03-1.55)
95 percentile broad sample<value≤98 percentile broad sample (category 2)	68	22	49.1	81	20	37.2	1.39 (1.17-1.69)	1.33 (0.92-1.92)
98 percentile broad sample<value≤99 percentile broad sample (category 3)	24	14	109.4	28	10	67.8	1.64 (1.26-2.20)	2.20 (1.40-3.48)
Value >99 percentile broad sample (category 4)	23	15	138.7	28	15	107.0	1.94 (1.36-2.86)	1.72 (1.10-2.69)

*Based on 587 new cardiovascular events in 4954 subjects of the broad sample. Cardiovascular events include coronary disease (angina, myocardial infarction, coronary insufficiency, and sudden cardiac death), heart failure, stroke, transient ischemic attacks, and intermittent claudication.

†Hazards ratio adjusted for age, sex, hypertension, diastolic blood pressure, pulse pressure, smoking, total cholesterol/HDL-cholesterol, diabetes mellitus, and previous cardiovascular disease. These proportional-hazards analyses are based on 555 subjects with new cardiovascular events among 4775 subjects with complete information regarding covariates.

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Appendix Item 6

Quality Assurance Protocol

Quality Assurance Protocol for Echocardiography Gen 3

Element	Frequency	Procedure	Statistics
Reproducibility	Annual	• Intra- Inter-observer measurement variability • Intra- Inter-observer qualitative assessment variability* Interpreters measure 20 scans twice	• Continuous measures: Mean ± sd • Qualitative measures: Kappa statistics? • Correlation coefficients
	Annual	• Temporal variability • Interpreters measure calibration scan set	• Mean ± sd $\lvert y - \bar{y} \rvert$ • Range $\lvert y - \bar{y} \rvert$ • Components of variability
	Once	• Sonographer variability • Sonographers scan 20 FHS personnel	• Subject • Within sonographer • Between sonographer
Descriptive statistics	Quarterly	• Generated by data management staff • Assessment of differences in quantitative & qualitative* variables across sonographers and observers for routine scans	• Measurement variability • Mean ± sd
Data cleaning	Monthly	• Generated by data management staff	• Out of range data • Missing data
QA reports	Quarterly	• Generated by data management staff • Reproducibility statistics included in reports	• Descriptive statistics • Data cleaning
Lab meetings	Bi-weekly	• FHS sonographers measure random or difficult studies together	
	Monthly	• FHS review QA reports • FHS Review lab flow, issues	
	Quarterly	• Review FHS reports with key personnel	

QA = quality assurance; sd = standard deviation; FHS = Framingham Heart Study

***Note: we have NOT assessed reproducibility on qualitative echo data before. This is essential to enhance integrity of data & usability of data set.**

Appendix Item 7

Tonometry Echo Brachial PAT Logsheet Complications & Premature Termination of Studies

TONOMETRY ECHO BRACHIAL PAT LOGSHEET COMPLICATIONS AND PREMATURE TERMINATION OF STUDIES APRIL 2002 THROUGH DECEMBER 2003 FOR GEN3, OMNI GEN2 AND NOS

Data taken from the log book records whether test was 'done', 'incomplete' or 'not done'. It is a snapshot of what occurred during the clinic visit i.e. it does not reflect the quality of the data etc. The data may change with different reports e.g. the participant may return for a test therefore a previously recorded 'test not done due to time constraint' may now be recorded as a test done etc.

		REASON FOR TEST NOT DONE								
Tonometry Test	**TTest Done**	**Subject Refusal**	**Subject Discom**	**Time Constraint**	**Equip Problem**	**Reason**		**Other, Specify**	**Reason**	
Yes	2665									
Incomplete	18	0	0	0	0			18	Can't find pulse due to obesity n=9 Technically difficult study can't find pulse n=9	
No	6	0	0	2	0			4	Seizure n=1 Retarded n=1 Allergy to electrodes n=1 Not feeling well n=1	
Total	2689									
Echo Test	**ETest Done**	**Subject Refusal**	**Subject Discom**	**Time Constraint**	**Equip Problem**	**Reason**		**Other, Specify**	**Reason**	
Yes	2678									
Incomplete	4	0	1	0	1	Computer problems n=1		2	Obesity no windows to get pictures n=1 Downs Syndrome difficulty in communicating n=1	
No	7	1* *same subject	1*	2	0			4	Recent chest surgery n=1 Retarded n=1 Allergy to electrodes n=1 Not feeling well n=1	
Total	2689									

Appendix Item 8

Echo Variable Coding

FRAMINGHAM STUDY ECHOCARDIOGRAPHY EXAM 6
CODING MANUAL

SAS NAME = ECHO6

SAS VARIABLE NAMES: IDTYPE ID EXAM SDATE SONOG_ID INTERP IDATE DDISK_ID DDISK_I1 TAPE_ID L2AODM_V L2AODM_S LMLVP_DV LMLVP_DS LMLVP_SV LMLVP_SS LMLVD_DV LMLVD_DS LMLVD_SV LMLVD_SS LMIVS_DV LMIVS_DS LMIVS_SV LMIVS_SS LMLADM_V LMLADM_S LMAORT_V LMAORT_S LMAOCU_V LMAOCU_S LMMVD_EV LMMVD_ES LMMVEI_V LMMVEI_S AOMVLS_V AOMVLS_S AOPKVL_V AOPKVL_S AOSYVL_V AOSYVL_S AOVTAT_V AOVTAT_S AOHR_V AOHR_S AOBTDR_V AOBTDR_S AOACTM_V AOACTM_S AODETM_V AODETM_S AOEJTM_V AOEJTM_S AOATET_V AOACC_V AOACC_S AODEC_V AODEC_S AOMPRG_V AOMPRG_S AOPPRG_V MIMVLD_V MIMVLD_S MIMVLA_V MIMVLA_S MIMVLE_V MIMVLE_S MIPVLE_V MIPVLE_S MIPVLA_V MIPVLA_S MIPE_A_V MIDVTI_V MIDVTI_S MIVTEW_V MIVTEW_S MIVTAW_V MIVTAW_S MIVTAT_V MIVT3_V MIVT3_S MIVTAJ_V MIVTAJ_S MIVTET_V MIVTAL_V MIVT3T_V MIVTEA_V MIHR_V MIHR_S MIBTDR_V MIBTDR_S MIACTM_V MIACTM_S MIDETM_V MIDETM_S MIFLTM_V MIFLTM_S MIACC_V MIACC_S MIDEEF_V MIDEEF_S MIMPRG_V MIMPRG_S MIPPRG_V MIPHTM_V MIPHTM_S MIPVAR_V MIPVAR_S PUMVLS_V PUMVLS_S PUPKVL_V PUPKVL_S PUSYVT_V PUSYVT_S PUVTAT_V PUVTAT_S PUHR_V PUHR_S PUBTDR_V PUBTDR_S PUPEJP_V PUPEJP_S PUACTM_V PUACTM_S PUDETM_V PUDETM_S PUEJTM_V PUEJTM_S PUPEAT_V PUPEET_V PUATET_V PUACC_V PUACC_S PUDEC_V PUDEC_S PUMPRG_V PUMPRG_S PUPPRG_V DATETYPE VDISK_ID VDISK_I1 TAPE_LOC SQAOLA SQLV SQMITINF SQLVOT SQ2D SQCWTR SQCWAV SQCOLDOP SQOVER READING LAENLARG MVNORMAL MVTHICK MVMS MVMAC MVMVP AONORMAL AOTHICK AOCUSPEX AOROOTNL AOROOTDI AOROOTCA LVSNORM LVSENLAR LVSWT LVSOTH1 LVWNORM LVWSEPT LVWANTER LVWPOST LVWINF LVWAPEX LVFNORM LVFEJFR LVEF_PER RHNORMAL RHRAENL RHRVENL RHRVHYPE RHPERIFL VRNORMAL VRMITRAL VRAORTIC VRTRICUS VRTRVELO MITSTEN AORSTEN CLINCORR LAOTHER MVOTHER AOOTHER LVFOTHER RHOTHER DOPPCOMM COMMENTS

CODING MANUAL
FRAMINGHAM STUDY

#RECORDS 3921

VARIABLE	INFORMATION
IDTYPE	STUDY 1 OFFSPRING STUDY 7 OMNI STUDY
ID	PARTICIPANT ID NUMBER
EXAM	EXAM NUMBER
SDATE	STUDY DATE 15AUG1994 - 02SEP1998

DATETYPE	TYPE OF STUDY 0=EXAM 1=REPEAT STUDY 2=OTHER
SONOG_ID	SONOGRAPHER ID 28 - 30
VDISK_ID	VIDEO OD #, PART I 28 - 30 . UNKNOWN (2)
VDISK_I1	VIDEO OD #, PART II 0 - 57 . UNKNOWN (3)
DDISK_ID	DATA OD #, PART I 28 - 174
DDISK_I1	DATA OD #, PART II 1 - 500
TAPE_ID	SVHS TAPE NUMBER 739 - 1362
TAPE_LOC	SVHS TAPE LOCATION 0 - 9930
SQAOLA	STUDY QUALITY - OD M-MODE AO/LA 1 GOOD 2 FAIR 3 POOR 4 INADEQUATE . UNKNOWN (11)
SQLV	STUDY QUALITY - OD M-MODE LV 1 GOOD 2 FAIR 3 POOR 4 INADEQUATE . UNKNOWN (11)
SQMITINF	STUDY QUALITY - OD PW MITRAL INFLOW 1 GOOD 2 FAIR 3 POOR 4 INADEQUATE . UNKNOWN (11)
SQLVOT	STUDY QUALITY - OD PW LVOT 1 GOOD 2 FAIR 3 POOR 4 INADEQUATE . UNKNOWN (11)

SQ2D STUDY QUALITY - SVHS 2-D STUDY
1 GOOD
2 FAIR
3 POOR
4 INADEQUATE

SQCWTR STUDY QUALITY - SVHS CW TR
1 GOOD
2 FAIR
3 POOR
4 INADEQUATE
5 NOT TAPED*
* THIS OPTION WAS ADDED DURING DATA COLLECTION AND WAS NOT AVAILABLE ON ALL DATA COLLECTION FORMS

SQCWAV STUDY QUALITY - SVHS CW AV
1 GOOD
2 FAIR
3 POOR
4 INADEQUATE

SQCOLDOP STUDY QUALITY - SVHS COLOR DOPPLER
1 GOOD
2 FAIR
3 POOR
4 INADEQUATE

SQOVER OVERALL STUDY QUALITY
1 GOOD
2 FAIR
3 POOR
4 INADEQUATE

INTERP INTERPRETER
28 - 174

READING READING NUMBER
1 FIRST READING
2 SECOND READING

IDATE INTERPRETATION DATE
23AUG1994 - 20DEC2000

LAENLARG LEFT ATRIAL ENLARGEMENT
0 NO
1 BORDERLINE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (23)

LAOTHER OTHER LA COMMENT

MVNORMAL MITRAL VALVE
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
4 PROSTHESIS
. UNKNOWN (20)

MVTHICK MITRAL VALVE THICKENING
0 NO
2 MILD
4 MODERATE/SEVERE
. UNKNOWN (42)

MVMS MITRAL VALVE MS
0 NORMAL
1 POSSIBLE
2 LIKELY
. UNKNOWN (26)

MVMAC MITRAL VALVE MAC
0 NO
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (43)

MVMVP MITRAL VALVE MVP
0 NO
1 MIN SUP DISPLACE
2 MILD
4 MODERATE/SEVERE
. UNKNOWN (42)

MVOTHER OTHER MV COMMENT

AONORMAL AORTIC VALVE
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
4 PROSTHESIS
. UNKNOWN (291)

AOTHICK AORTIC VALVE THICKENING
0 NO
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (321)

AOCUSPEX AORTIC VALVE CUSP EXCURSION
0 NO
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (370)

AOROOTNL AORTIC ROOT
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
4 PROSTHESIS
. UNKNOWN (17)

AOROOTDI AORTIC ROOT DILATION
0 NO
2 PRESENT
. UNKNOWN (19)

AOROOTCA AORTIC ROOT CALCIUM
0 NO
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (33)

AOOTHER OTHER AV/AOR COMMENT

LVSNORM LV STRUCTURE
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
4 PROSTHESIS
. UNKNOWN (147)

LVSENLAR LV ENLARGEMENT
0 NO
1 BORDERLINE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (164)

LVSWT LVWT CONCENTRIC
0 NO
1 BORDERLINE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (192)

LVSOTH1 LVWT OTHER
0 NO
1 DUSK
2 ASH
3 ISH
4 OTHER
. UNKNOWN (154)

LVWNORM LV REGIONAL WMA
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
. UNKNOWN (257)

LVWSEPT LV REGIONAL WMA, SEPTUM
0 NORMAL
1 PARADOX.
2 HYPOKINETIC
3 AKINETIC
4 DYSKINETIC
. UNKNOWN (265)

LVWANTER LV REGIONAL WMA, ANTERIOR/ANTEROLATERAL
0 NORMAL
2 HYPOKINETIC
3 AKINETIC
4 DYSKINETIC
. UNKNOWN (275)

LVWPOST LV REGIONAL WMA, POSTERIOR
0 NORMAL
2 HYPOKINETIC
3 AKINETIC
4 DYSKINETIC
. UNKNOWN (269)

LVWINF LV REGIONAL WMA, INFERIOR
0 NORMAL
2 HYPOKINETIC
3 AKINETIC
4 DYSKINETIC
. UNKNOWN (280)

LVWAPEX LV REGIONAL WMA, APEX
0 NORMAL
2 HYPOKINETIC
3 AKINETIC
4 DYSKINETIC
. UNKNOWN (283)

LVFNORM LV SYSTOLIC FUNCTION
0 NORMAL
1 PROB NORMAL
2 REGIONAL
4 GLOBAL
. UNKNOWN (192)

LVFEJFR LV EJECTION FRACTION
0 NORMAL
1 BORDERLINE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (192)

LVFOTHER OTHER LV COMMENT

LVEF_PER LV EJECTION FRACTION PERCENT
0 - 80
. UNKNOWN (3680)

RHNORMAL RIGHT HEART/PERICARDIUM
0 NORMAL
1 PROB NORMAL
2 ABNORMAL
. UNKNOWN (94)

RHRAENL RIGHT ATRIAL ENLARGEMENT
0 NO
2 MILD
4 MODERATE/SEVERE
. UNKNOWN (105)

RHRVENL RIGHT VENTRICULAR ENLARGEMENT
0 NO
2 MILD
4 MODERATE/SEVERE
. UNKNOWN (105)

RHRVHYPE RIGHT VENTRICULAR HYPERTROPHY
0 NO
2 MILD
4 MODERATE/SEVERE
. UNKNOWN (171)

RHPERIFL RIGHT HEART PERICARDIUM: PERICARDIAL FLUID
0 NO SYS.
2 SMALL
4 MED/LARGE
. UNKNOWN (94)

RHOTHER OTHER RIGHT HEART/PERICARDIUM COMMENT

VRNORMAL VALVE REGURGITATION
0 NONE
2 PRESENT
. UNKNOWN (79)

VRMITRAL VALVE REGURGITATION: MITRAL
0 NONE
1 TRACE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (98)

VRAORTIC VALVE REGURGITATION: AORTIC
0 NONE
1 TRACE
2 MILD
3 MODERATE
4 SEVERE
. UNKNOWN (136)

