A lifetime of specialist care

Royal Brompton & Harefield NHS
NHS Foundation Trust

Assessment of Ventricular Function

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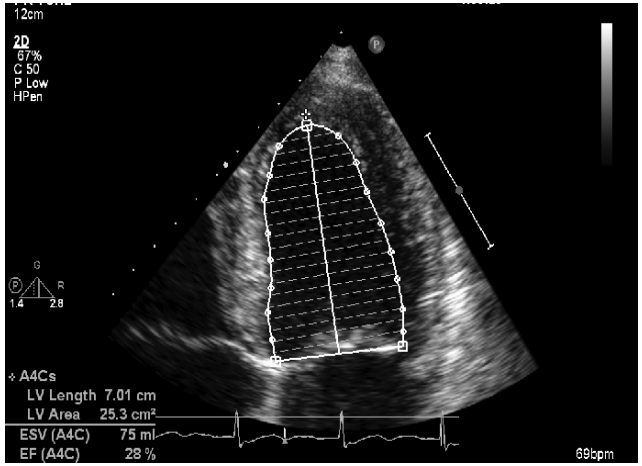
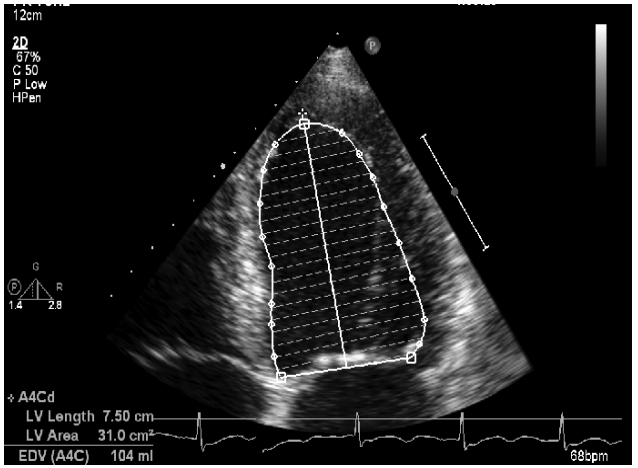
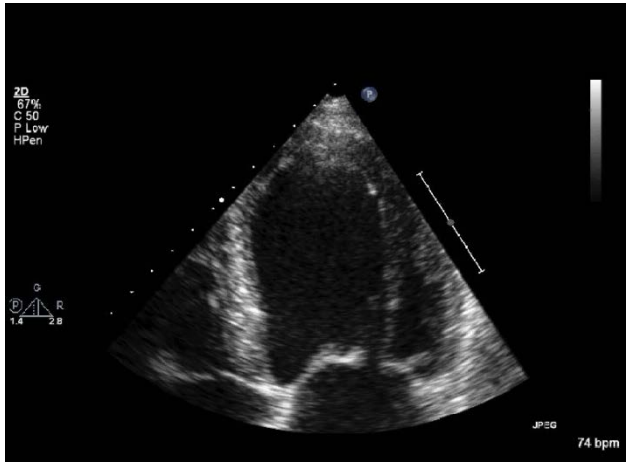
Paediatricians with Expertise in Cardiology
Special Interest Group

