PDF 18- Basic Echocardiographic Examination

Objectives: The objectives for the basic TEE discussion:

- Understand the important echocardiographic findings seen in a basic exam
- Understand the anatomic relationship of normal cardiac structures
- Describe how to perform a basic exam
- Describe the indications, contraindications and potential complications of a TEE exam

A Systematic Structure-Based Exam:

There are different approaches to performing a comprehensive TEE examination. My approach is to perform a systematic structure-based exam. The reason for being systematic this is to avoid missing/skipping any important component of the exam. The rational for performing a structure-based exam is to utilize all the power of the machine to optimize visualization of the region of interest. A view-based exam (obtaining the 20 basic views) is favored by many, but this requires visualizing the deeper structures at the same time you are interrogating closer structures. If you decrease the depth you can better evaluate closer structures (magnified image, better temporal resolution). Also, the depth is decreased as much as possible and the focus is placed to ensure the region of interest is as close to the probe as possible in the near field (minimizing beam width and maximizing lateral resolution).

Below is the order I perform a comprehensive exam in the OR:

- Opening Shot-initial "overall big picture"- 4-5C view
- Valves: MV, AV, TV, PV
- Interatrial Septum
- Left Atrial Appendage
- Diastolic Function
- Coronary sinus
- Systolic Function
- Aorta
- Extra stuff (HD Calculations)

Opening Shot: -initial "overall big picture"- 4-5C view

This is obtained as soon as the probe is placed and immediately the echocardiographer becomes aware of the patients overall status: systolic function, volume status, gross valvular pathology, significant pericardial effusions, and the overall size and condition of the cardiac chambers are apparent. This "overall big picture takes about 15-20 seconds to obtain. In general a 4-5 chamber view at 0 degrees is used and the probe is quickly to turned to the left (to look for a left sided effusion) and to the right (to look for a right sided effusion and to qualitatively interrogate RV function).

Valves:

In the OR, following the opening shot, I immediately perform all parts of the exam that involve Doppler or gated 3D acquisition prior to the start of the case (before electrical interference from the electrocautery device).

Mitral valve: interrogation with and without color- at 0, 60, 90, 120-150 degrees (figure 9). The exact degrees is not as important as ensuring that the valve is interrogated from multiple planes with and without color. The valve may also be interrogated from 0 degrees by advancing the probe (to look at

posterior aspects of the valve) and withdrawing the probe (to look at more anterior aspects of the valve. Also a short axis (en-face) view of the valve is obtained and interrogated from the TG basal short axis view, or from a 3D enface view. In patients with mitral valve disease the mitral valve area should be calculated using the pressure half time, the deceleration time, or the proximal isovelocity surface area method. A detailed discussion of these calculations is beyond the scope of this syllabus, but is discussed in the narrated basic mitral valve lecture found at http://www.ptemasters.com/lectures/ .

Aortic Valve:
The aortic valve is interrogated with and without color in short and long axis. The aortic valve area should be calculated using: 2D planimetry (ME AV SAX view), continuity equation, 3D planimetry.

Tricuspid Valve:
The tricuspid valve is interrogated with and without color from multiple views including: ME 4-chamber view, ME-RV inflow-outflow view.

Pulmonic Valve:
The pulmonic valve is interrogated with and without color, usually from the ME-RV inflow-outflow view at around 60-90 degrees.

Interatrial septum:
The interatrial septum is interrogated from multiple views for a PFO or ASD. The color flow max velocity should be serially decreased to around 25-35 cm/sec to allow for visualization of low velocity flow(1).

Left atrial appendage (LAA):
The left atrial appendage is interrogated for thrombus. This should be interrogated between 45-110 degrees with the probe withdrawn and turned to the left and the depth decreased. The LAA should be zoomed in on and interrogated with and without color, and with the use of pulsed-wave Doppler to assess flow velocities. A pulsed wave Doppler velocity of > 55 cm/sec at the origin of the LAA has a negative predictive value of >95% for thrombus, but in general velocities > 40 cm/sec make thrombus unlikely (2).

Diastolic function:
Diastolic function should be evaluated using the following:
Transmitral pulsed-wave Doppler analysis
Lateral and septal mitral annular tissue Doppler velocities
Pulmonary venous pulsed-wave Doppler analysis
Color M-mode flow propagation velocity.
A detailed discussion of the evaluation diastolic function and how to perform the above modalities is beyond the goals of this syllabus, but is available for free as a PDF download via the following link: http://www.ptemasters.com/media/12493/pdf_13-_diastolic_fx__basic___advanced__v4.pdf there is also a narrated diastolic function basic lecture available at: http://www.ptemasters.com/lectures/ .