VRTRICUS VALVE REGURGITATION: TRICUSPID

0	NONE
1	TRACE
2	MILD
3	MODERATE
4	SEVERE
.	UNKNOWN (129)

VRTRVELO VALVE REGURGITATION: TRICUSPID VELOCITY

0	(<2)
1	(2-2.4)
2	(2.5-2.9)
3	(3.0-3.6)
4	(>3.6)
.	UNKNOWN (3095)

MITSTEN MITRAL STENOSIS

0	NONE
1	TRIVIAL
2	MILD
3	MODERATE
4	SEVERE
.	UNKNOWN (57)

AORSTEN AORTIC STENOSIS

0	NONE
1	TRIVIAL
2	MILD
3	MODERATE
4	SEVERE
.	UNKNOWN (145)

DOPPCOMM OTHER DOPPLER COMMENTS

COMMENTS STUDY COMMENT

CLINCORR CLINICAL CORRELATION

0	NOT APPLICABLE
2	YES
.	UNKNOWN (3210)

L2AODM_V 2D AORTIC ROOT DIAMETER AVG VALUE

1.739 - 3.913	
.	UNKNOWN (3872)

L2AODM_S 2D AORTIC ROOT DIAMETER STD DEV

0.004 - 0.141	
.	UNKNOWN (3891)

LMLVP_DV MM LEFT VENTRICULAR POSTERIOR WALL DIASTOLE AVG VALUE

0.558 - 1.840	
.	UNKNOWN (753)

LMLVP_DS MM LEFT VENTRICULAR POSTERIOR WALL DIASTOLE STD DEV

0.016 - 0.441	
.	UNKNOWN (1991)

LMLVP_SV MM LEFT VENTRICULAR POSTERIOR WALL SYSTOLE AVG VALUE
0.624 - 2.405
. UNKNOWN (785)

LMLVP_SS MM LEFT VENTRICULAR POSTERIOR WALL SYSTOLE STD DEV
0.017 - 0.657
. UNKNOWN (2325)

LMLVD_DV MM LEFT VENTRICULAR DIAMETER DIASTOLE AVG VALUE
3.361 - 7.763
. UNKNOWN (845)

LMLVD_DS MM LEFT VENTRICULAR DIAMETER DIASTOLE STD DEV
0.016 - 0.410
. UNKNOWN (1823)

LMLVD_SV MM LEFT VENTRICULAR DIAMETER SYSTOLE AVG VALUE
1.646 - 6.932
. UNKNOWN (886)

LMLVD_SS MM LEFT VENTRICULAR DIAMETER SYSTOLE STD DEV
0.017 - 0.338
. UNKNOWN (2234)

LMIVS_DV MM INTER-VENTRICULAR SEPTUM THICKNESS DIASTOLE AVG VALUE
0.593 - 1.992
. UNKNOWN (595)

LMIVS_DS MM INTER-VENTRICULAR SEPTUM THICKNESS DIASTOLE STD DEV
0.016 - 0.190
. UNKNOWN (1892)

LMIVS_SV MM INTER-VENTRICULAR SEPTUM THICKNESS SYSTOLE AVG VALUE
0.610 - 2.373
. UNKNOWN (637)

LMIVS_SS MM INTER-VENTRICULAR SEPTUM THICKNESS SYSTOLE STD DEV
0.016 - 0.253
. UNKNOWN (2315)

LMLADM_V MM LEFT ATRIAL DIAMETER MEAN AVG SYSTOLE
2.510 - 6.238
. UNKNOWN (63)

LMLADM_S MM LEFT ATRIAL DIAMETER MEAN STD DEV
0.017 - 1.950
. UNKNOWN (494)

LMAORT_V MM AORTIC ROOT DIAMETER AVG VALUE
2.166 - 4.842
. UNKNOWN (35)

LMAORT_S MM AORTIC ROOT DIAMETER STD DEV
0.016 - 0.445
. UNKNOWN (798)

LMAOCU_V	MM AORTIC CUSP SEPARATION AVG VALUE 0.464 - 2.649 . UNKNOWN (1145)
LMAOCU_S	MM AORTIC CUSP SEPARATION STD DEV 0.017 - 0.399 . UNKNOWN (2571)
LMMVD_EV	MMODE LA DIAMETER END SYSTOLE AVG VALUE 1.763 - 5.714 . UNKNOWN (3743)
LMMVD_ES	MMODE LA DIAMETER END SYSTOLE STD DEV 0.020 - 0.212 . UNKNOWN (3770)
LMMVEI_V	MM MITRAL VALVE E POINT SEPTAL SEPARATION AVG VALUE 0.010 - 2.751 . UNKNOWN (713)
LMMVEI_S	MM MITRAL VALVE E POINT SEPTAL SEPARATION STD DEV 0.016 - 0.314 . UNKNOWN (2014)
AOMVLS_V	AORTIC VALVE MEAN VELOCITY SYSTOLE AVG VALUE 0.779 - 3.070 . UNKNOWN (3857)
AOMVLS_S	AORTIC VALVE MEAN VELOCITY SYSTOLE STD DEV 0.012 - 0.456 . UNKNOWN (3859)
AOPKVL_V	AORTIC VALVE PEAK VELOCITY AVG VALUE 1.384 - 4.401 . UNKNOWN (3857)
AOPKVL_S	AORTIC VALVE PEAK VELOCITY STD DEV 0.013 - 0.249 . UNKNOWN (3859)
AOSYVL_V	AORTIC VALVE SYSTOLIC VTI AVG VALUE 0.238 - 1.160 . UNKNOWN (3857)
AOSYVL_S	AORTIC VALVE SYSTOLIC VTI STD DEV 0 - 0.091 . UNKNOWN (3859)
AOVTAT_V	AORTIC VALVE VTI:AT AVG VALUE 0.059 - 0.441 . UNKNOWN (3857)
AOVTAT_S	AORTIC VALVE VTI:AT STD DEV 0.001 - 0.050 . UNKNOWN (3859)

AOHR_V AORTIC VALVE HEART RATE AVG VALUE
41 - 94
. UNKNOWN (3861)

AOHR_S AORTIC VALVE HEART RATE STD DEV
0.1 - 29.2
. UNKNOWN (3866)

AOBTDR_V AORTIC VALVE BEAT DURATION AVG VALUE
0.640 - 1.481
. UNKNOWN (3861)

AOBTDR_S AORTIC VALVE BEAT DURATION STD DEV
0.002 - 0.253
. UNKNOWN (3866)

AOACTM_V AORTIC VALVE ACCELERATION TIME AVG VALUE
0.050 - 0.150
. UNKNOWN (3857)

AOACTM_S AORTIC VALVE ACCELERATION TIME STD DEV
0.002 - 0.027
. UNKNOWN (3861)

AODETM_V AORTIC VALVE DECELERATION TIME AVG VALUE
0.160 - 0.440
. UNKNOWN (3857)

AODETM_S AORTIC VALVE DECELERATION TIME STD DEV
0.003 - 0.385
. UNKNOWN (3860)

AOEJTM_V AORTIC VALVE EJECTION TIME AVG VALUE
0.220 - 0.500
. UNKNOWN (3857)

AOEJTM_S AORTIC VALVE EJECTION TIME STD DEV
0.002 - 0.381
. UNKNOWN (3859)

AOATET_V AORTIC VALVE AT/ET AVG VALUE
0.117 - 0.422
. UNKNOWN (3857)

AOACC_V AORTIC VALVE ACCELERATION SLOPE AVG VALUE*
13.750 - 49.768
. UNKNOWN (3857)
*NORMAL VALUE NOT VERIFIED

AOACC_S AORTIC VALVE ACCELERATION SLOPE STD DEV*
0.232 - 14.357
. UNKNOWN (3859)
*NORMAL VALUE NOT VERIFIED

AODEC_V AORTIC VALVE DECELERATION SLOPE AVG VALUE*
4.67 - 20.606
. UNKNOWN (3857)
*NORMAL VALUE NOT VERIFIED

AODEC_S AORTIC VALVE DECELERATION SLOPE STD DEV*
0.009 - 3.971
. UNKNOWN (3859)
*NORMAL VALUE NOT VERIFIED

AOMPRG_V AORTIC VALVE MEAN PRESSURE GRADIENT AVG VALUE
3.927 - 43.234
. UNKNOWN (3857)

AOMPRG_S AORTIC VALVE MEAN PRESSURE GRADIENT STD DEV
0.046 - 4.903
. UNKNOWN (3859)

AOPPRG_V AORTIC VALVE PEAK PRESSURE GRADIENT AVG VALUE
7.659 - 77.485
. UNKNOWN (3857)

MIMVLD_V MITRAL VALVE MEAN VELOCITY DIASTOLE AVG VALUE
0.372 - 1.916
. UNKNOWN (3908)

MIMVLD_S MITRAL VALVE MEAN VELOCITY DIASTOLE STD DEV
0.006 - 0.236
. UNKNOWN (3909)

MIMVLA_V MITRAL VALVE MEAN VELOCITY A WAVE AVG VALUE
0.424 - 2.066
. UNKNOWN (3911)

MIMVLA_S MITRAL VALVE MEAN VELOCITY A WAVE STD DEV
0.021 - 0.333
. UNKNOWN (3912)

MIMVLE_V MITRAL VALVE MEAN VELOCITY E WAVE AVG VALUE
0.644 - 1.923
. UNKNOWN (3908)

MIMVLE_S MITRAL VALVE MEAN VELOCITY E WAVE STD DEV
0.015 - 0.428
. UNKNOWN (3909)

MIPVLE_V MITRAL VALVE PEAK VELOCITY E AVG VALUE
0.936 - 2.601
. UNKNOWN (3908)

MIPVLE_S MITRAL VALVE PEAK VELOCITY E STD DEV
0.012 - 0.182
. UNKNOWN (3909)

MIPVLA_V MITRAL VALVE PEAK VELOCITY A AVG VALUE
0.628 - 2.868
. UNKNOWN (3911)

MIPVLA_S MITRAL VALVE PEAK VELOCITY A STD DEV
0.023 - 0.361
. UNKNOWN (3912)

MIPE_A_V MITRAL VALVE PEAK E/A AVG VALUE
0.677 - 1.923
. UNKNOWN (3911)

MIDVTI_V MITRAL VALVE DIASTOLIC VTI AVG VALUE
0.289 - 0.793
. UNKNOWN (3908)

MIDVTI_S MITRAL VALVE DIASTOLIC VTI STD DEV
0.012 - 0.222
. UNKNOWN (3909)

MIVTEW_V MITRAL VALVE VTI E WAVE AVG VALUE
0.184 - 0.574
. UNKNOWN (3908)

MIVTEW_S MITRAL VALVE VTI E WAVE STD DEV
0.004 - 0.178
. UNKNOWN (3909)

MIVTAW_V MITRAL VALVE VTI A WAVE AVG VALUE
0.059 - 0.318
. UNKNOWN (3911)

MIVTAW_S MITRAL VALVE VTI A WAVE STD DEV
0.005 - 0.060
. UNKNOWN (3912)

MIVTAT_V MITRAL VALVE VTI:AT AVG VALUE*
0.184 - 0.458
. UNKNOWN (3911)
*NORMAL VALUE NOT VERIFIED

MIVT3_V MITRAL VALVE VTI .333 AVG VALUE
0.101 - 0.299
. UNKNOWN (3908)

MIVT3_S MITRAL VALVE VTI .333 STD DEV
0.001 - 0.094
. UNKNOWN (3909)

MIVTAJ_V MITRAL VALVE VTI ADJUSTABLE AVG VALUE
0.102 - 0.300
. UNKNOWN (3908)

MIVTAJ_S MITRAL VALVE VTI ADJUSTABLE STD DEV
0 - 0.094
. UNKNOWN (3909)

MIVTET_V MITRAL VALVE VTI E/TOTAL AVG VALUE
0.463 - 1.00
. UNKNOWN (3908)

MIVTAL_V MITRAL VALVE VTI A/TOTAL AVG VALUE
0.184 - 0.458
. UNKNOWN (3911)

MIVT3T_V MITRAL VALVE VTI .333/TOTAL AVG VALUE
0.329 - 0.537
. UNKNOWN (3908)

MIVTEA_V MITRAL VALVE VTI E/A AVG VALUE
1.381 - 4.394
. UNKNOWN (3911)

MIHR_V MITRAL VALVE HEART RATE AVG VALUE
39 - 91
. UNKNOWN (3909)

MIHR_S MITRAL VALVE HEART RATE STD DEV
0.4 - 16.2
. UNKNOWN (3910)

MIBTDR_V MITRAL VALVE BEAT DURATION AVG VALUE
0.680 - 1.530
. UNKNOWN (3909)

MIBTDR_S MITRAL VALVE BEAT DURATION STD DEV
0.004 - 0.278
. UNKNOWN (3910)

MIACTM_V MITRAL VALVE ACCELERATION TIME AVG VALUE*
0.050 - 0.080
. UNKNOWN (3908)
*NORMAL VALUE NOT VERIFIED

MIACTM_S MITRAL VALVE ACCELERATION TIME STD DEV*
0.004 - 0.023
. UNKNOWN (3909)
*NORMAL VALUE NOT VERIFIED

MIDETM_V MITRAL VALVE DECELERATION TIME AVG VALUE
0.140 - 0.470
. UNKNOWN (3908)

MIDETM_S MITRAL VALVE DECELERATION TIME STD DEV
0.010 - 0.250
. UNKNOWN (3909)

MIFLTM_V MITRAL VALVE FILLING TIME AVG VALUE
0.360 - 1.060
. UNKNOWN (3908)

MIFLTM_S MITRAL VALVE FILLING TIME STD DEV
0.010 - 0.180
. UNKNOWN (3909)

MIACC_V MITRAL VALVE ACCELERATION SLOPE AVG VALUE*
8.650 - 46.315
. UNKNOWN (3908)
*NORMAL VALUES NOT VERIFIED

MIACC_S MITRAL VALVE ACCELERATION SLOPE STD DEV*
1.201 - 29.146
. UNKNOWN (3909)
*NORMAL VALUES NOT VERIFIED

MIDEEF_V MITRAL VALVE DECELERATION AVG VALUE*
2.286 - 7.245
. UNKNOWN (3908)
*NORMAL VALUES NOT VERIFIED

MIDEEF_S MITRAL VALVE DECELERATION STD DEV*
0.101 - 3.092
. UNKNOWN (3909)
*NORMAL VALUES NOT VERIFIED

MIMPRG_V MITRAL VALVE MEAN PRESSURE GRADIENT AVG VALUE
0.790 - 16.091
. UNKNOWN (3908)

MIMPRG_S MITRAL VALVE MEAN PRESSURE GRADIENT STD DEV
0.035 - 3.535
. UNKNOWN (3909)

MIPPRG_V MITRAL VALVE PEAK PRESSURE GRADIENT AVG VALUE
3.504 - 27.066
. UNKNOWN (3908)

MIPHTM_V MITRAL VALVE PRESSURE HALFTIME AVG VALUE
0.061 - 0.185
. UNKNOWN (3908)

MIPHTM_S MITRAL VALVE PRESSURE HALFTIME STD DEV
0.006 - 0.027
. UNKNOWN (3910)

MIPVAR_V PREDICTED MITRAL VALVE VALVE AREA BY PHT AVG VALUE
1.204 - 3.602
. UNKNOWN (3908)