Circumferential fibres

Calculation of LVEF

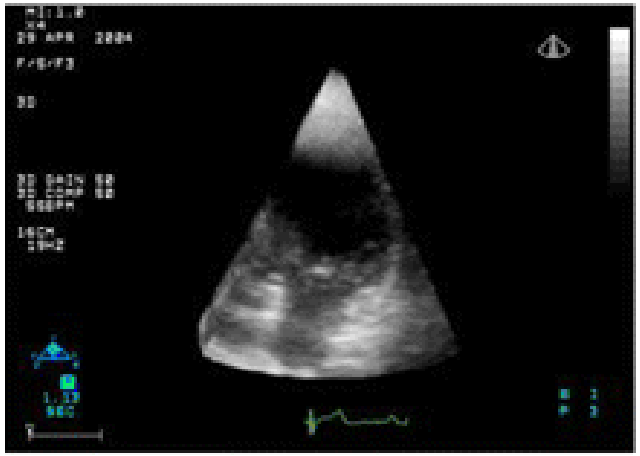


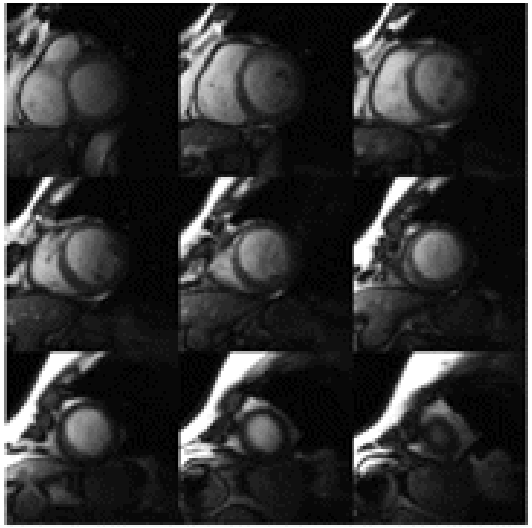


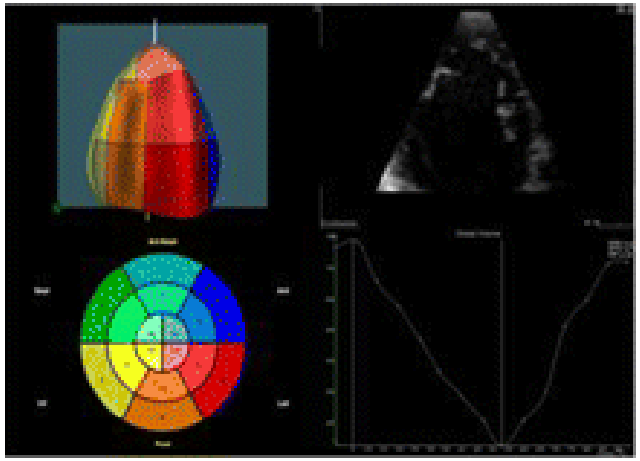


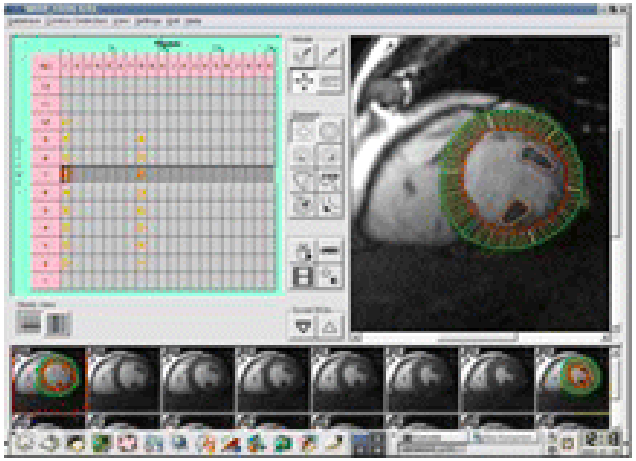
- Modified biplane Simpson's rule
- Measures EDV and ESV (ml)
- Calculated EF (%) $\frac{\text{EDV} - \text{ESV}}{\text{EDV}} \times 100$