Coronary sinus:

The size of the coronary sinus is evaluated. A large coronary sinus may indicate a persistent left superior vena cava which complicates cannulation and cardioplegia administraion. If a persistent left SVC is suspected, contrast material may be injected into a left upper extremity IV and contrast material will be seen entering the coronary sinus prior to the RA (if the persistent Left SVC is present). (Fig 10)

Systolic function is qualitatively evaluated looking at all myocardial segments from multiple 2D views. (See figure 1 below).
A detailed quantitative analysis may be made using the following parameters:

- Fractional shortening (FS),
- Fractional area of change (FAC),
- Ejection Fraction (LVEF, using Simpson's method of discs for 2D or Q-lab for 3D)
- Dp/dt (the change in pressure with respect to time during isovolumetric LV contraction.
- Tissue Doppler peak systolic velocity
- Strain Rate
- End systolic Elastance
- Preload recruitable stroke work

For a detailed discussion of basic and advanced qualitative and quantitative LV systolic function see the following link: http://www.ptemasters.com/lectures/ and click on the systolic function lecture.

Aorta:

The aorta should be evaluated by turning the probe to the left and decreasing the depth to around 4-6 cm. The probe is then advanced into the stomach while visualizing the aorta until it can no longer be visualized then the probe is withdrawn until the arch is seen and then structures are no longer visible. This is done at both zero and 90 degrees or (if possible) using the X-plane function on a 3d matrix probe. The probe is then turned back to the right and a ME AV LAX view is obtained and the angle is slightly decreased to around 90-110 degrees. The probe is then withdrawn and the ascending aorta inspected. For a detailed discussion of the evaluation of the thoracic aorta see the thoracic aorta lecture at the following link: http://www.ptemasters.com/lectures/

Extra Stuff: depending on the patient:

Depending on the patients coexisting pathology additional hemodynamic calculations may be relevant these include but are not limited to the following:

- Quantitative assessment of systolic function, as described above.
- Pressure gradients across valves
- Calculation of valve areas using calculations as well as planimetry and 3d tracing.
- Calculation/estimation o f intracardiac pressures
- Calculation of effective regurgitant orifice area, regurgitant volume, regurgitant fraction

A detailed discussion of these calculations is beyond the scope of this basic discussion but is provided during the hemodynamic calculations lecture at the following link: http://www.ptemasters.com/lectures/

INDICATIONS(3-6):

In category I indications TEE is frequently useful in improving outcome; these cases are supported by the strongest evidence, or expert opinion.

These indications were first published in 1996 by the American Society of Anesthesiologists (ASA) and the Society of Cardiovascular Anesthesiologists (SCA).

They are likely somewhat outdated, and are not listed in the content outline for the PTEeXAM (<http://www.echoboards.org/pte/outline.html>).

I would not waste time memorizing these lists, but I would read them and be familiar with them.

The Important thing to consider when performing a TEE is the risk/benefit ratio. If the information gained by doing the exam will potentially change management, and improve patient care, and the patient is at low risk for complications, then the exam should be performed.

This has to be determined on a case by case basis.

Category I indications:

- Evaluation of acute, persistent and life-threatening hemodynamic instability in the operating room, or ICU in which ventricular function and its determinants are uncertain and have not responded to treatment.
- Intraoperative use in valve repair.
- Intraoperative use in congenital heart disease for most lesions requiring cardiopulmonary bypass.
- Intraoperative use during repair of hypertrophic obstructive cardiomyopathy.
- Intraoperative use for endocarditis when preoperative testing was inadequate or extension of infection to perivalvular tissue is suspected.
- Intraoperative assessment of aortic valve function in repair of aortic dissections.
- Intraoperative evaluation of pericardial window procedures.

Category II indications are supported by weaker evidence or expert opinion. TEE may be useful in improving outcome in these cases.

Category II indications:

- Perioperative use in patients at increased risk of myocardial ischemia or infarction.
- Perioperative use in patients at increased risk of hemodynamic disturbances.
- Intraoperative assessment of valve replacement
- Intraoperative assessment of repair of cardiac aneurysms
- Intraoperative evaluation of removal of cardiac tumors
- Intraoperative detection of foreign bodies
- Intraoperative detection of air emboli during cardiotomy for heart transplantation and during upright neurological procedures.
- Intraoperative use during intracardiac thrombectomy or pulmonary emobolectomy
- Intraoperative use for suspected cardiac trauma
- Preoperative assessment of patients with suspected acute thoracic aortic dissections, aneurysms or disruptions.
- Intraoperative use during repair of thoracic aortic dissections without suspected aortic valve involvement.
- Intraoperative evaluation of pericardectomy, pericardial effusion or evaluation of pericardial surgery. (note pericardial window is a class I indication)
- Intraoperative evaluation of anastomotic sites during heart and/or lung transplantation.
- Monitoring placement and function of assist devices.

Category III indications are supported by little current scientific evidence or expert support. TEE is infrequently useful in improving outcome.

Category III indications:

- Intraoperative evaluation of myocardial perfusion, coronary artery anatomy, graft patency or cardioplegia administration.
- Intraoperative use during cardiomyopathies other than hypertrophic cardiomyopathy.
- Intraoperative use for uncomplicated endocarditis during non-cardiac surgery.
- Intraoperative assessment of repair of thoracic aortic injuries.
- Intraoperative use for uncomplicated pericariditis
- Intraoperative evaluation of pleuropulmonary diseases
- Monitoring placement of intra-aortic balloon pump, automatic implantable cardiac defibrillators or pulmonary artery catheters.