MIPVAR_S PREDICTED MITRAL VALVE VALVE AREA BY PHT STD DEV
0.101 - 0.412
. UNKNOWN (3910)

PUMVLS_V LV OUTFLOW TRACT MEAN VELOCITY SYSTOLE AVG VALUE
0.395 - 0.904
. UNKNOWN (3870)

PUMVLS_S LV OUTFLOW TRACT MEAN VELOCITY SYSTOLE STD DEV
0.004 - 0.158
. UNKNOWN (3872)

PUPKVL_V LV OUTFLOW TRACT PEAK VELOCITY AVG VALUE
0.686 - 1.522
. UNKNOWN (3870)

PUPKVL_S LV OUTFLOW TRACT PEAK VELOCITY STD DEV
0.005 - 0.101
. UNKNOWN (3870)

PUSYVT_V LV OUTFLOW TRACT SYSTOLIC VTI AVG VALUE*
0.146 - 0.334
. UNKNOWN (3870)
*NORMAL VALUES NOT VERIFIED

PUSYVT_S LV OUTFLOW TRACT SYSTOLIC VTI STD DEV*
0.001 - 0.081
. UNKNOWN (3870)
*NORMAL VALUES NOT VERIFIED

PUVTAT_V LV OUTFLOW TRACT VTI:AT AVG VALUE*
0.032 - 0.146
. UNKNOWN (3870)
*NORMAL VALUES NOT VERIFIED

PUVTAT_S LV OUTFLOW TRACT VTI:AT STD DEV*
0.001 - 0.025
. UNKNOWN (3870)
*NORMAL VALUES NOT VERIFIED

PUHR_V LV OUTFLOW TRACT HEART RATE AVG VALUE
44 - 94
. UNKNOWN (3870)

PUHR_S LV OUTFLOW TRACT HEART RATE STD DEV
0.1 - 32.5
. UNKNOWN (3886)

PUBTDR_V LV OUTFLOW TRACT BEAT DURATION AVG VALUE*
0.640 - 1.360
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUBTDR_S LV OUTFLOW TRACT BEAT DURATION STD DEV*
0.002 - 0.275
. UNKNOWN (3886)
* NORMAL VALUES NOT VERIFIED

PUPEJP_V LV OUTFLOW TRACT PRE-EJECTION PERIOD AVG VALUE*
0.020 - 0.310
. UNKNOWN (3871)
* NORMAL VALUES NOT VERIFIED

PUPEJP_S LV OUTFLOW TRACT PRE-EJECTION PERIOD STD DEV*
0.002 - 0.396
. UNKNOWN (3892)
* NORMAL VALUES NOT VERIFIED

PUACTM_V LV OUTFLOW TRACT ACCELERATION TIME AVG VALUE*
0.050 - 0.190
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUACTM_S LV OUTFLOW TRACT ACCELERATION TIME STD DEV*
0.003 - 0.043
. UNKNOWN (3872)
* NORMAL VALUES NOT VERIFIED

PUDETM_V LV OUTFLOW TRACT DECELERATION TIME AVG VALUE*
0.150 - 0.320
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUDETM_S LV OUTFLOW TRACT DECELERATION TIME STD DEV*
0.002 - 0.086
. UNKNOWN (3872)
* NORMAL VALUES NOT VERIFIED

PUEJTM_V LV OUTFLOW TRACT EJECTION TIME AVG VALUE*
0.270 - 0.390
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUEJTM_S LV OUTFLOW TRACT EJECTION TIME STD DEV*
0.002 - 0.106
. UNKNOWN (3872)
* NORMAL VALUES NOT VERIFIED

PUPEAT_V LV OUTFLOW TRACT PRE-EJECTION PERIOD/ACCEL. TIME AVG VALUE
0.133 - 1.783
. UNKNOWN (3871)

PUPEET_V LV OUTFLOW TRACT PRE-EJECTION PERIOD/EJECTION TIME AVG VALUE
0.043 - 0.828
. UNKNOWN (3871)

PUATET_V LV OUTFLOW TRACT ACCELERATION TIME/EJECTION TIME AVG VALUE*
0.130 - 0.545
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUACC_V LV OUTFLOW TRACT ACCELERATION SLOPE AVG VALUE*
5.088 - 21.840
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUACC_S LV OUTFLOW TRACT ACCELERATION SLOPE STD DEV*
0.078 - 4.546
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUDEC_V LV OUTFLOW TRACT DECELERATION SLOPE AVG VALUE*
2.462 - 8.022
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUDEC_S LV OUTFLOW TRACT DECELERATION SLOPE STD DEV*
0.029 - 1.627
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUMPRG_V LV OUTFLOW TRACT MEAN PRESSURE GRADIENT AVG VALUE*
0.791 - 3.986
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUMPRG_S LV OUTFLOW TRACT MEAN PRESSURE GRADIENT STD DEV*
0.007 - 0.774
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

PUPPRG_V LV OUTFLOW TRACT PEAK PRESSURE GRADIENT AVG VALUE*
1.882 - 9.260
. UNKNOWN (3870)
* NORMAL VALUES NOT VERIFIED

Appendix Item 9

2-D + M-Mode Illustrations

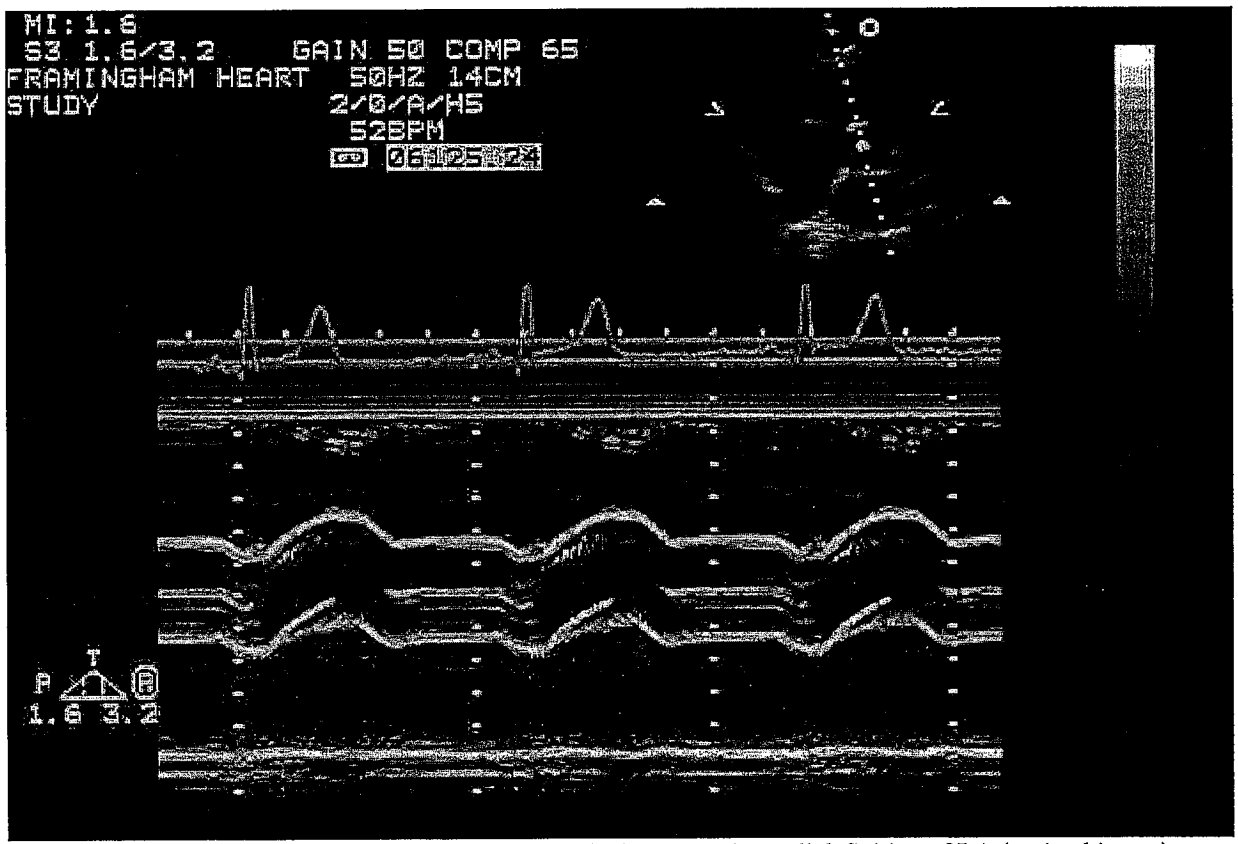

Fig. 1a – Example of M-mode of Ao Root, AV, LA with clear posterior wall definition of LA (optimal image).

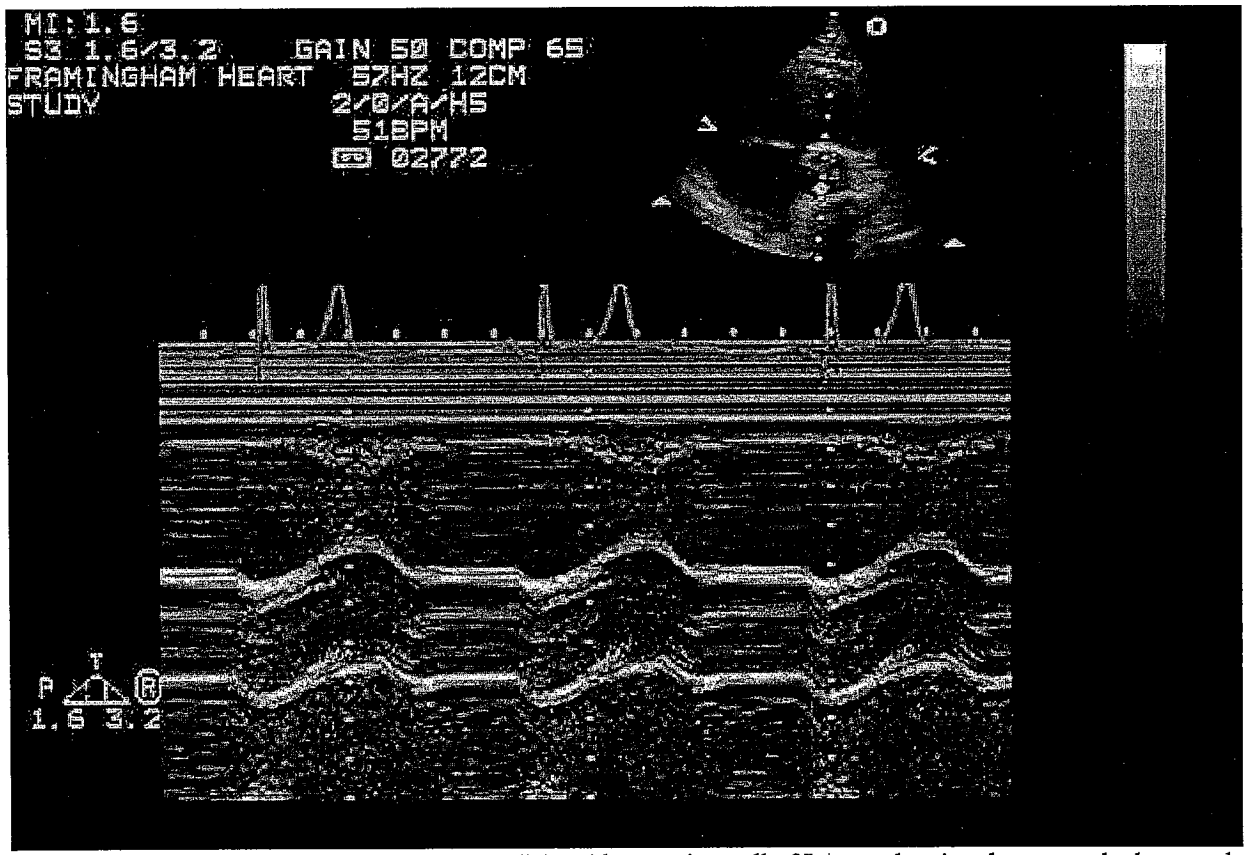

Fig. 1b – Example of M-mode of Ao Root, AV, LA, with posterior wall of LA not showing due to overly decreased depth (suboptimal image).

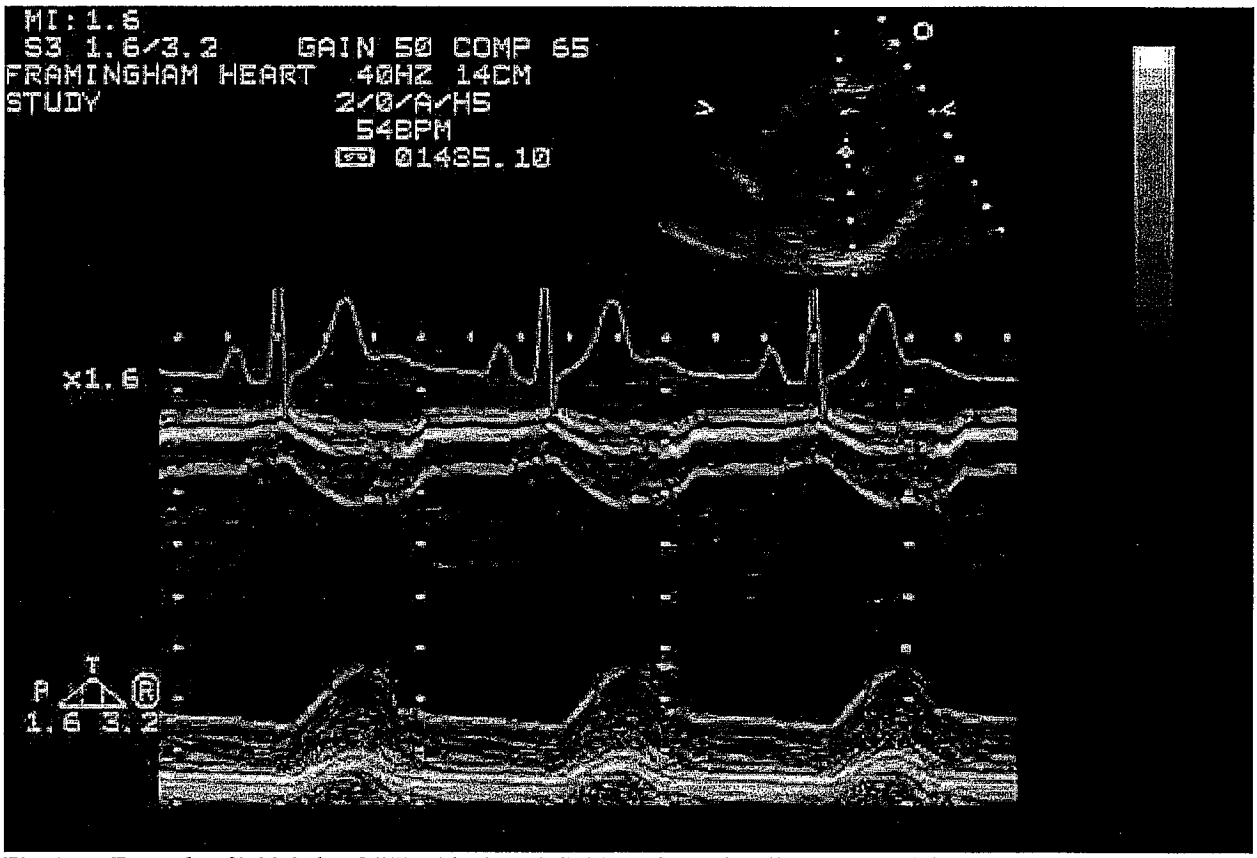

Fig. 2a – Example of M-Mode of LV with clear definition of septal wall, LV internal dimension, and posterior wall (optimal image).