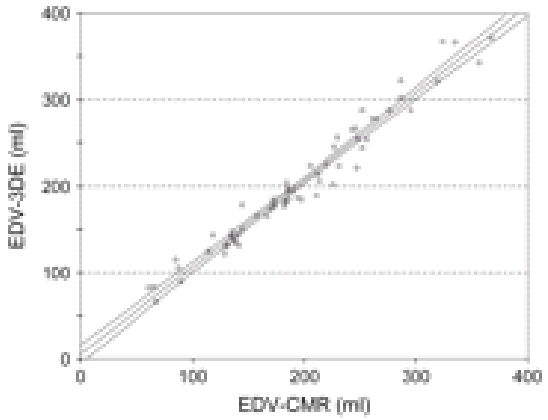
3D Assessment of LV function

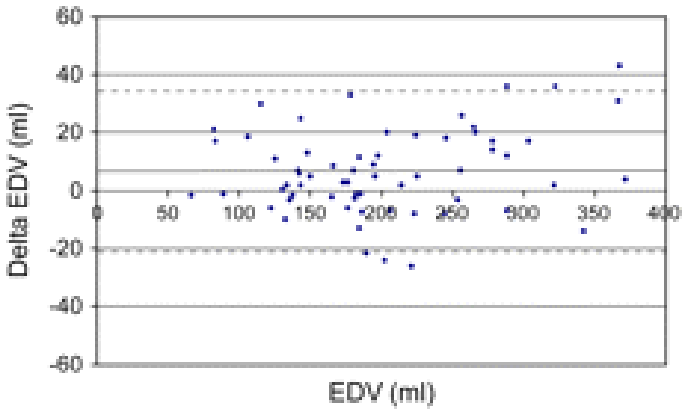


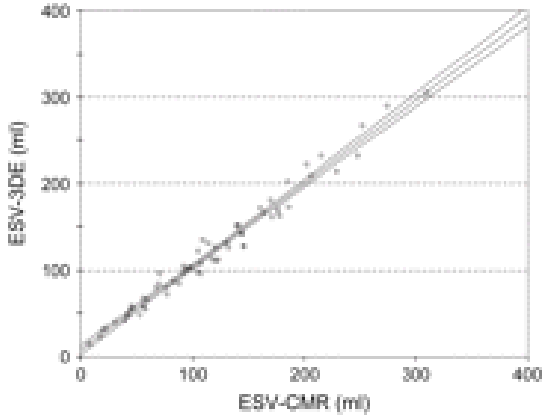


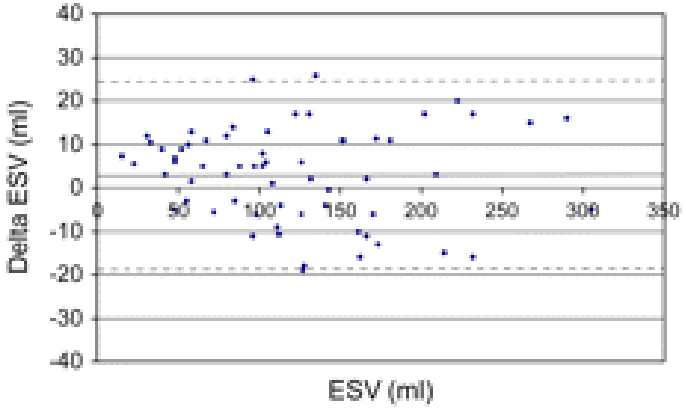


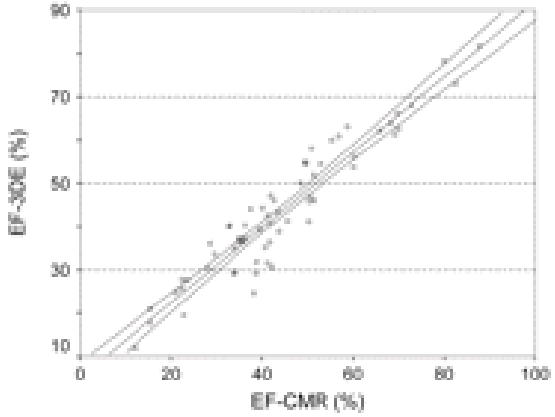


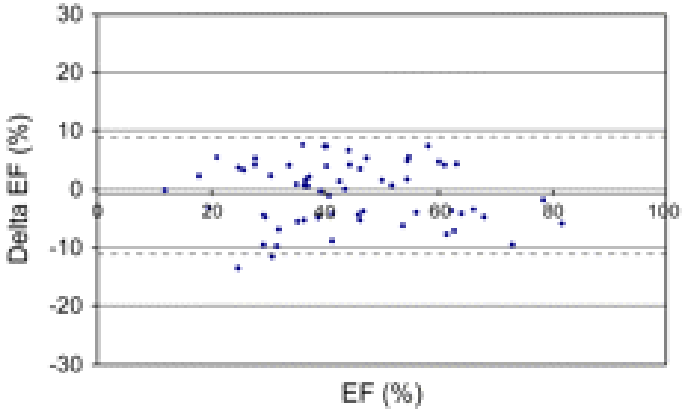






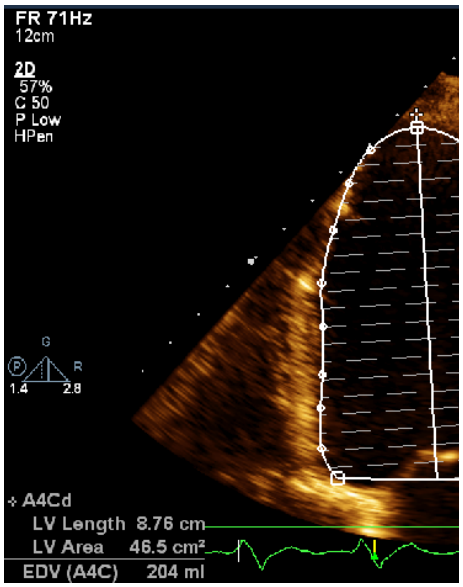


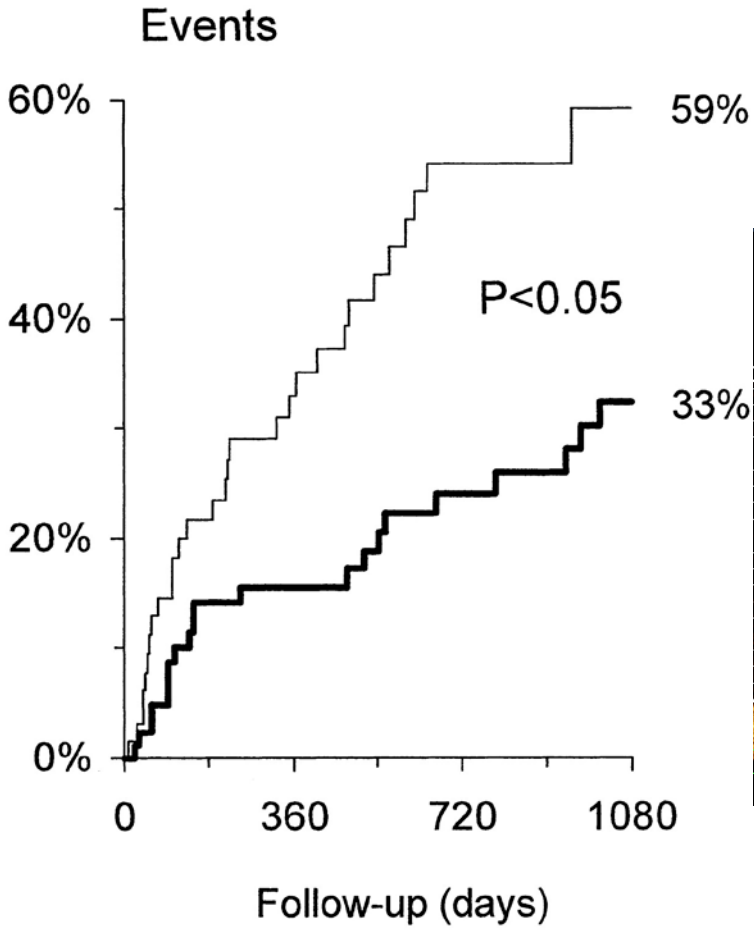