Absolute contraindications to TEE include(7):

- Esophageal strictures, webs or rings
- Patient refusal
- Esophageal perforation
- Obstruction esophageal neoplasms
- Tracheoesophageal fistula
- Postesophageal surgery (esophagectomy/esophagogastrectomy)
- Esophageal trauma

Some consider cervical spine instability to be an absolute contraindication, but the latest articles do **not** include this.

Relative contraindications to TEE include(3,6):

- Esophageal diverticula, varices, or fistulas
- Previous esophageal surgery
- History of previous gastric surgery, mediastinal irradiation, unexplained swallowing difficulties, and other conditions that may be worsened by placement and manipulation of TEE probe (eg. coagulopathy)

Possible Complications of TEE include(6-8):

- Dysphagia
- Vocal cord paralysis and transient hoarseness
- Odynophagia (Oropharyngeal or dental injury)
- Tracheal compression
- Left atrial compression
- Great vessel compression
- Dislodgement of endotracheal tube
- Aspiration or bronchospasm
- Arrhythmias
- Endocarditis from bacteremia
- Esophageal perforation (0.01-0.02%)

Figure 1: Qualitative Assessment of LV systolic (3)

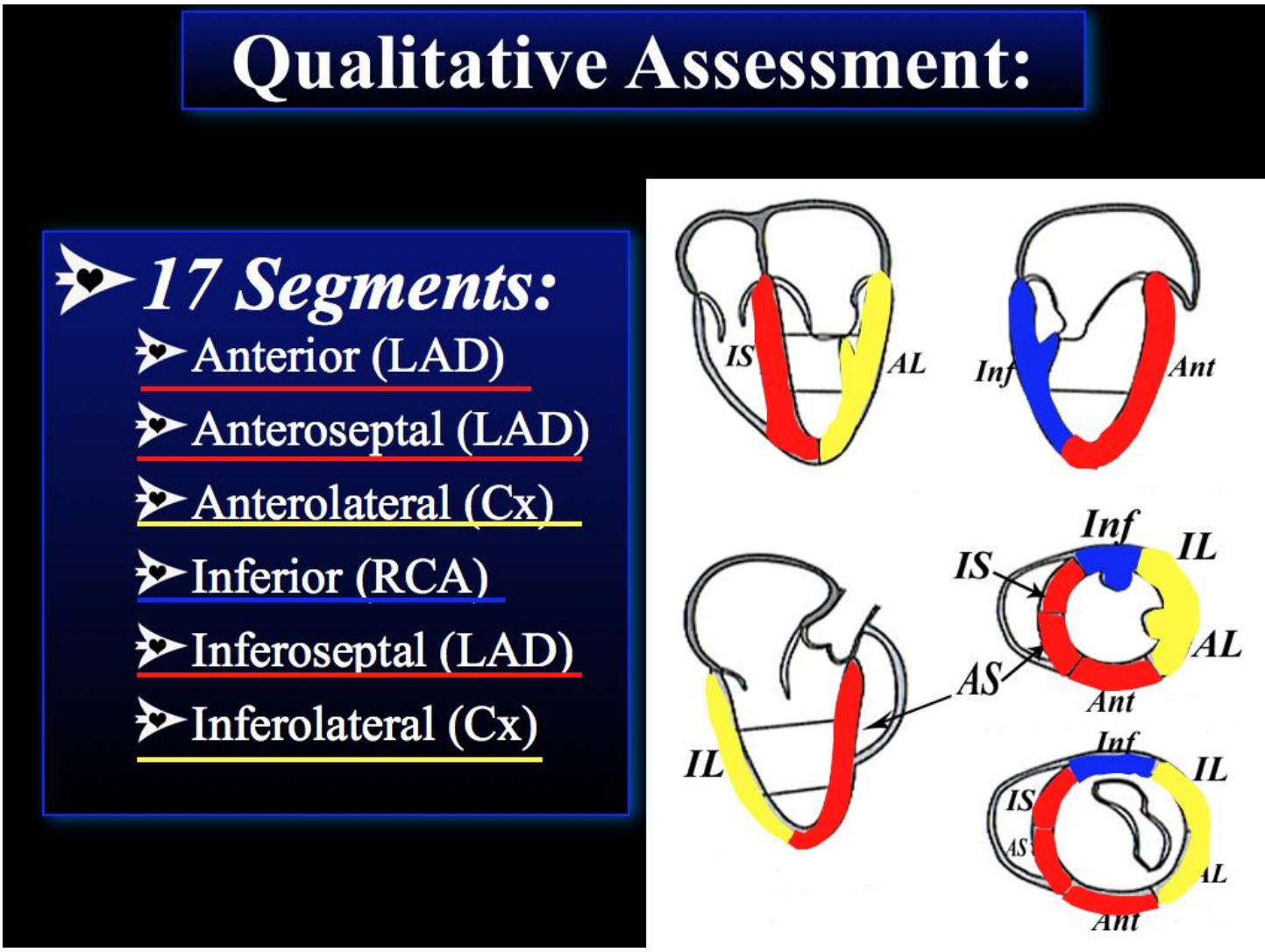


Figure 2: Standard views with labels(3).