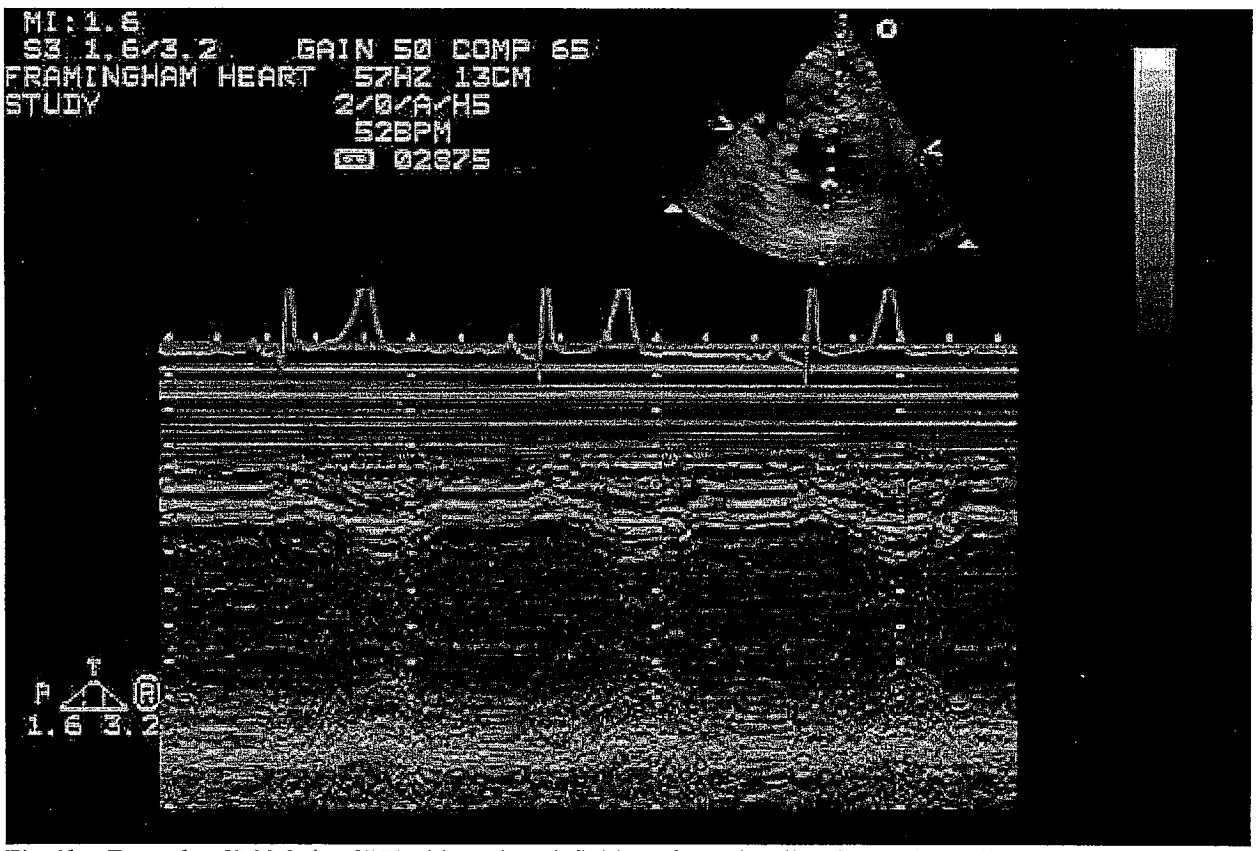

Fig. 2b – Example of M-Mode of LV with unclear definition of septal wall and posterior wall. LV is somewhat "eggy" because window is too low (suboptimal image).

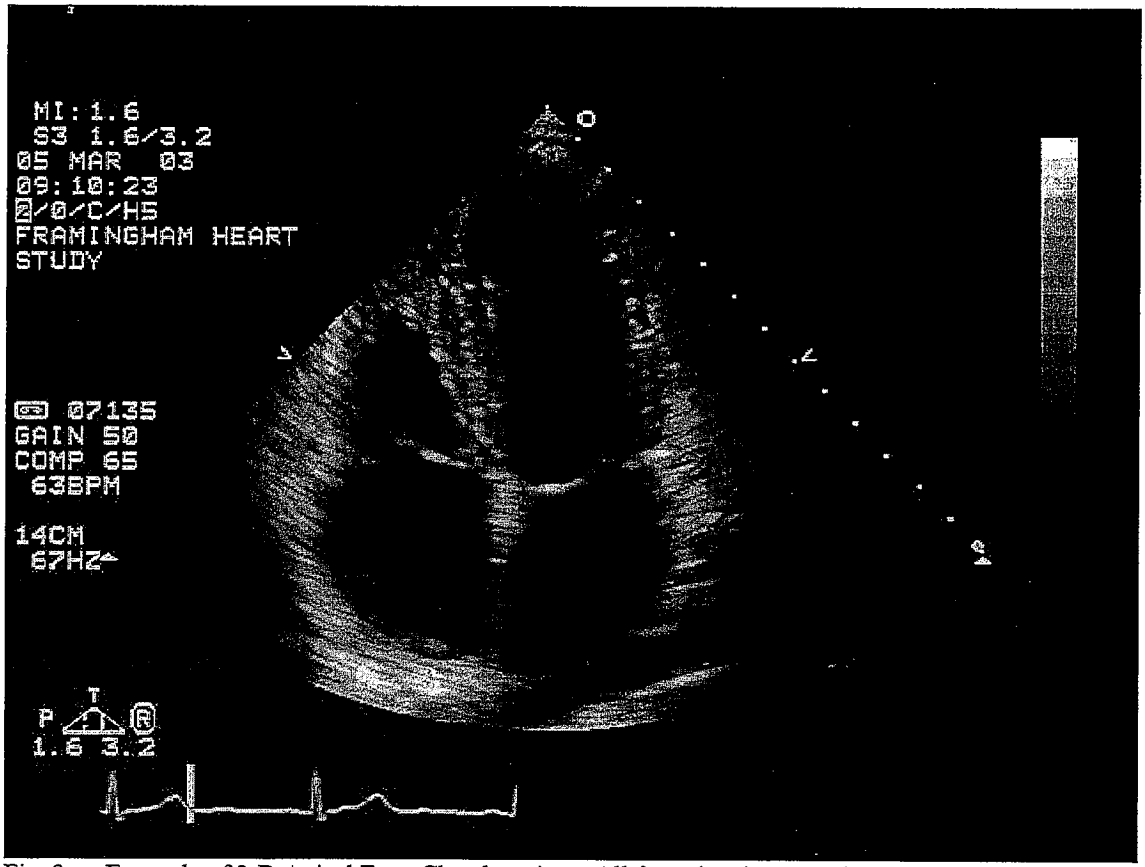

Fig. 3a – Example of 2-D Apical Four-Chamber view. All four chambers are showing well and on-axis; clear wall definition, mitral valve as well as tricuspid valve are showing well. Septum is in a vertical line and the entire heart is on-axis (optimal image)

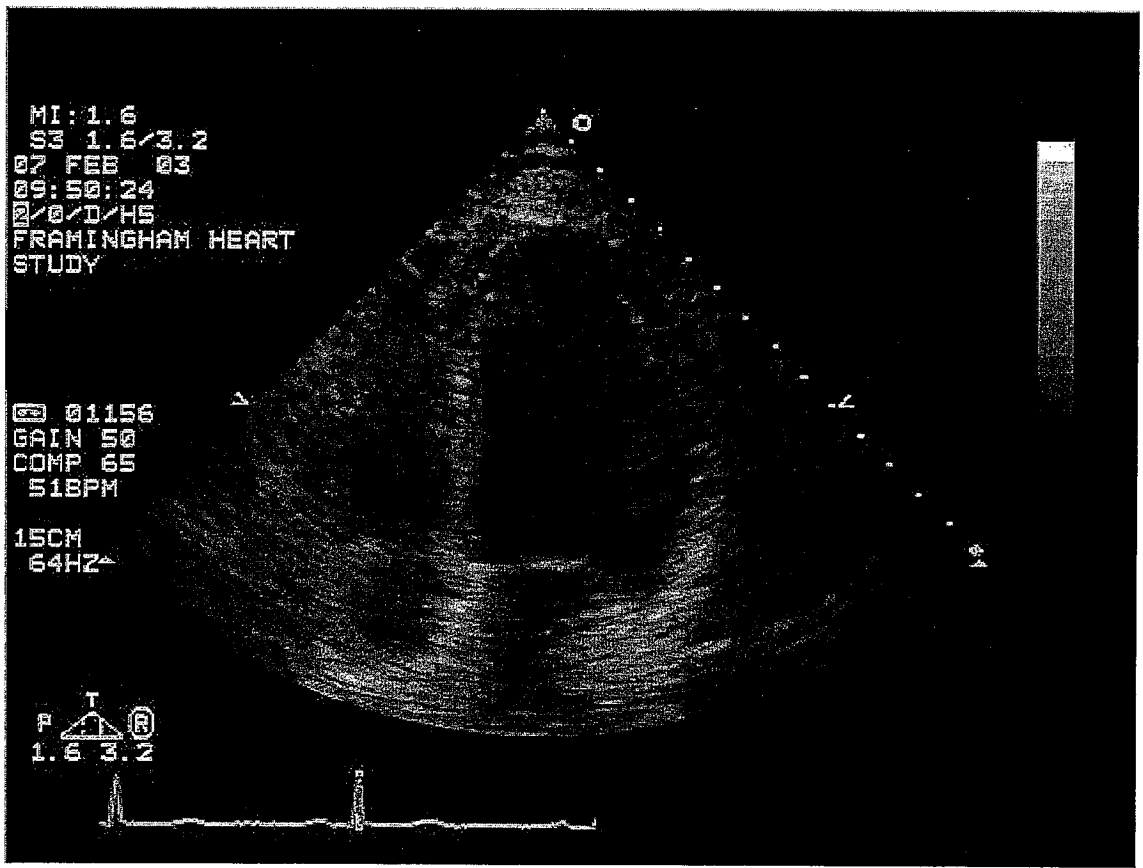

Fig. 3b - Example of 2-D Apical Four-Chamber view. The image is off-axis with unclear definition of the endocardium. The right atrium and ventricle are not fully open (suboptimal image).

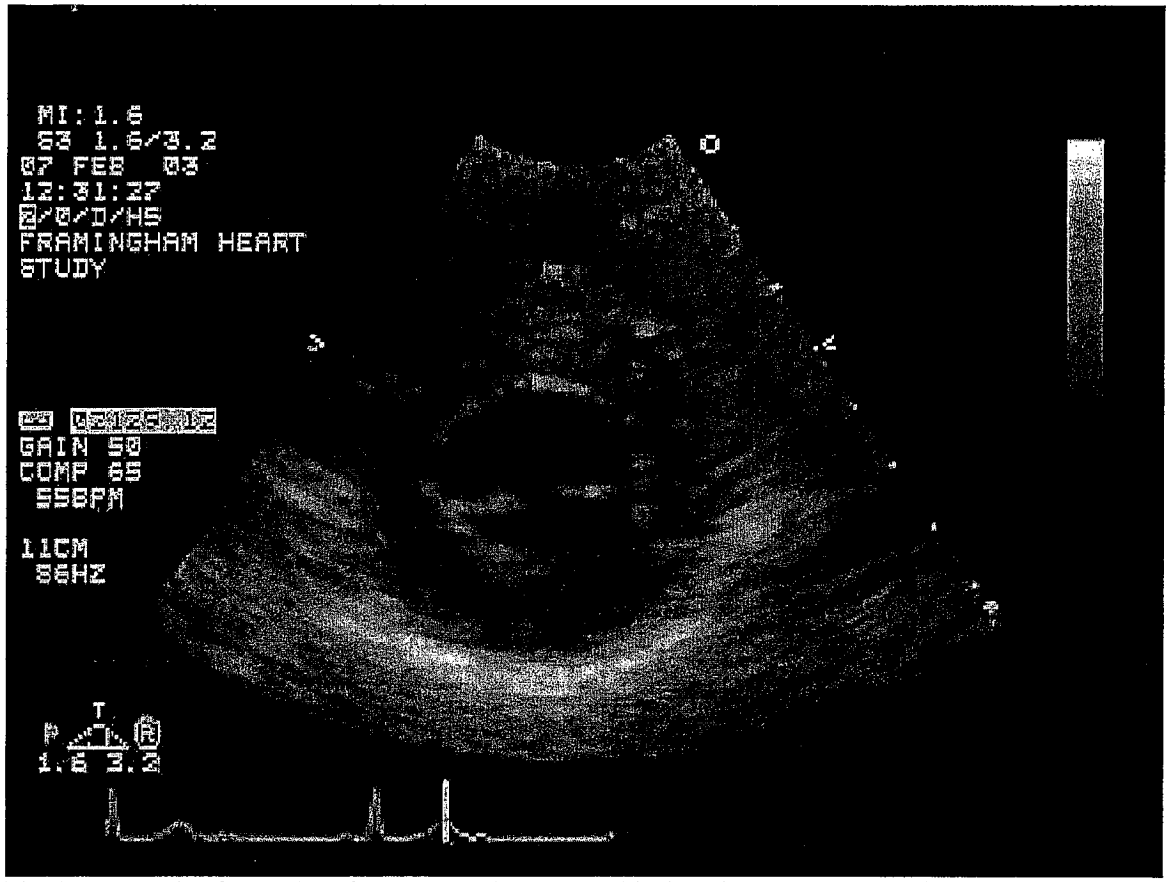

Fig. 4a - Example of 2-D PSA of LV. Image is on-axis with clear definition of epicardium and endocardium (optimal image).