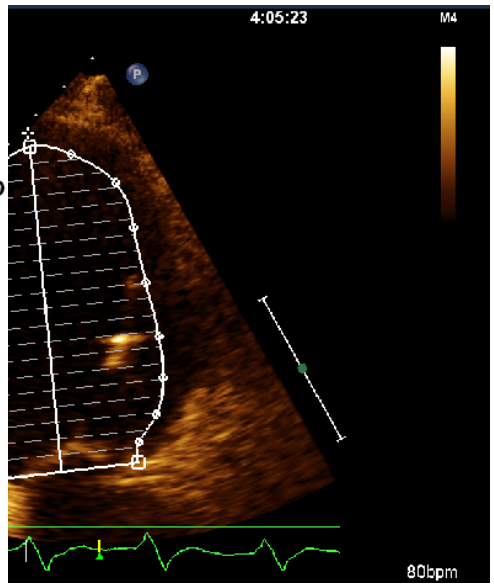


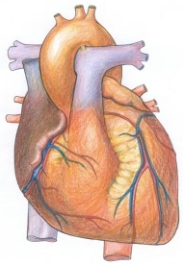
Nitkin et al
Eur J Echo 2006

LVEF and Outcome





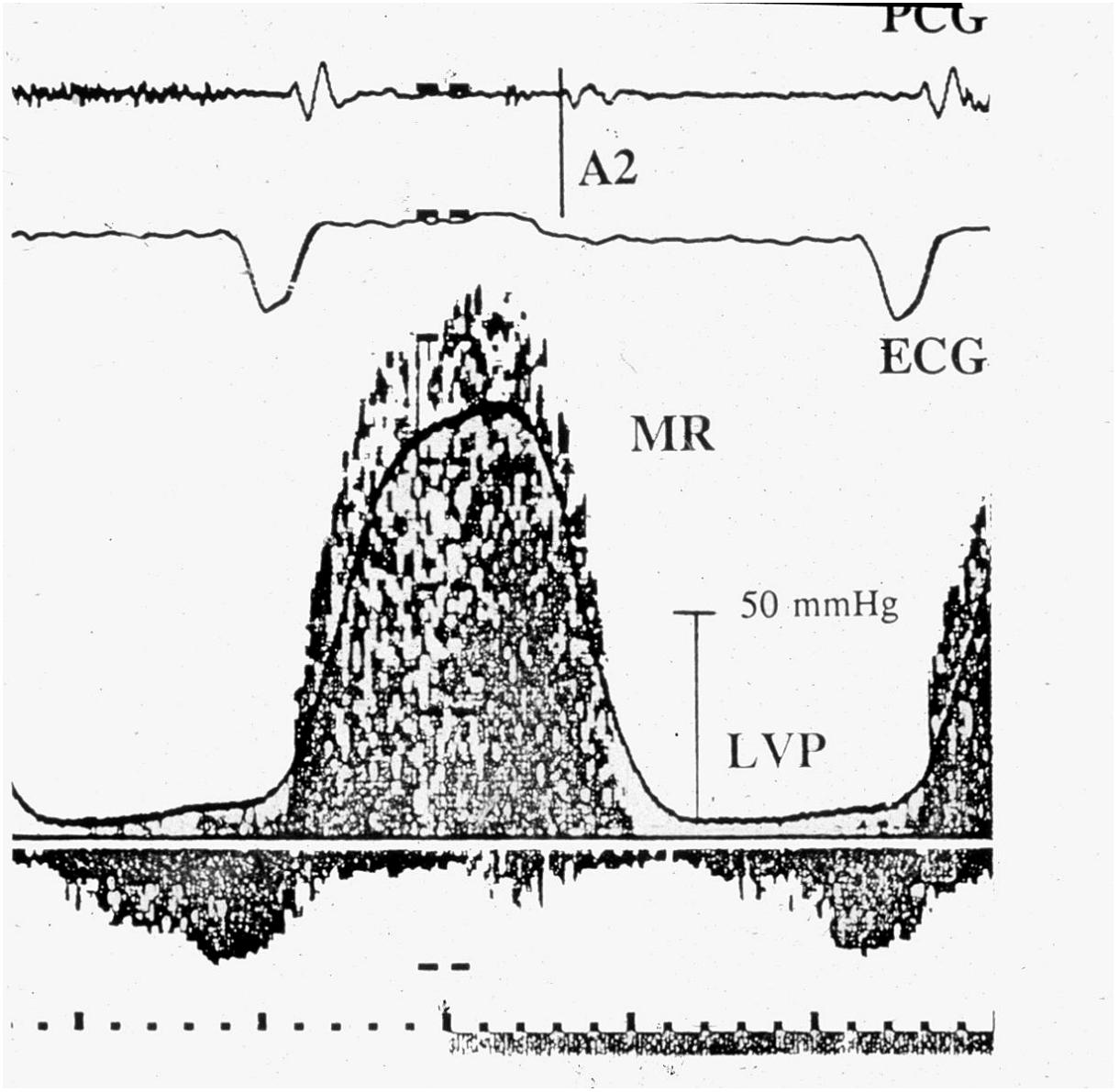




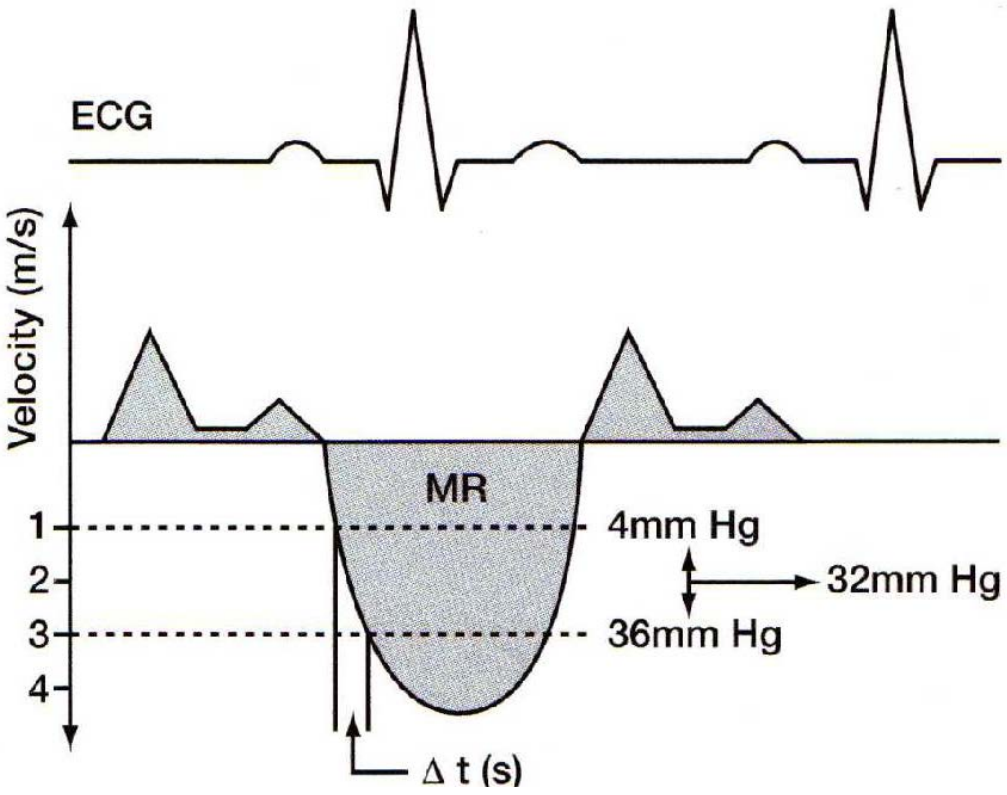
Doppler Assessment of LV function

Doppler Assessment of LV function

1. Peak dP/dt
2. Stroke volume
3. Cardiac output


PCG
A2
ECG
MR
50 mmHg
LVP