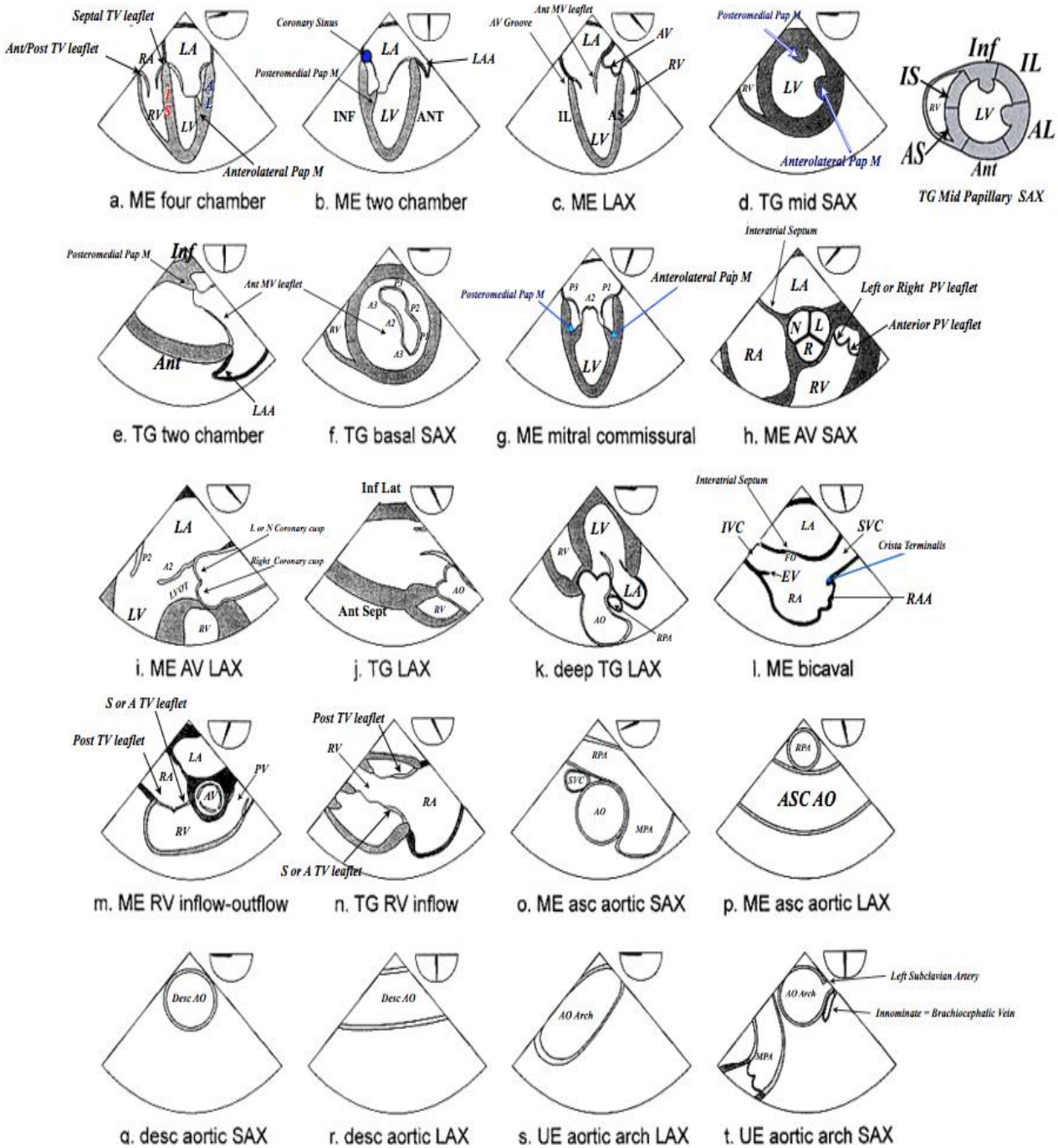


Figure 3: Wall Motion Grading(3)

Wall Motion (ASE)

Endocardial Wall motion	Grade	Endocardial Movement	Endocardial Thickening
Normal	1	Normal	> 30%
Mild Hypokinesis	2	Slightly Decreased	10-30%
Severe Hypokinesis	3	Severely Decreased	< 10%
Akinesis	4	No Movement	No thickening
Dyskinesis	5	Outward during systole	Thins during systole
Paradoxical Motion		Outward during systole	Thickens during systole