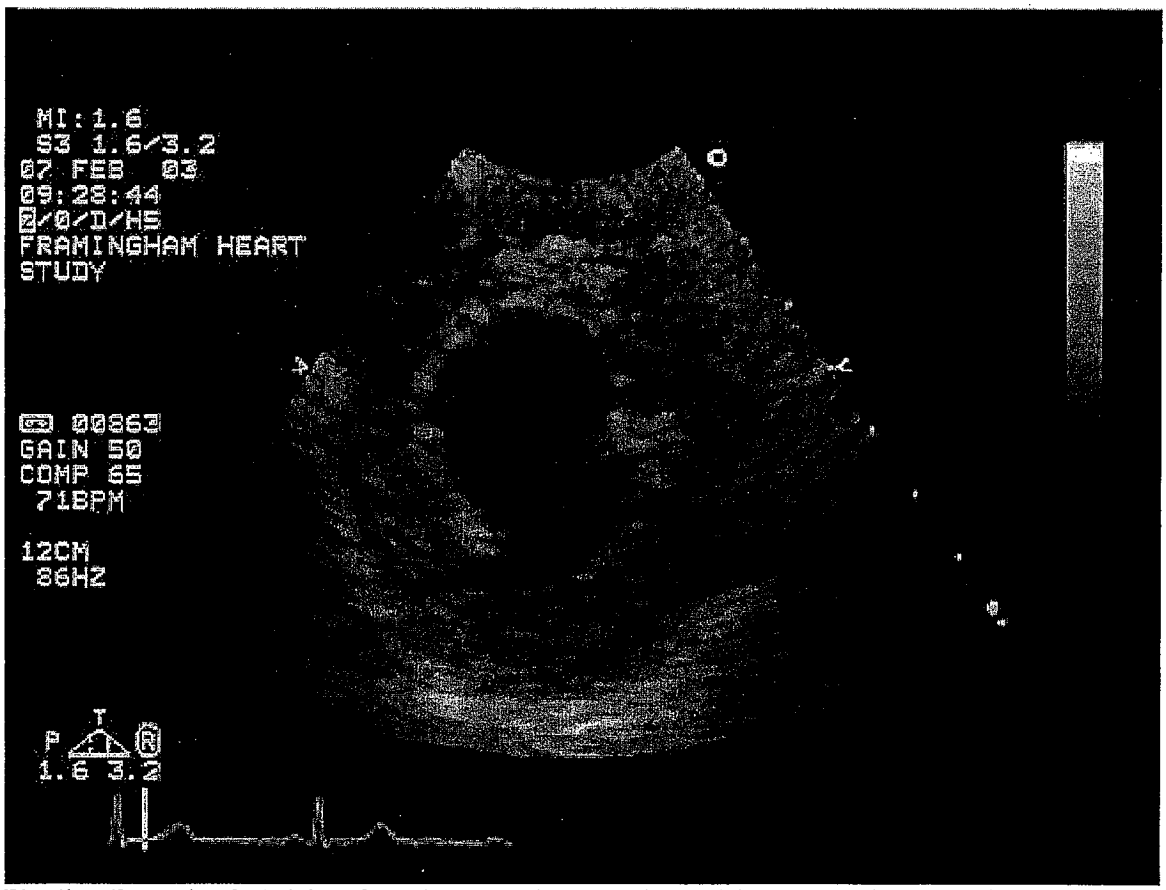

Fig. 4b. – Example of 2-D PSA of LV demonstrating eggy shape of the ventricle (suboptimal image).

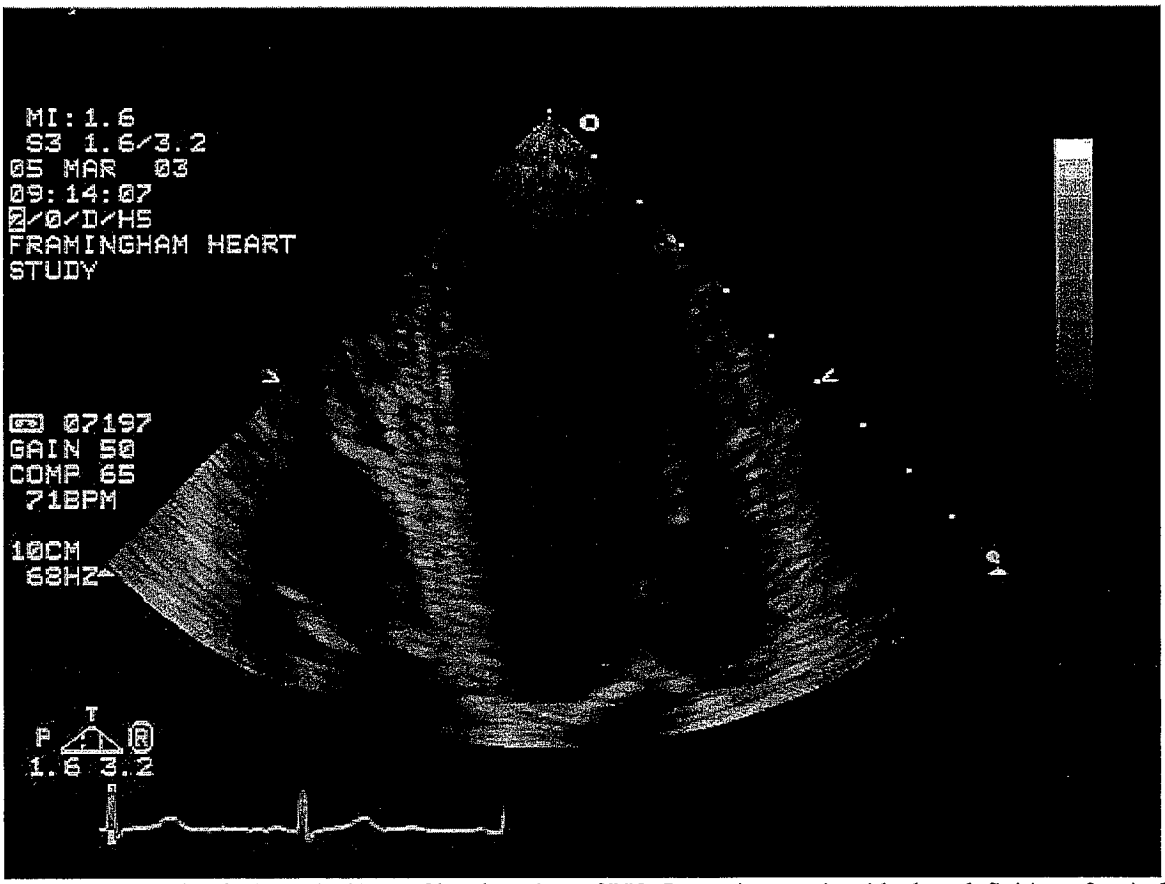

Fig. 5a – Example of 2-D Apical Four-Chamber view of LV. Image is on-axis with clear definition of apical endocardium and mitral valve annulus and leaflets are clearly shown. Longitudinal measurement is made from apex to imaginary line across mitral annulus. (optimal image)

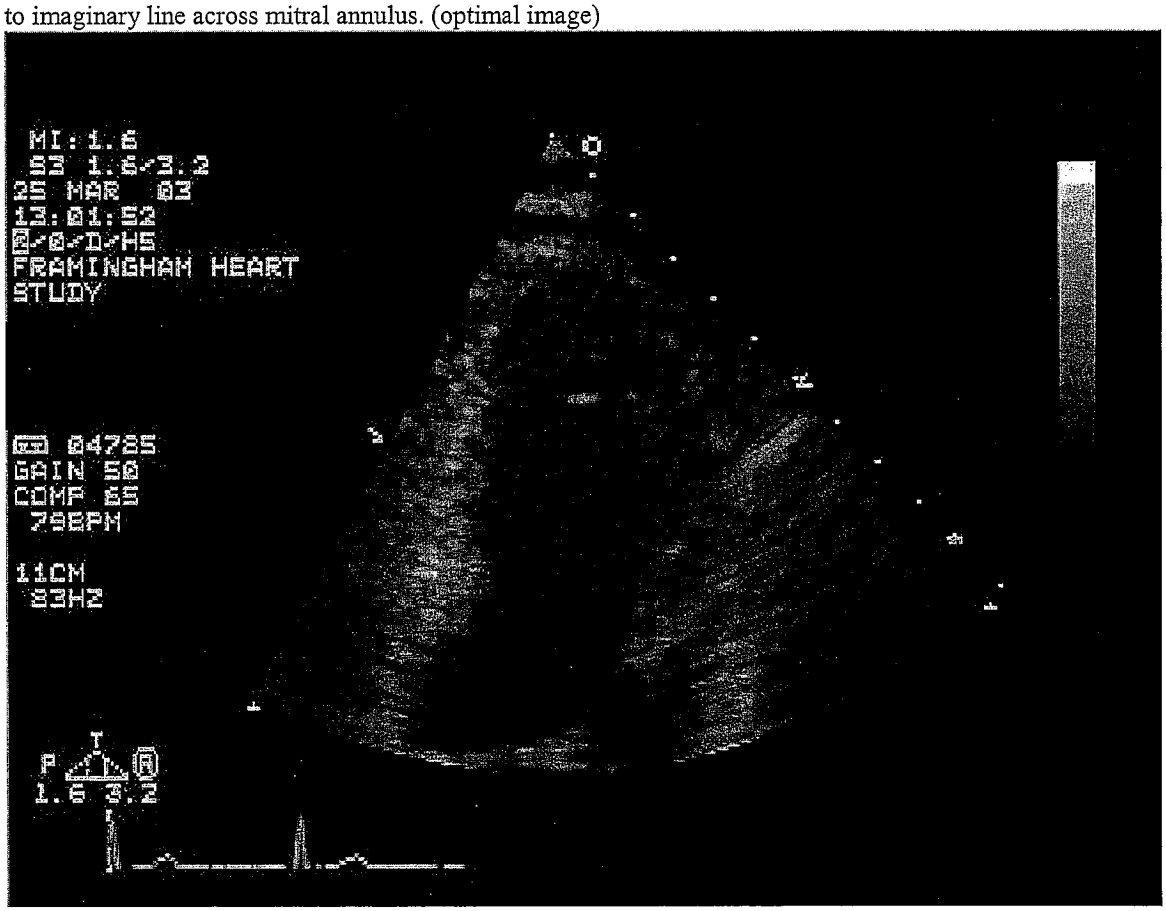

Fig. 5b – Example of 2-D Apical Four-Chamber view of LV. LV is off-axis and apical endocardium is not clearly visualized. Mitral valve annulus is not visible. (suboptimal)

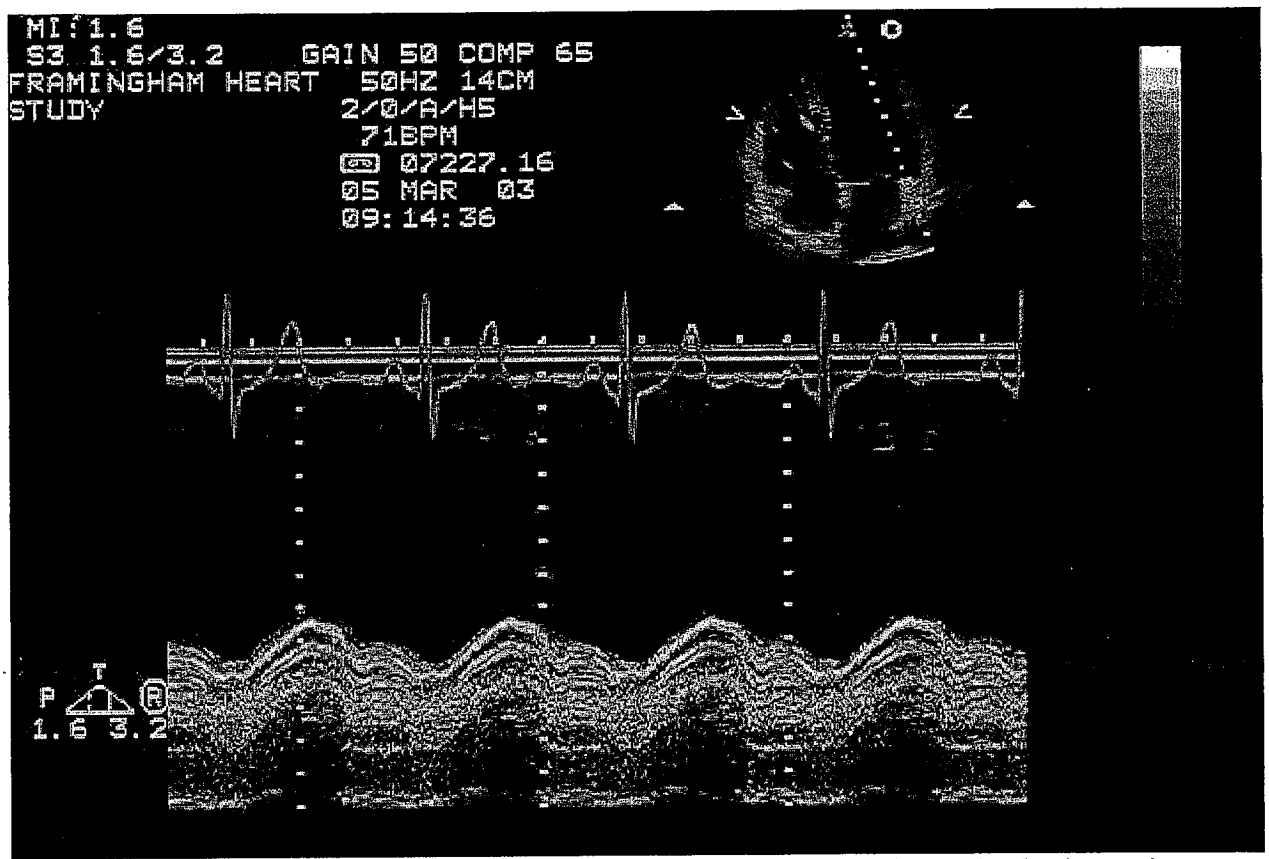

Fig. 6a – Example of M-Mode Apical Four-Chamber view of MV annulus. Apical Four-chamber is on-axis, cursor placed in correct position at MV annulus. Clear echoes of MV annulus movements (optimal image).

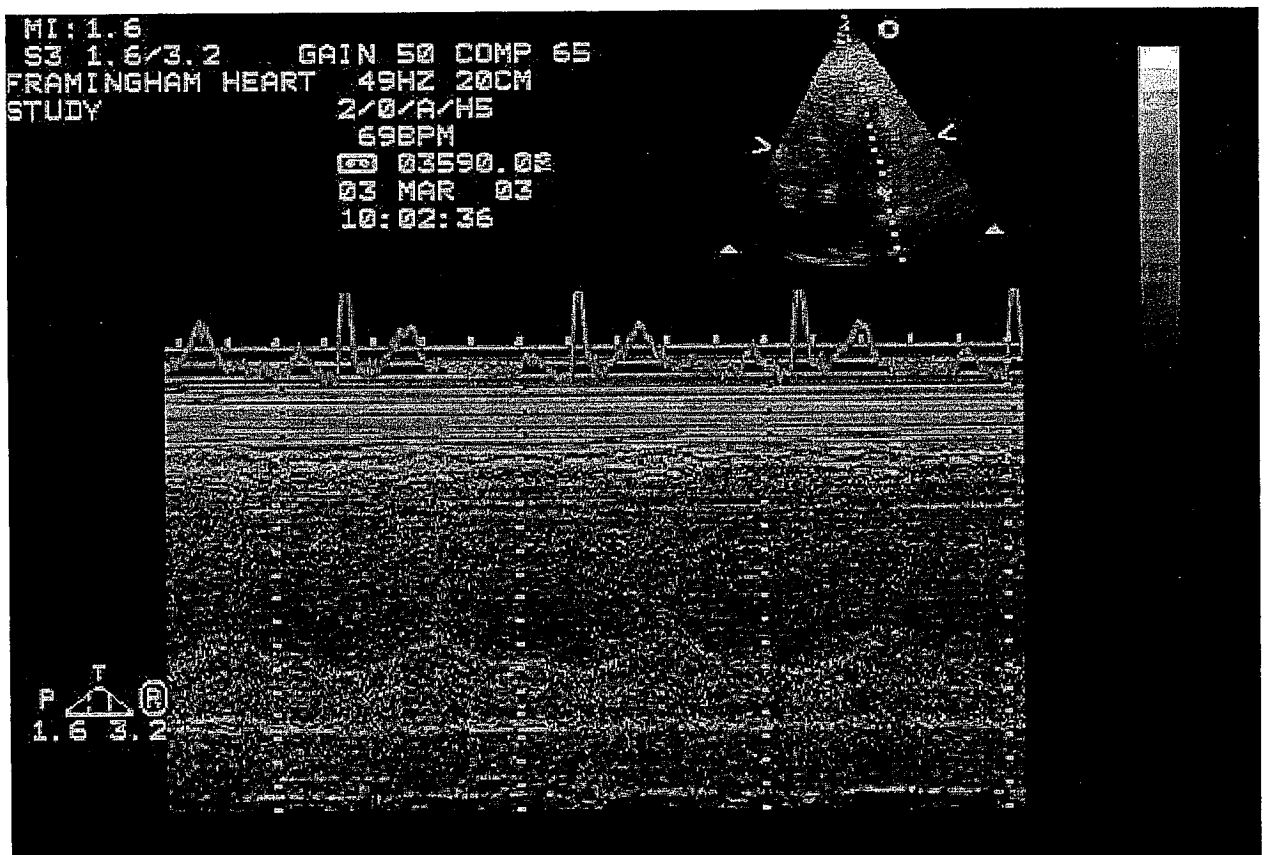

Fig. 6b – Example of M-Mode Apical Four-Chamber view of MV annulus. 2-D four-chamber view is not clear. Echoes of MV annulus movements are not well-defined and has a grainy appearance (suboptimal image).