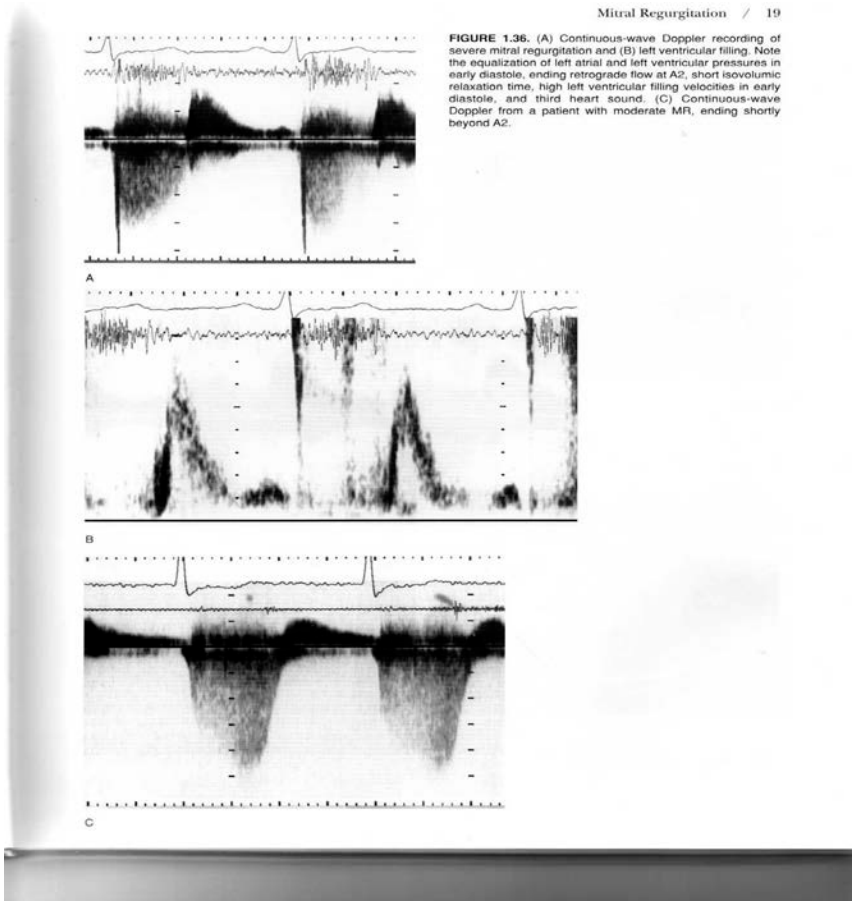
Calculation of peak dP / dt



Clinical significance of dP/dt

LV systolic function	Time for LV to generate 32mmHg	dP/dt (mmHg/sec)
Normal	<27ms	>1200
Mild-moderate dysfunction	27-40ms	800-1200
Severe dysfunction	>40ms	<800

dp/dt



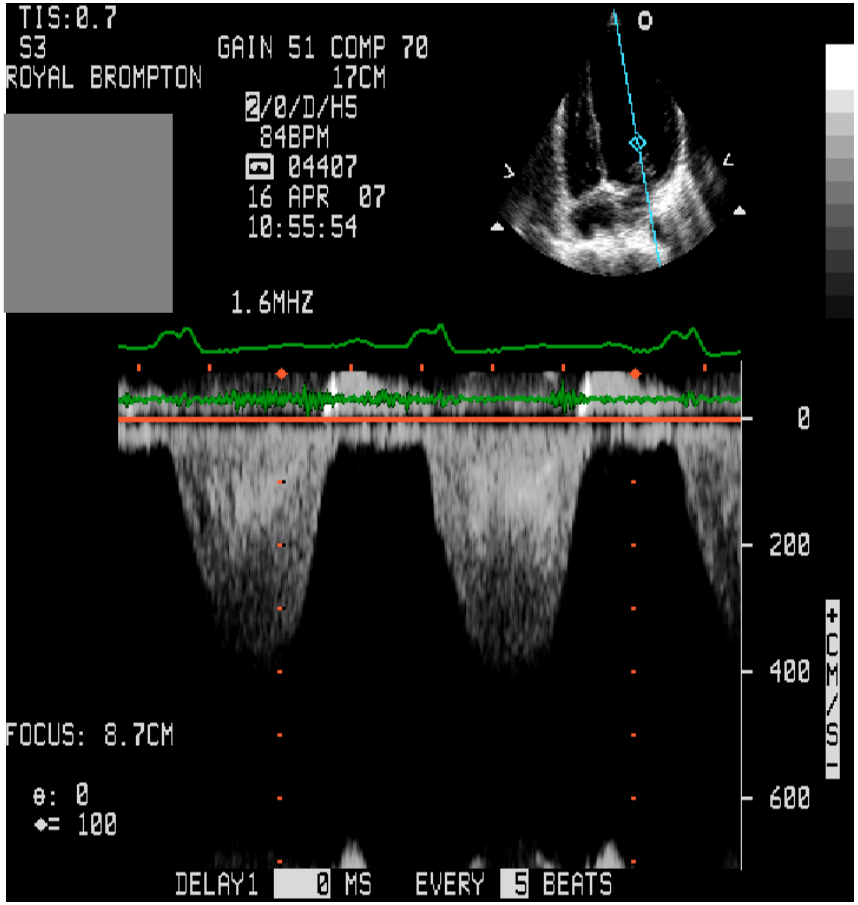
Mitral Regurgitation / 19

FIGURE 1.36. (A) Continuous-wave Doppler recording of severe mitral regurgitation and (B) left ventricular filling. Note the equalization of left atrial and left ventricular pressures in early diastole, ending retrograde flow at A2, short isovolumic relaxation time, high left ventricular filling velocities in early diastole, and third heart sound. (C) Continuous-wave Doppler from a patient with moderate MR, ending shortly beyond A2.