Fig 4-ME 4 Chamber view

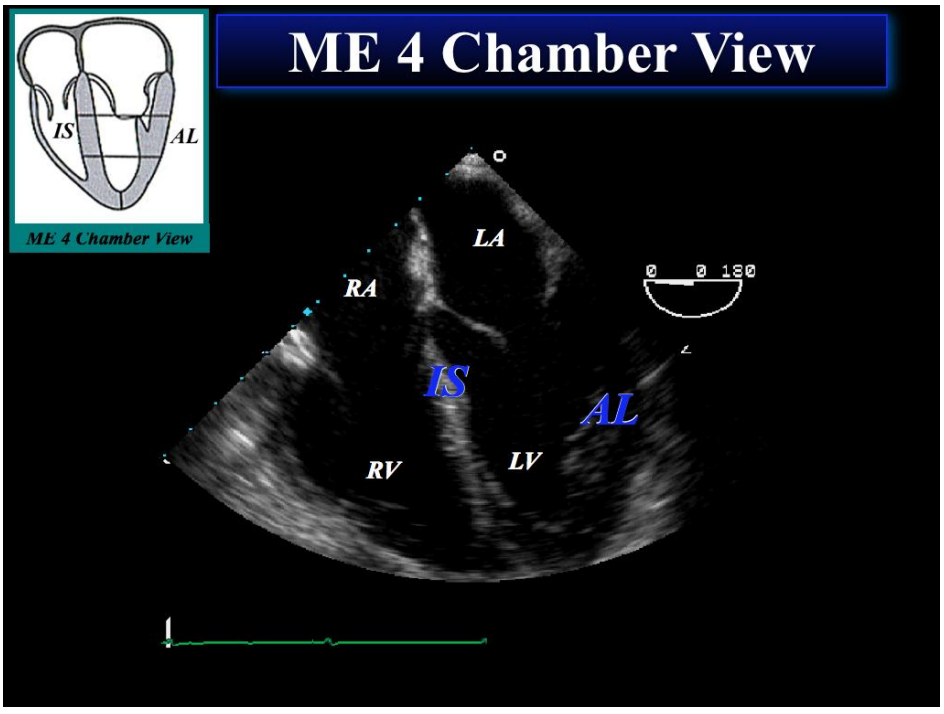


Fig 5: ME 2-Chamber view

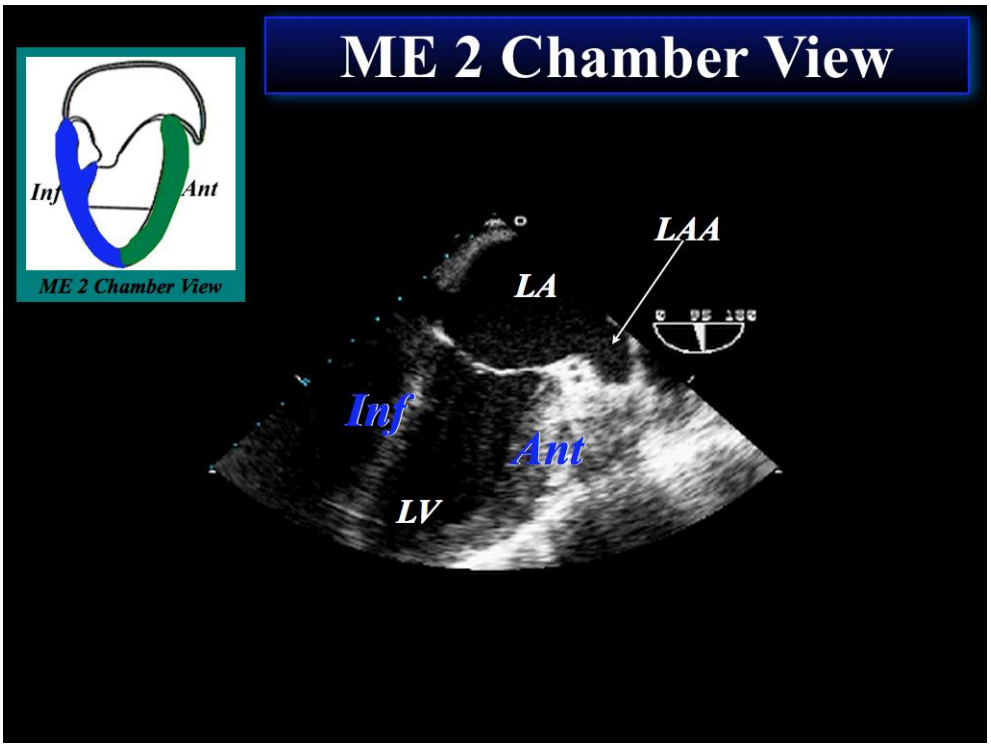


Fig 6: ME Lax view

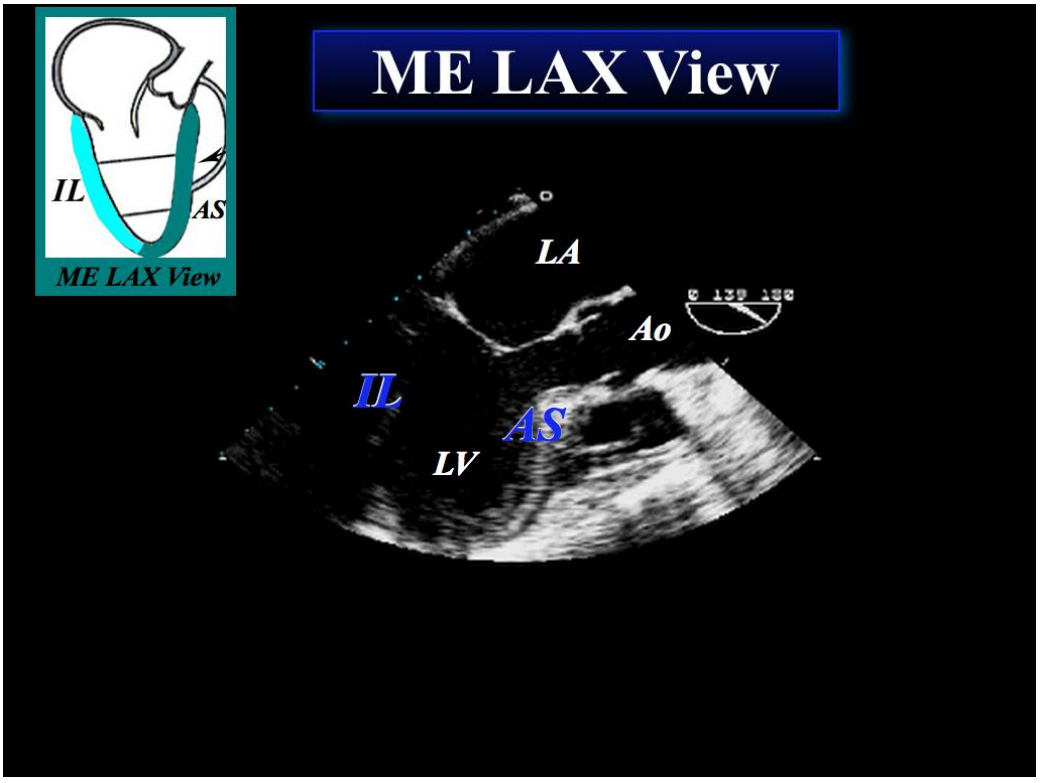


Fig 7: TG SAX view

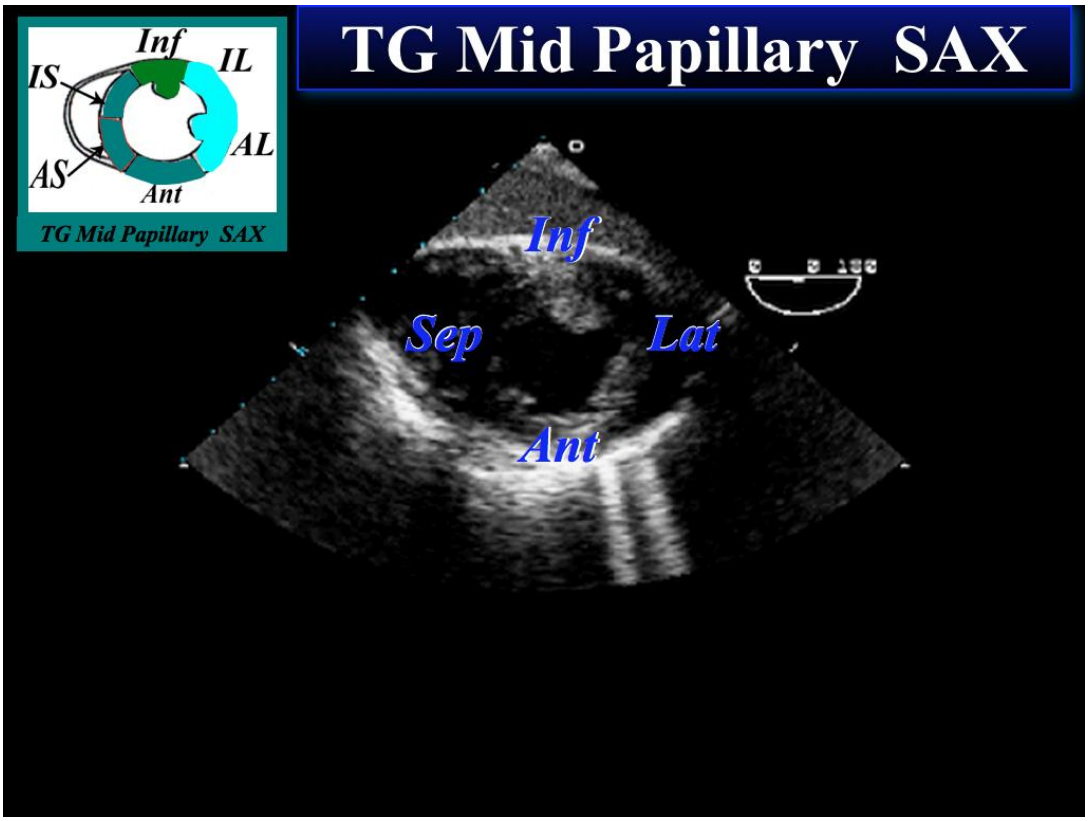


Fig 8- TG Two chamber view

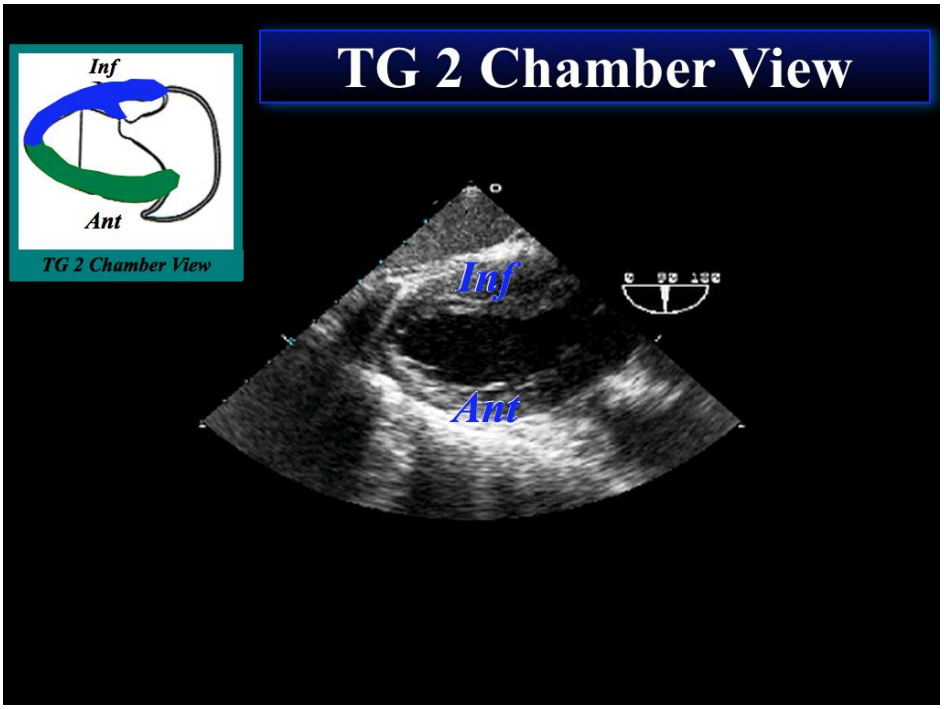


Figure 9- 2D-echo evaluation of the mitral valve-scallop identification

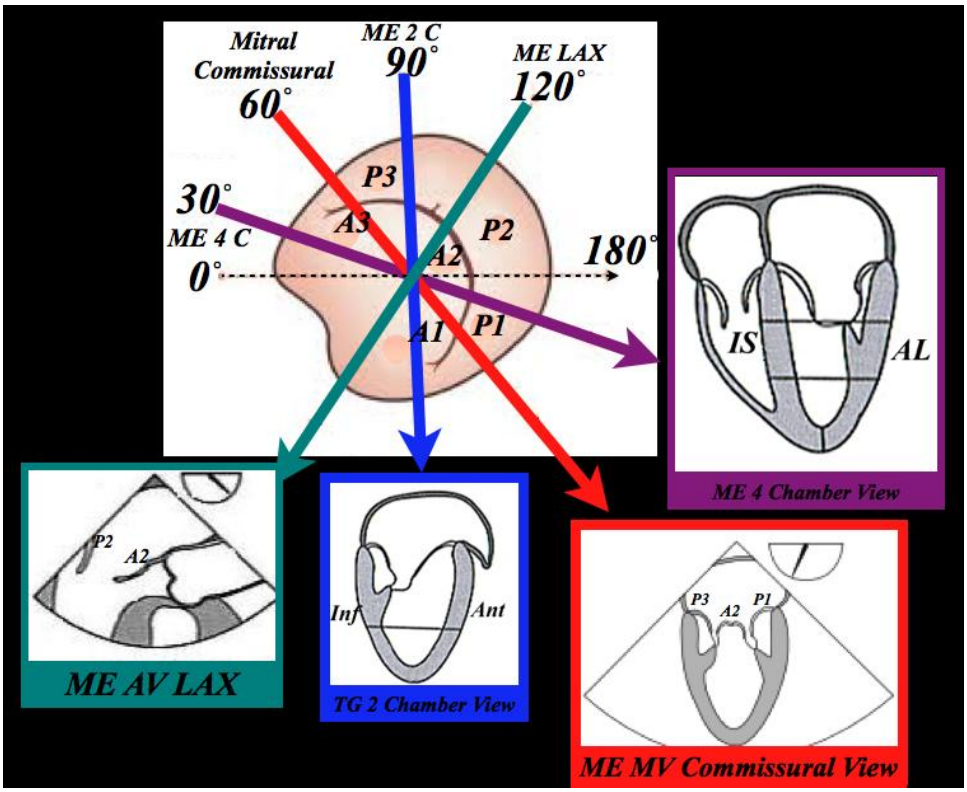