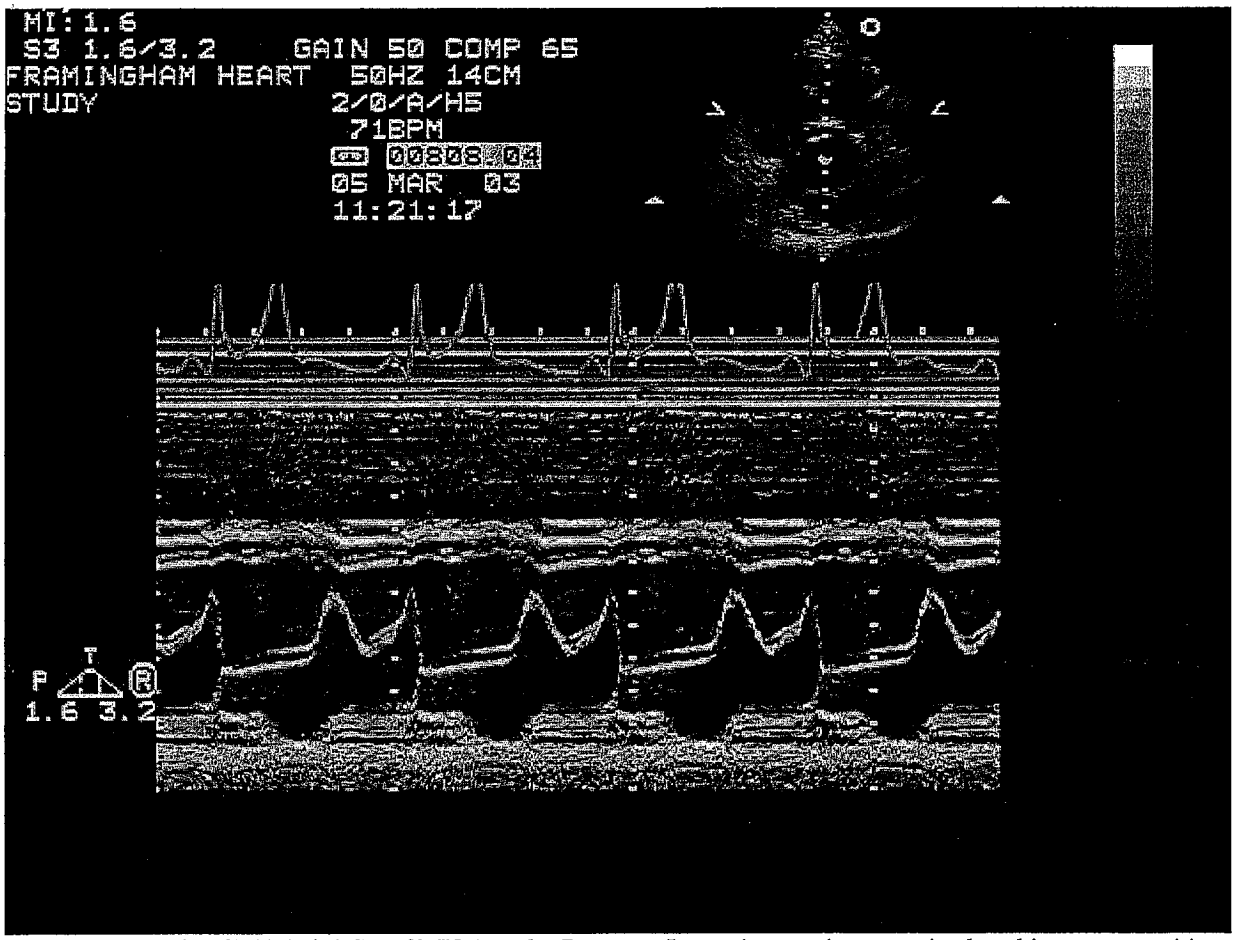

Fig. 7a – Example of M-Mode PSA of MV Annular Descent. Image is on-axis, cursor is placed in correct position on MV with E-Point Septal Separation (EPSS) clearly visualized and easily measurable (optimal image).

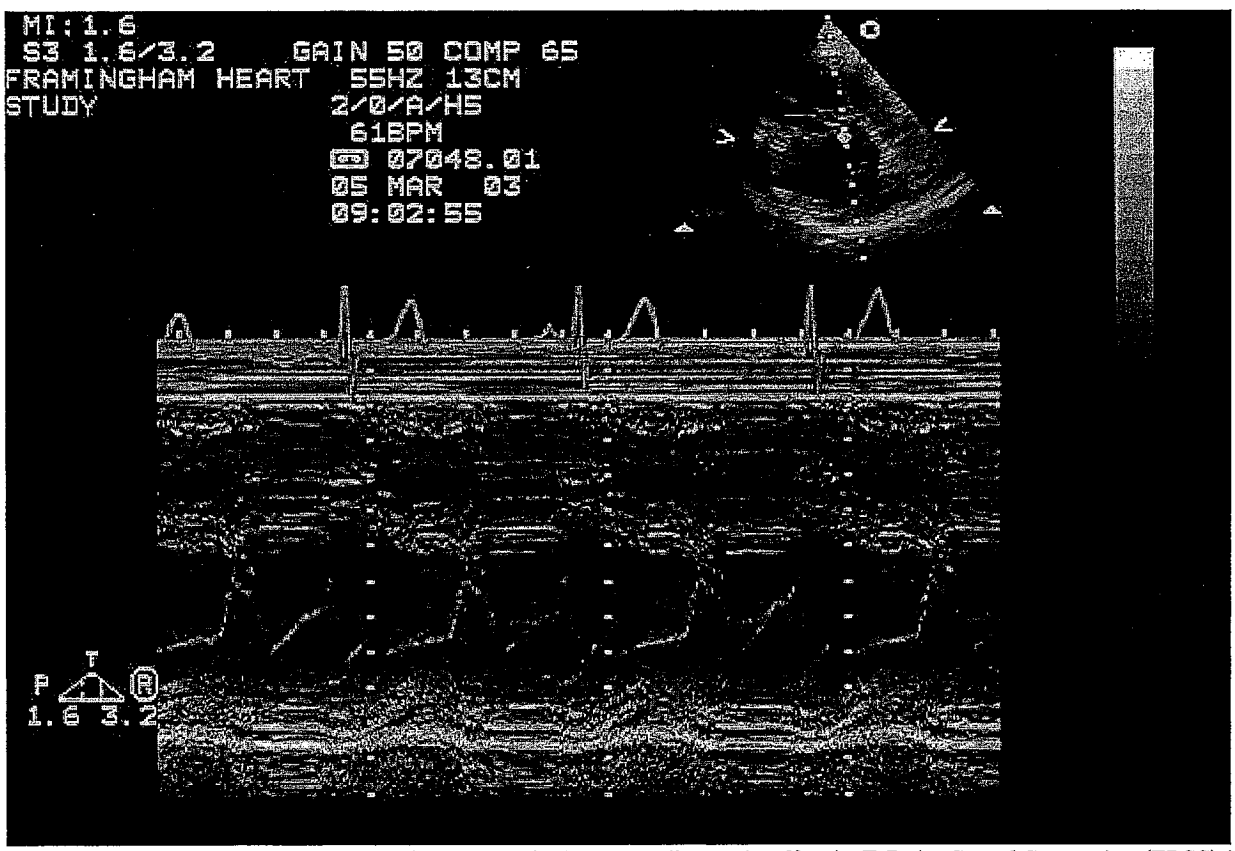

Fig. 7b – Example of M-Mode PSA of MV Annular Descent. Image is off-axis, E-Point Septal Separation (EPSS) is neither clearly visualized nor easily measurable (sub-optimal image).

Appendix Item 10

FHS Exam Components

FRAMINGHAM STUDY PHYSICAL EXAMINATION COMPONENT GEN 3 Exam Period: 2003- 2005 GEN 3 EXAM 1					052203
	2003-05				
GEN 3 COMPONENTS	EXAMS: 1				

ANTHROPOMETRY (Gen 3 Exam 1)					
Height	•				
Weight	•				
Waist Girth	•				
Neck Circumference	•				
Hand Preference for Writing	•				

BLOOD PRESSURE (Gen 3 Exam 1)					
Resting (2)	•				

PEDIGREE VERIFICATION (Gen 3 Exam 1)					
Pedigree	•				

LIFESTYLES/HABITS (Gen 3 Exam 1)					
Willett Food Intake Questionnaire	•				
Tobacco - Cigarettes	•				
Tobacco – Pipes	•				
Tobacco - Cigars	•				
Tobacco – Passive Smoke Exp.	•				
Alcohol	•				
Work Status	•				
Sociodemographic	•				

MEDICAL HISTORY (Gen 3 Exam 1)					
Hospitalization	•				
MD Visits	•				
Hypertension	•				
Prescription Meds	•				
Non-Prescription Meds	•				
Female Genitourinary * * Menopause, Hysterectomy, OCP and HRT use	•				
Medical History - Smoking	•				
Respiratory dx/ Questionnaire	•				
Chest Pain	•				
Atrial Fibrillation / Syncope	•				
Cerebrovascular Disease	•				
Venous & Peripheral Arterial Disease	•				
CVD Procedures	•				
Cancer	•				
Raynaud's Questionnaire	•				

FRAMINGHAM STUDY PHYSICAL EXAMINATION COMPONENT GEN 3 Exam Period: 2003- 2005 GEN 3 EXAM 1					052203
	2003-05				
GEN 3 COMPONENTS	EXAMS: 1				

MD PHYSICAL EXAM (Gen 3 Exam 1)					
MD Physical Exam	•				

CHEMISTRIES (Gen 3 Exam 1)					
Cholesterol	•				
HDL	•				
Triglycerides	•				
Fasting Glucose	•				
Fibrinogen	•				
Creatinine Serum	•				
Urine	•				
Uric Acid	•				

URINALYSIS (Gen 3 Exam 1)					
Urinalysis	•				

VASCULAR TESTING (Gen 3 Exam 1)					
Tonometry	•				
M-Mode Echocardiography	•				
Brachial Artery Reactivity	•				

ELECTROCARDIOGRAM/ WALK (Gen 3 Exam 1)					
Electrocardiogram	•				
Heart Rate Variability ECG					

FRAMINGHAM STUDY PHYSICAL EXAMINATION COMPONENT GEN 3 Exam Period: 2003- 2005 GEN 3 EXAM 1					052203
	2003-05				
GEN 3 COMPONENTS	EXAMS: 1				

PULMONARY FUNCTION (Gen 3 Exam 1)					
Spirometry Testing	•				
Carbon Monoxide Level	•				

PHYSICAL ACTIVITY/FITNESS (Gen 3 Exam 1)					
Physical Activity Questionnaire	•				
Rest/Activity/Cycle/Day	•				
SF-12	•				
Self-report weekly exercise/yr	•				

COGNITION (Gen 3 Exam 1)					
MMSE					

PSYCHOSOCIAL (Gen 3 Exam 1)					
Subjective Health					
CES-D	•				
Type A					
Social Network					

CLINICAL DIAGNOSTIC IMPRESSION (Gen 3 Exam 1)					
Heart	•				
Peripheral Vascular Disease	•				
Neurologic Disease	•				
Endocrine	•				
GU	•				
Pulmonary	•				
Rheumatologic Disorders	•				
GI	•				
Blood	•				
Other	•				
Infectious Disease	•				
(End of GEN 3 Exam 1)					

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Omni Exam Period: 1994- 2001
Omni Cohort (1- 2)

101702

	1994-1998	1999-2001			
OMNI COMPONENTS	EXAMS: 1	2			
ANTHROPOMETRY Omni Cohort (Exams 1- 2)					
Height	•	•			
Weight	•	•			
Skinfolds	•				
Thigh Girth	•				
Arm Girth	•				
Waist Girth	•	•			
Hip Girth	•	•			
Neck Circumference		•			
Knee Height	•	•			
BLOOD PRESSURE Omni Cohort (Exams 1- 2)					
Resting (2)	•	•			
URINALYSIS Omni Cohort (Exams 1- 2) **See Exam 2 - Coding only glucose and albumin*					
Urinalysis	•	•*			
LIFESTYLES/HABITS Omni Cohort (Exams 1- 2)					
Coffee/Tea	•	•			
Tobacco	•	•			
Alcohol	•	•			
Work Status	•	•			
Sociodemographic	•	•			
Willett Questionnaire		•			

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS: **Omni Exam Period: 1994-2001** **Omni Cohort (1- 2)** **101702**					
	1994-1998	1999-2001			
OMNI COMPONENTS	EXAMS: 1	2			

MEDICAL HISTORY/INTERIM Omni Cohort (Exams 1- 2) ****Menopause, Hysterectomy, OCP and HRT use.*** **** *Prostrate disease and surgery.***					
Interim Hospitalization	•	•			
Interim MD Visits	•	•			
Hypertension	•	•			
Syncope	•	•			
Arthritis History	•	•			
Oral Contraceptive History	•	•			
Female Genitourinary *	•	•			
Male Genitourinary * *	•	•			
Thyroid/ GI	•	•			
Respiratory	•	•			
Heart	•	•			
CVD	•	•			
Peripheral	•	•			
Cancer	•	•			
Other Non-Vascular Diseases	•	•			
Vascular Procedures	•	•			
Cardiovascular Meds	•	•			
Estrogen Replacement Therapy	•	•			
NSAID'S	•	•			
Raynaud's Questionnaire	•	•			

MD PHYSICAL EXAM Omni Cohort (Exams 1- 2)					
MD Physical Exam	•	•			

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Omni Exam Period: 1994-2001
Omni Cohort (1- 2)

101702

	1994-1998	1999-2001			
OMNI COMPONENTS	**EXAMS: 1**	**2**			

CHEMISTRIES Omni Cohort (Exams 1- 2)					
Cholesterol	•	•			
HDL	•	•			
HDL 3	•				
Triglycerides	•	•			
LDL					
CBC	•				
Chemical Profile					
Insulin	•				
Fasting Glucose	•				
Glucose		•			
Oral Glucose Tolerance Test	•				
Apoprotein A_1, B_1					
ApoE Phenotype					
Fibrinogen	•	•			
Estradiol					
Testosterone (Men)					
FSH/LH					
T_4, TSH					
Sinking pre B					
Homocysteine	•	•			
Postmethionine Load					
Glycosylated Hb		•			