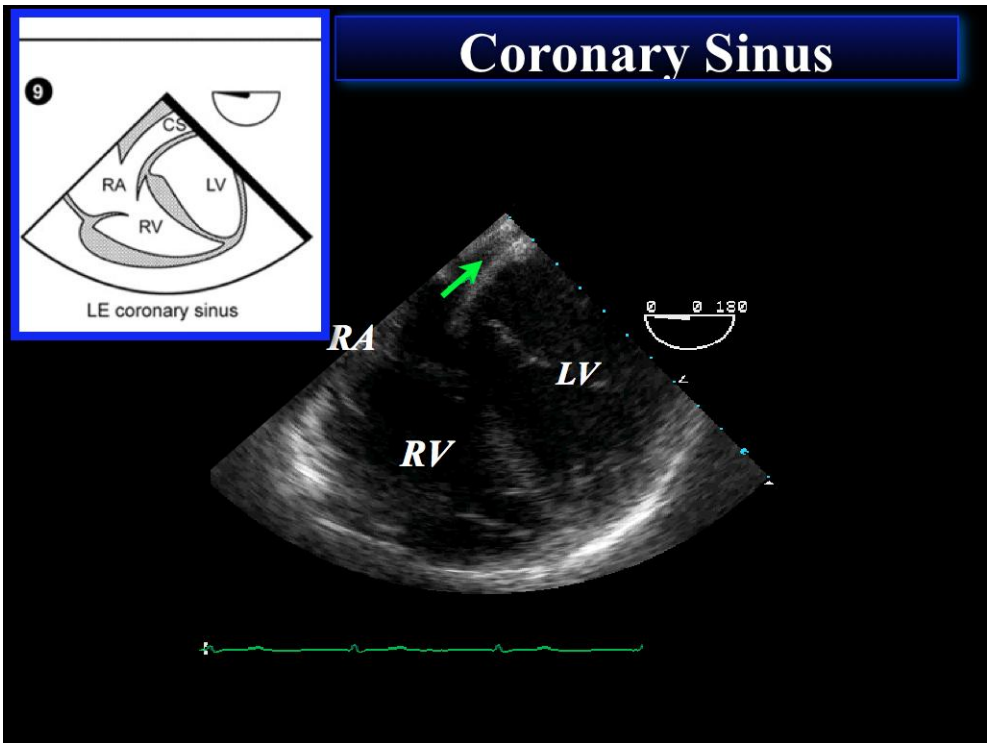


Figure 10-coronary sinus



Below are tables covering the grading of valvular stenosis and regurgitation

AORTIC STENOSIS (JASE 2009)(9)

	NORMAL	MILD	MOD	SEV
Peak V (m/sec)		2.6-2.9	3-3.9	≥4.0
Peak ΔP (mmHg)	8-20	20-39	40-69	≥70
Mean ΔP(mmHg)		15-29	30-49	≥50
AV area (cm^2)	3-4	1.6-2.9	1-1.5	<1.0
A/BSA (cm^2/M^2)		>0.85	0.6-0.85	<0.6
TVI_{LVOT}/TVI_{AV}		>0.50	0.25-0.50	<0.25