ECHOCARDIOGRAPHY/BRACHIAL ULTRASOUND Omni Cohort (Exams 1- 2)					
Echocardiography – M. Mode	•				
2 D, Doppler	•				
Brachial Artery Reactivity		•			

DOPPLER Omni Cohort (Exams 1- 2)					
Carotid Doppler	•				
Ankle-Arm Doppler BP	•				

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Omni Exam Period: 1994-2001
Omni Cohort (1- 2)

101702

	1994-1998	1999-2001			
OMNI COMPONENTS	EXAMS: 1	2			
ELECTROCARDIOGRAM/WALK Omni Cohort (Exams 1- 2)					
Electrocardiogram	•	•			
Heart Rate Variability ECG					
Treadmill Exercise Test					
HOLTER MONITOR Omni Cohort (Exams 1- 2)					
Holter Monitor					
PULMONARY FUNCTION Omni Cohort (Exams 1- 2)					
Testing					
Carbon Monoxide Level					
PHYSICAL ACTIVITY/FITNESS Omni Cohort (Exams 1- 2)					
Physical Activity	•	•			
Rest/Activity/Cycle/Day	•	•			
Katz ADL	•	•			
Nagi I-ADL	•	•			
Rosow Breslau	•	•			
Falls and Fractures	•	•			
COGNITION Omni Cohort (Exams 1- 2)					
MMSE	•	•			
PSYCHOSOCIAL Omni Cohort (Exams 1- 2)					
Subjective Health	•	•			
CES-D		•			
Type A					
Social Network		•			

(End of Omni Cohort Exams 1-2)

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (1- 5)

120102

	1971-75	1979-82	1984-87	1987-90	1991-95
OFFSPRING COMPONENTS	EXAMS: 1	2	3	4	5

ANTHROPOMETRY Offspring Cohort (1- 5)					
Height	•	•	•	•	•
Weight	•	•	•	•	•
Skinfolds		•	•	•	•
Thigh Girth				•	•
Arm Girth		•		•	•
Waist Girth				•	•
Hip Girth				•	•
Neck Circumference					
Knee Height					

BLOOD PRESSURE Offspring Cohort (1- 5)					
Resting (2)	•	•	•	•	•

URINALYSIS Offspring Cohort (1- 5) **See Exam 7 - Coding only glucose and albumin*					
Urinalysis		•	•	•	•

LIFESTYLES/HABITS Offspring Cohort (1- 5) **See Exam 7- On Willett Questionnaire*					
Coffee/Tea		•	•	•	•
Tobacco	•	•	•	•	•
Alcohol	•	•	•	•	•
Work Status		•	•		
Sociodemographic		•	•	•	•

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (1- 5)

120102

	1971-75	1979-82	1984-87	1987-90	1991-95
OFFSPRING COMPONENTS	EXAMS: 1	2	3	4	5

MEDICAL HISTORY/INTERIM Offspring Cohort (1- 5) *Menopause, Hysterectomy, OCP and HRT use. * *Prostrate disease and surgery.					
Interim Hospitalization		•	•	•	•
Interim MD Visits		•	•	•	•
Hypertension	•	•	•	•	•
Syncope	•	•	•	•	•
Arthritis History					•
Oral Contraceptive History	•	•	•	•	•
Female Genitourinary *	•	•	•	•	•
Male Genitourinary * *		•	•	•	•
Thyroid/ GI	•	•			•
Respiratory		•	•	•	•
Heart	•	•	•	•	•
CVD	•	•	•	•	•
Peripheral	•	•	•	•	•
Cancer		•	•	•	•
Other Non-Vascular Diseases	•	•		•	
Vascular Procedures					•
Cardiovascular Meds	•	•	•	•	•
Estrogen Replacement Therapy	•	•	•	•	•
NSAID'S			•	•	•
Raynaud's Questionnaire					

MD PHYSICAL EXAM Offspring Cohort (1- 5)					
MD Physical Exam	•	•	•	•	•

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (1- 5)

120102

	1971-75	1979-82	1984-87	1987-90	1991-95
OFFSPRING COMPONENTS	EXAMS: 1	2	3	4	5

CHEMISTRIES Offspring Cohort (1- 5) *See Exam 7: Selected Sample.*					
Cholesterol	•	•	•	•	•
HDL	•	•	•		
HDL 3				•	•
Triglycerides	•	•	•	•	•
LDL	•	•	•		
CBC	•	•			
Chemical Profile	•	•			
Insulin					•
Fasting Glucose		•			•
Glucose	•	•	•	•	
Oral Glucose Tolerance Test					•
Apoprotein A_1, B_1			•		
ApoE Phenotype			•		
Fibrinogen					
Estradiol			•		
Testosterone (Men)			•		
FSH/LH			•		
T_4, TSH			•		
Sinking pre B	•				
Homocysteine					
Postmethionine Load					
Glycosylated Hb					•

ECHOCARDIOGRAPHY/BRACHIAL ULTRASOUND Offspring Cohort (1- 5)					
Echocardiography – M. Mode		•		•	•
2 D, Doppler				•	•
Brachial Artery Reactivity					

DOPPLER Offspring Cohort (1- 5)					
Carotid Doppler					•
Ankle-Arm Doppler BP					

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (1- 5)

120102

	1971-75	1979-82	1984-87	1987-90	1991-95
OFFSPRING COMPONENTS	EXAMS: 1	2	3	4	5
ELECTROCARDIOGRAM/WALK Offspring Cohort (1- 5)					
Electrocardiogram	•	•	•	•	•
Heart Rate Variability ECG		•		•	
Treadmill Exercise Test					
HOLTER MONITOR Offspring Cohort (1- 5)					
Holter Monitor		•	•		
PULMONARY FUNCTION Offspring Cohort (1- 5)					
Testing	•	•		•	•
Carbon Monoxide Level		•		•	•
PHYSICAL ACTIVITY/FITNESS Offspring Cohort (1- 5)					
Physical Activity		•		•	•
Rest/Activity/Cycle/Day		•		•	•
Katz ADL					•
Nagi I-ADL					•
Rosow Breslau					•
Falls and Fractures				•	•
COGNITION Offspring Cohort (1- 5)					
MMSE					•
PSYCHOSOCIAL Offspring Cohort (1- 5)					
Subjective Health					•
CES-D			•		
Type A		•	•		
Social Network					

(End of Offspring Cohort Exams 1-5)

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (6- 7)

120102

	1996-98	1998-01			
OFFSPRING COMPONENTS	EXAMS: 6	7			

ANTHROPOMETRY Offspring Cohort (6- 7)					
Height	•	•			
Weight	•	•			
Skinfolds	•				
Thigh Girth	•				
Arm Girth	•				
Waist Girth	•	•			
Hip Girth	•	•			
Neck Circumference		•			
Knee Height		•			

BLOOD PRESSURE Offspring Cohort (6- 7)					
Resting (2)	•	•			

URINALYSIS Offspring Cohort (6- 7) **See Exam 7 - Coding only glucose and albumin*					
Urinalysis	•	*•			

LIFESTYLES/HABITS Offspring Cohort (6- 7) **See Exam 7- On Willett Questionnaire* ***On exercise questionnaire*					
Coffee/Tea	•	*•			
Tobacco	•	•			
Alcohol	•	•			
Work Status	•	**•			
Sociodemographic	•	•			

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (6- 7)

120102

	1996-98	1998-01			
OFFSPRING COMPONENTS	EXAMS: 6	7			

MEDICAL HISTORY/INTERIM Offspring Cohort (6- 7) **Menopause, Hysterectomy, OCP and HRT use.* ** *Prostrate disease and surgery.*					
Interim Hospitalization	•	•			
Interim MD Visits	•	•			
Hypertension	•	•			
Syncope	•	•			
Arthritis History	•				
Oral Contraceptive History	•	•			
Female Genitourinary *	•	•			
Male Genitourinary * *	•	•			
Thyroid/ GI	•	•			
Respiratory	•	•			
Heart	•	•			
CVD	•	•			
Peripheral	•	•			
Cancer	•	•			
Other Non-Vascular Diseases	•				
Vascular Procedures	•	•			
Cardiovascular Meds	•	•			
Estrogen Replacement Therapy	•	•			
NSAID'S	•	•			
Raynaud's Questionnaire		•			

MD PHYSICAL EXAM Offspring Cohort (6- 7)					
MD Physical Exam	•	•			

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS: Offspring Exam Period: 1971 - 2001 Offspring Cohort (6- 7)					120102
	1996-98	1998-01			
OFFSPRING COMPONENTS	EXAMS: 6	7			

CHEMISTRIES Offspring Cohort (6- 7) *See Exam 7: Selected Sample					
Cholesterol	•	•			
HDL	•	•			
HDL 3					
Triglycerides	•	•			
LDL					
CBC					
Chemical Profile					
Insulin		•			
Fasting Glucose	•	•			
Glucose					
Oral Glucose Tolerance Test		*•			
Apoprotein A_1, B_1					
ApoE Phenotype					
Fibrinogen	•				
Estradiol					
Testosterone (Men)					
FSH/LH					
T_4, TSH					
Sinking pre B					
Homocysteine	•				
Postmethionine Load	•				
Glycosylated Hb		•			

ECHOCARDIOGRAPHY/BRACHIAL ULTRASOUND Offspring Cohort (6- 7)					
Echocardiography – M. Mode	•				
2 D, Doppler	•				
Brachial Artery Reactivity		•			

DOPPLER Offspring Cohort (6- 7)					
Carotid Doppler	•				
Ankle-Arm Doppler BP		•			

FRAMINGHAM STUDY PHYSICAL EXAMINATION CORE COMPONENTS:

Offspring Exam Period: 1971 - 2001
Offspring Cohort (6- 7)

120102

	1996-98	1998-01			
OFFSPRING COMPONENTS	EXAMS: 6	7			

ELECTROCARDIOGRAM/WALK Offspring Cohort (6- 7)					
Electrocardiogram	•	•			
Heart Rate Variability ECG	•				
"Walk Test"		•			

HOLTER MONITOR Offspring Cohort (6- 7)					
Holter Monitor					

PULMONARY FUNCTION Offspring Cohort (6- 7)					
Testing	•	•			
Carbon Monoxide Level	•				

PHYSICAL ACTIVITY/FITNESS Offspring Cohort (6- 7)					
Physical Activity	•	•			
Rest/Activity/Cycle/Day	•	•			
Katz ADL	•	•			
Nagi I-ADL	•	•			
Rosow Breslau	•	•			
Falls and Fractures	•	•			

COGNITION Offspring Cohort (6- 7)					
MMSE	•	•			

PSYCHOSOCIAL Offspring Cohort (6- 7)					
Subjective Health	•	•			
CES-D	•	•			
Type A					
Social Network		•			
(End of Offspring Cohort Exams 6 – 7)					

Appendix Item 11

FHS Echo Specific Reading Guidelines

FHS Echo Specific Reading Guidelines 2004					
LA enlargement*	□ no	□ borderline	□ mild	□ moderate	□ severe
Mitral Valve MV thickening Mitral stenosis MAC MVP	□ no **<0.5 cm** □ no □ no □ no	□borderline>0.4-0.5cm □ possible **2.5-3.9 cm^2** □ MSD **2mm behind annulus**	□ mild **0.5-0.7 cm** □ likely **<2.5 cm^2** □ mild **M-mode < 3 mm 2-D focal** □ mild **>2 to <4 mm**	□ mod. **MM 3-5 2-D >1/3 ring**	□ mod/severe □ **0.8 cm** □severe **MM >5 mm 2D □½ circumference** □ mod/severe □ **4 mm**
AorticValve/Root AV thickening Ao cusp excursion (MM+2-D sense) Aotic root dilation Aortic root calcium	□ no □ no□**1.5 cm** □ no □ no		□ mild **focal/limited** □ mild **1.-1.4 cm** □present_ **3.6 ♀; 3.8♂cm** □ mild **focal <½ ring**	□ mod. **diffuse, some thin leaflet seen** □ mod. **0.5-0.9cm** □ moderate **>½ ring**	□ sev. **diffuse, 'white-out' AV** □ sev. **<0.5 cm** □ severe **entire ring**
LV Structure* LV enlargement □ LVWT, □ LVWT, other	□ no □ no □ no	□ borderline □ borderline	□ mild □ mild □ ASH **sw:pw >1.3 & sw□1.3**	□ moderate □ moderate □ ISH **not ASH & sw □ 1.2 cm_ 1.1_ pw □ 1.2 cm_ 1.1_**	□ severe □ severe □ DUSK **discrete upper septal knuckle (visual)**
LV Systolic Fxn LV ejection fraction	□ normal □ **55%**	□ borderline **50-54%**	□ mild □**40-49%**	□ moderate □**30-39%**	□ severe □□**29%**
RA/RV/TV/peric.§ RA enlargement RV enlargement RV hypertrophy Pericardial fluid	□ LA nl **RA<LA** □ no **0.9-2.6 cm** □ no □**0.6 cm** □ no/sys.		□ mild **grade cf. w/ LA** □ mild **>2.7 PLA** □ mild **0.7-0.9 cm** □ mild **localized**	□ mod. **c/w LA** □mod LV□LV(LVnl) □ mod □**1.0 cm** □ med **surrounds** □ **> .5 cm**	□ sev c/w **LA** □ sev **RV** □**LV** (LV nl) □ sev □**1.0 cm** □ large **surrounds** □ **> .5 cm**
Valve Regurg. Mitral {Helmke} Aortic {Perry} Tricuspid	□ none □ none □ none	□ trace **w/in 1 cm valve** □ trace □ trace **w/in 1 cm valve**	□ mild **RJA/LAA □19%** □ mild **JH/LVOH 10-24%** □ mild **RJA/RAA □19%**	□ moderate **20-40%** □ moderate **JH/LVOH 25-49%** □ moderate **20-40%**	□ severe **□41%** □ severe **JH/LVOH □50%** □ severe □□**1**
Mitral Stenosis· **Aortic Stenosis·**	□ none **4-6 cm^2** □ none**3-5 cm^2**	□ trace **2.5-3.9 cm^2** □ trace **2-3 cm^2 g10-15 mm Hg**	□ mild **1.5-2.5 cm^2** □ mild **1.1-2 cm^2; g16-29 mmHg**	□ mod. **1.0-1.5 cm^2** □ mod. **.75-1.1cm^2; g30-49 mm Hg**	□ severe **< 1 cm^2** □ severe **□0.75 cm^2; g□50 mm Hg**

***NOTE:** For LA/LVwt/LVID check height & sex specific nomograms; delete MM measure if off-axis &/or doesn't make sense.
For LA consider both parasternal & apical views;
For LVID if eccentric (short/long axis dimension >1.3 don't measure MM), overrule if dilated in apical views.

§**Note R** □ morphology is subjective & should take into account height, sex & relation to L □ size

NOTE: Assessment of valvular regurgitation is based on subjective impressions of jet area.

NOTE: Assessment of valvular stenosis should consider LV function and body size

Appendix Item 12

Echo Bibliography

Framingham Heart Study: Bibliography Related to Echocardiography

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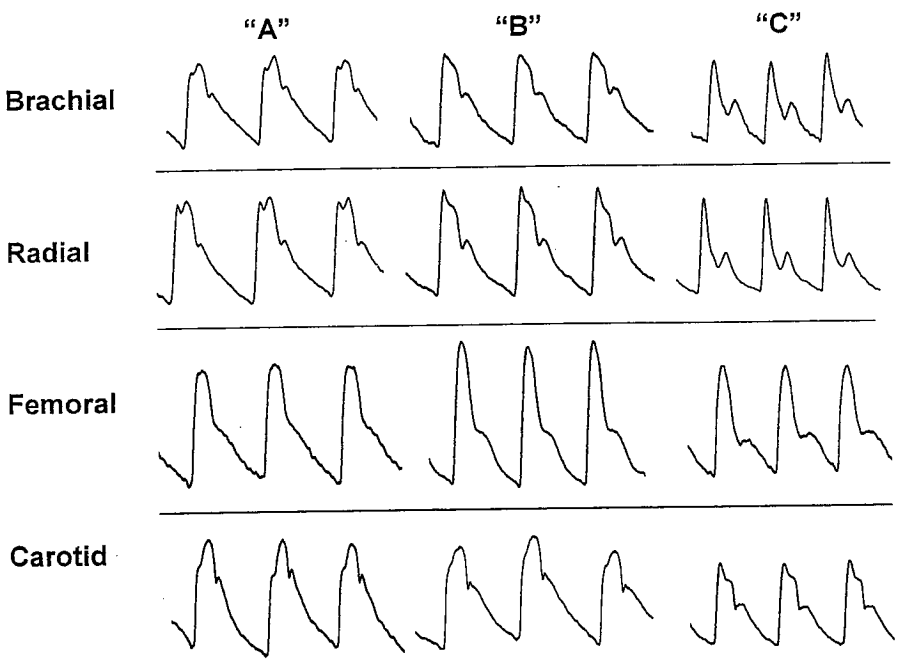
Appendix Item 13

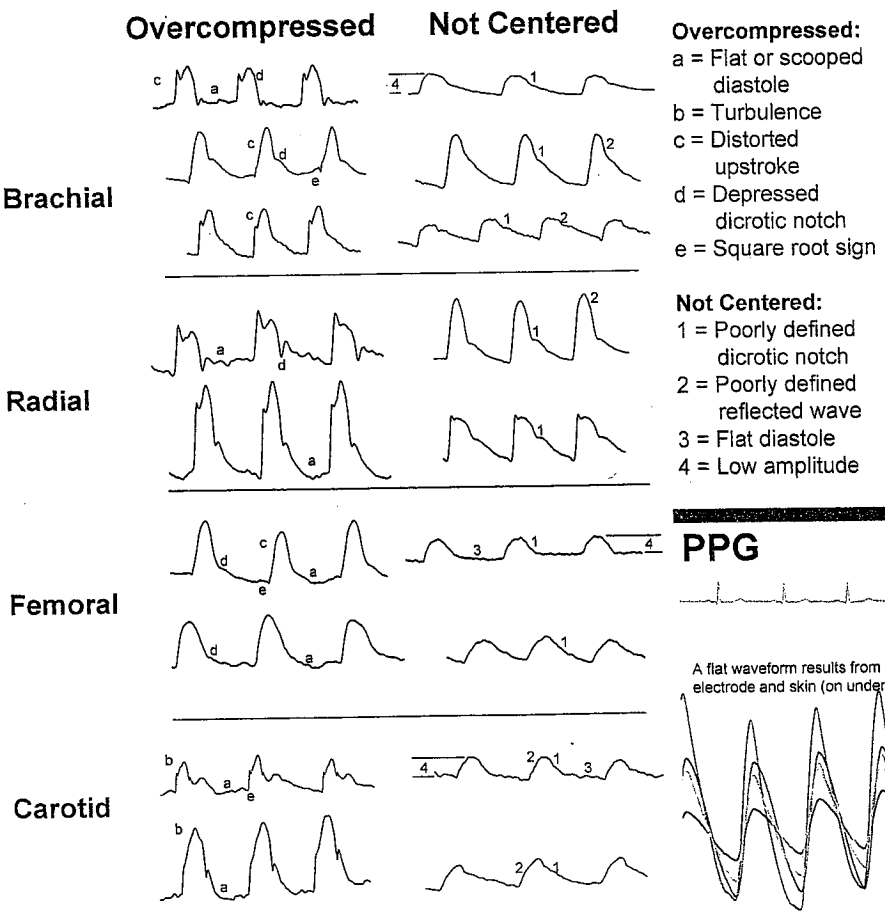
NIHem Data Acquisition Instructional Poster

CONFIDENTIAL

NIHem Data Acquisiti

Tonometry

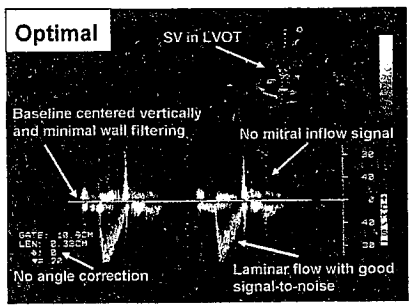


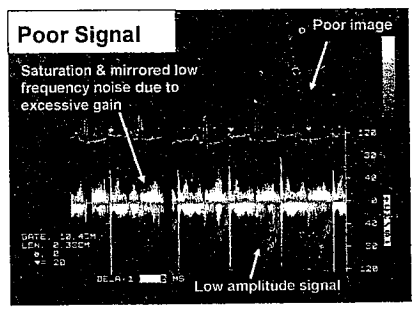


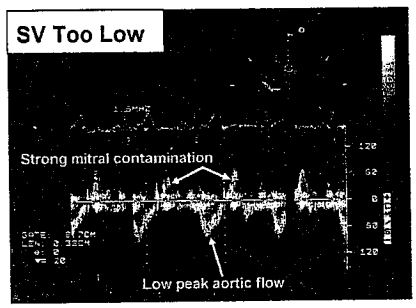
Overcompressed:
- a = Flat or scooped diastole
- b = Turbulence
- c = Distorted upstroke
- d = Depressed dicrotic notch
- e = Square root sign

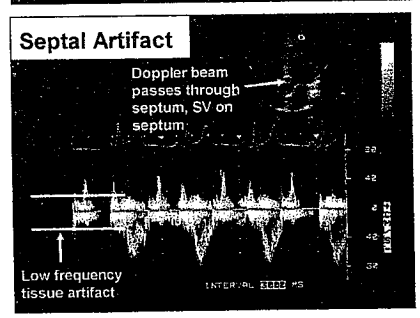
Not Centered:
- 1 = Poorly defined dicrotic notch
- 2 = Poorly defined reflected wave
- 3 = Flat diastole
- 4 = Low amplitude

LVOT Flow

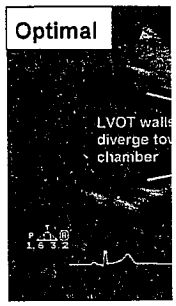


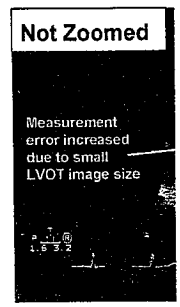


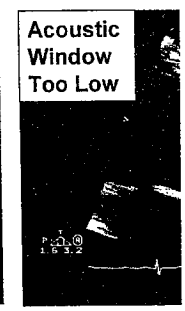




LVOT Dia

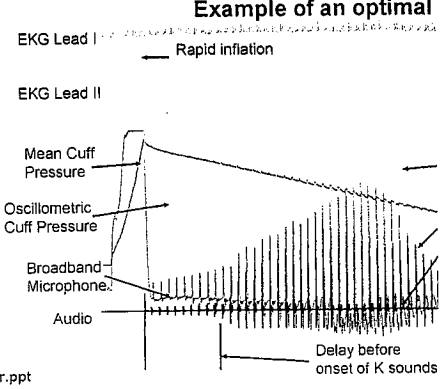






PPG

Blood Pressure



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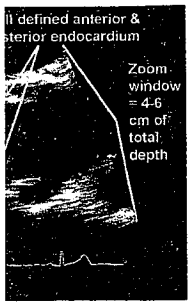
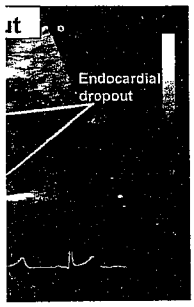
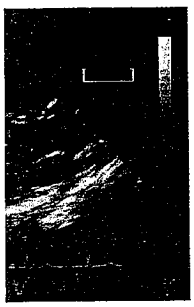
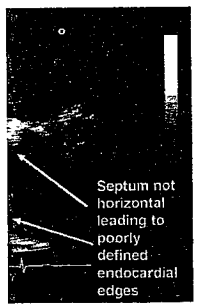
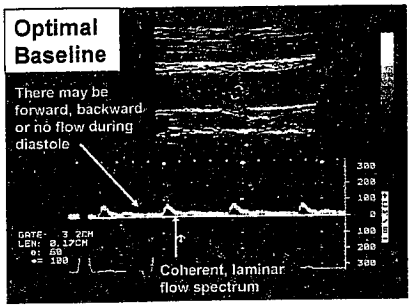


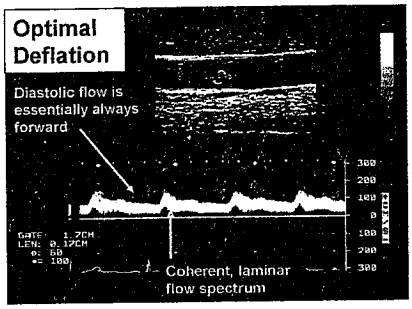


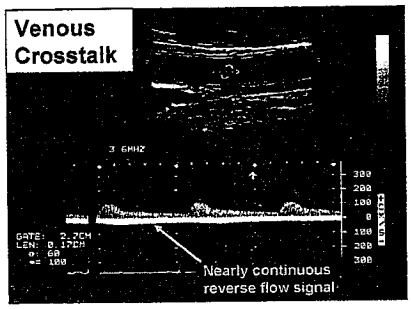


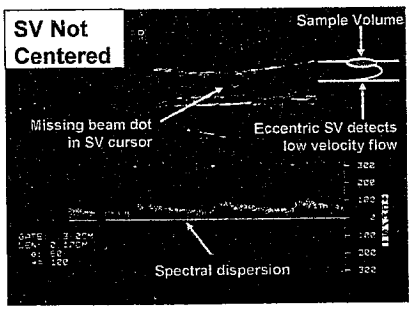


Brachial Reactivity

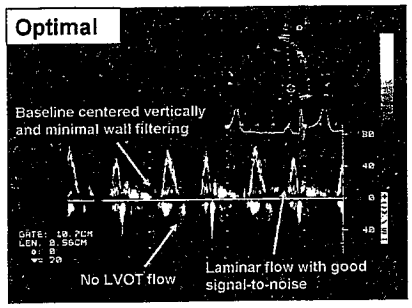


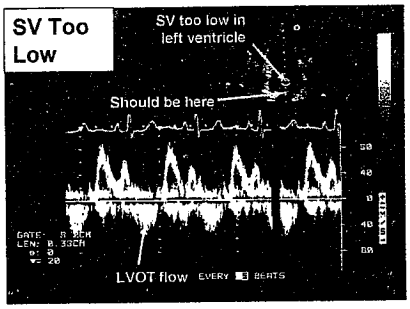


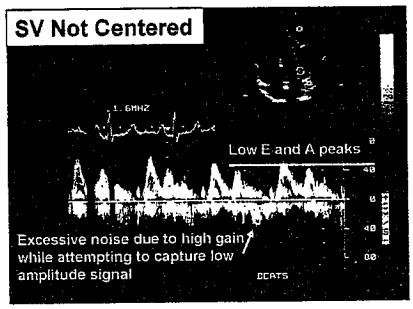


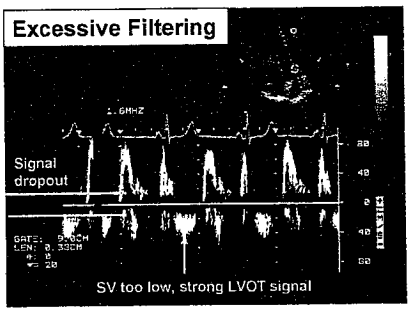


Mitral

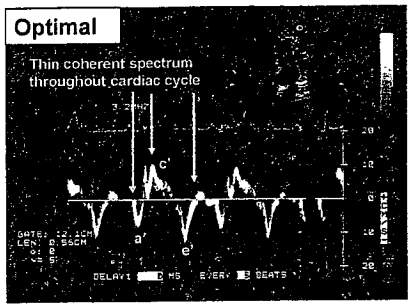


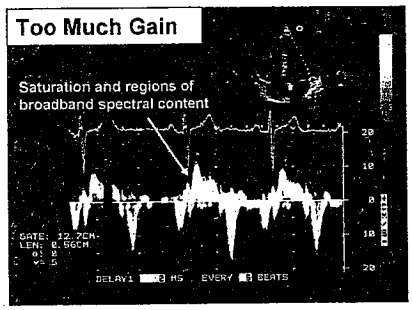


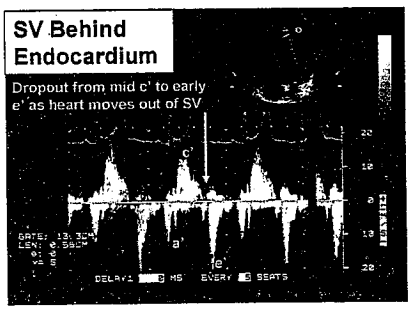




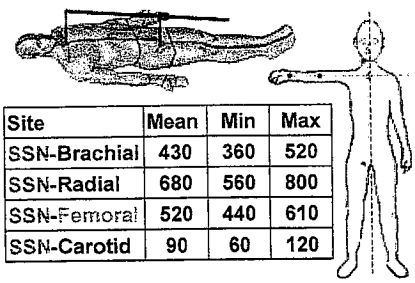
DTV







Typical transit distances (mm)



Site	Mean	Min	Max
SSN-Brachial	430	360	520
SSN-Radial	680	560	800
SSN-Femoral	520	440	610
SSN-Carotid	90	60	120

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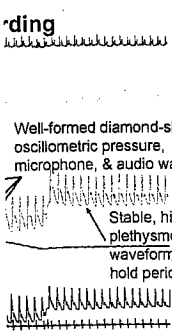
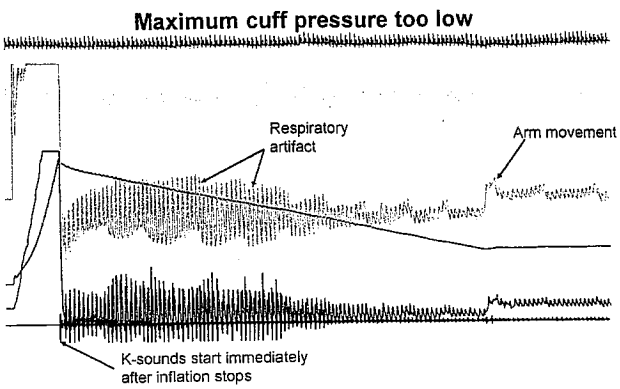


Maximum cuff pressure too low



Cuff too loose, poor positioning