MITRAL STENOSIS (JASE 2009)(9)

	NORMAL	MILD	MOD	SEVERE
Mean ΔP (mmHg)		<5	5-10	>10
PHT(msec)	30-89	90-150	150-220	≥220
MVA (cm^2)	>2.5	1.6-2.5	1.0-1.5	<1.0

MITRAL REGURGITATION (AHA/ASE)(10)

	MILD	MODERATE	SEVERE
Jet Area/LA area	<20%	20-40%	>40%
Pulm vein flow	S NL	S Blunted	S Reversal
Jet Area (cm^2)	<4	4-10	≥10
Reg Vol (ml)	<30	30-59	≥60
Reg Fraction	<30%	30-49%	≥50%
EROA (cm^2)	<0.20	0.20-0.39	≥0.40
Vena contracta (mm)	<3	3-7	>7
PISA Radius (mm)†	<4	4-10	>10
CWD signal strength	Faint	Mod Dense	Very Dense

† = with Aliasing Velocity = 40cm/sec & $V_{MRpeak} \approx 500$cm/sec

TRICUSPID INSUFFICIENCY (ASE/AHA)(10)

	MILD	MOD	SEVERE
CWD Jet Density	Soft	More dense	Very Dense
Jet Area (cm^2)	<5	5-10	>10
VC width (mm)			>7
Hepatic Venous flow	Sys Dom	Sys Blunting	Sys Reversal

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