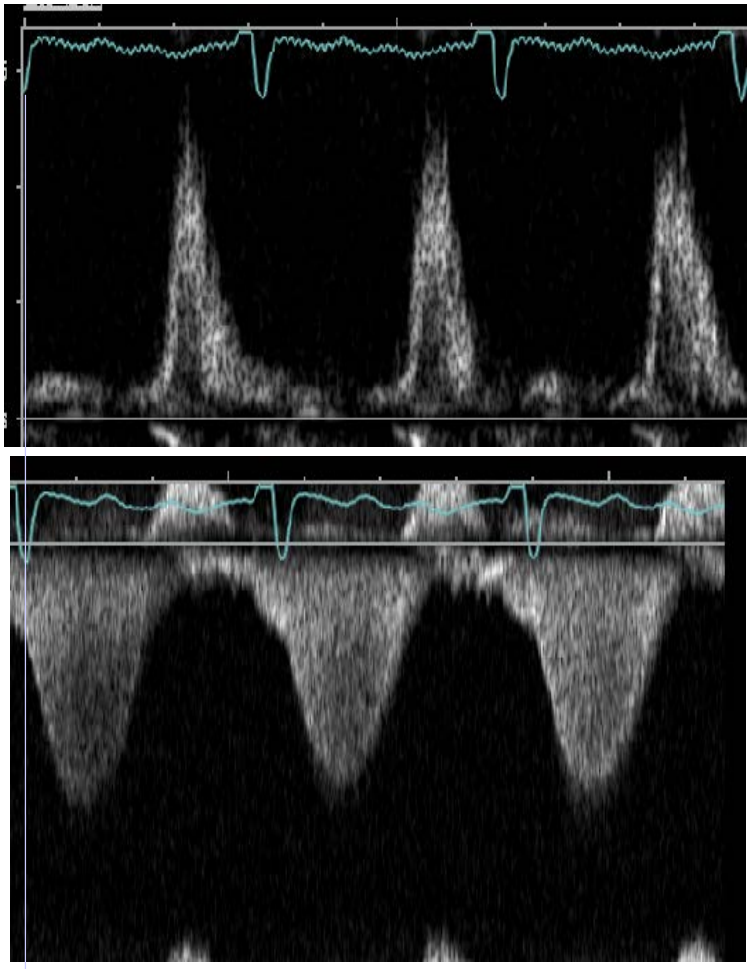
A

B

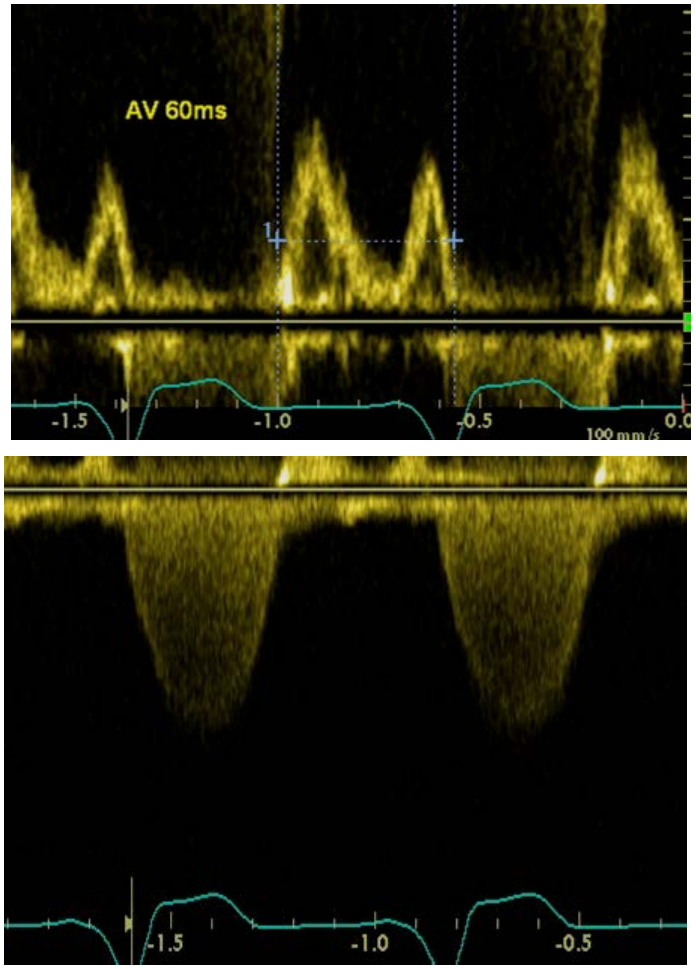
C



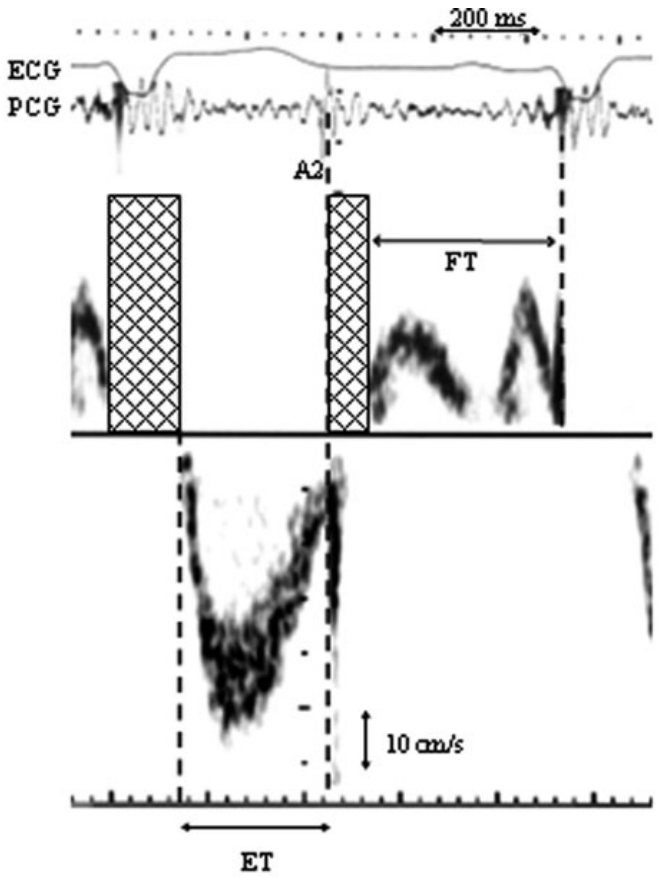
LV filling pre-pacing



LV filling with pacing and optimised AV delay



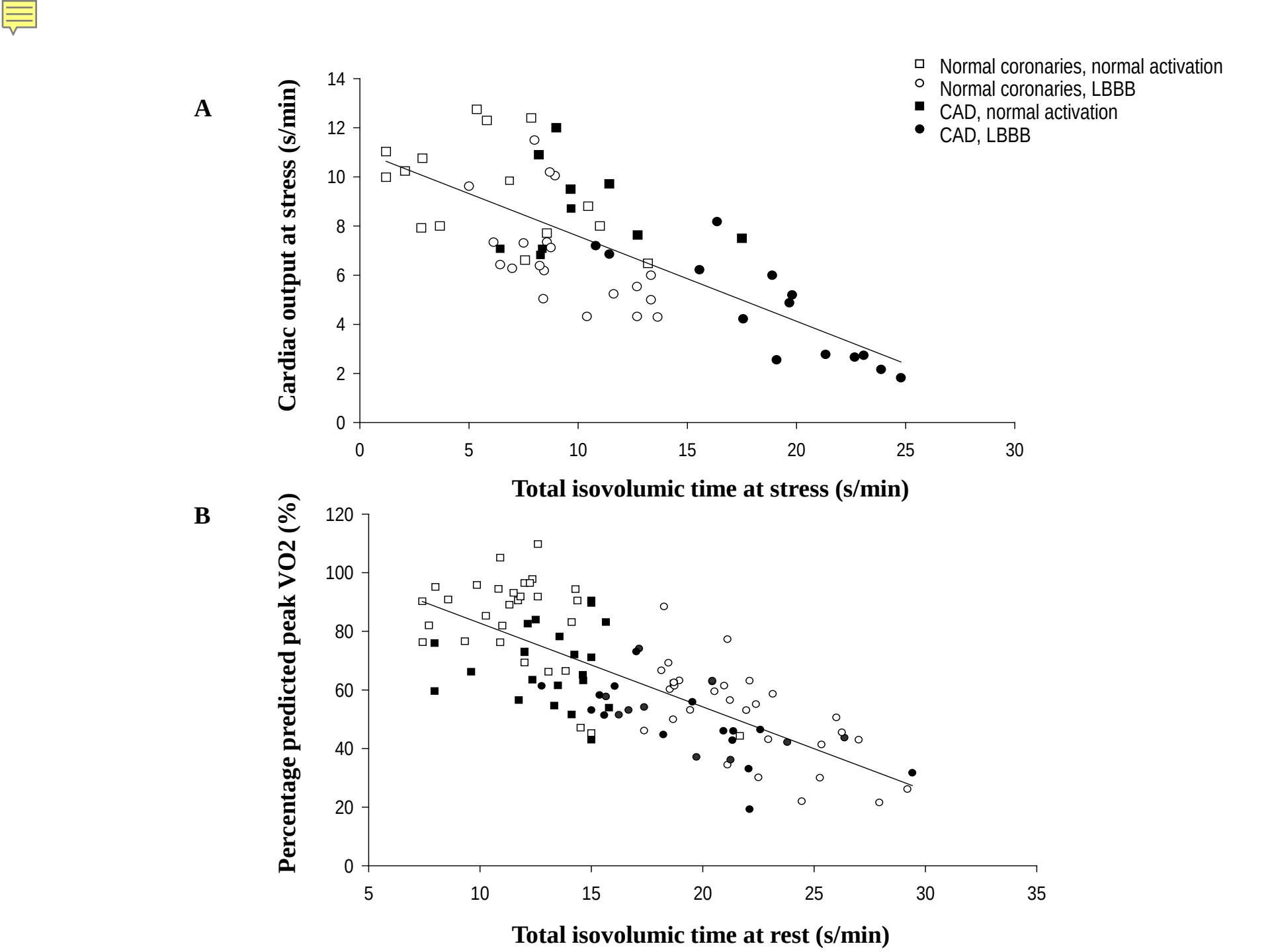
Total Isovolumic Time

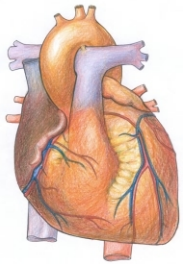


HR = 64 bpm

Ejection time 300 ms, total ejection time per minute (0.30*64) = 19.2 s/min
Filling time 400 ms, total filling time per minute (0.40*64) = 26.6 s/min

t-IVT = 60 – (19.2 + 26.6) = 14.6 s/min

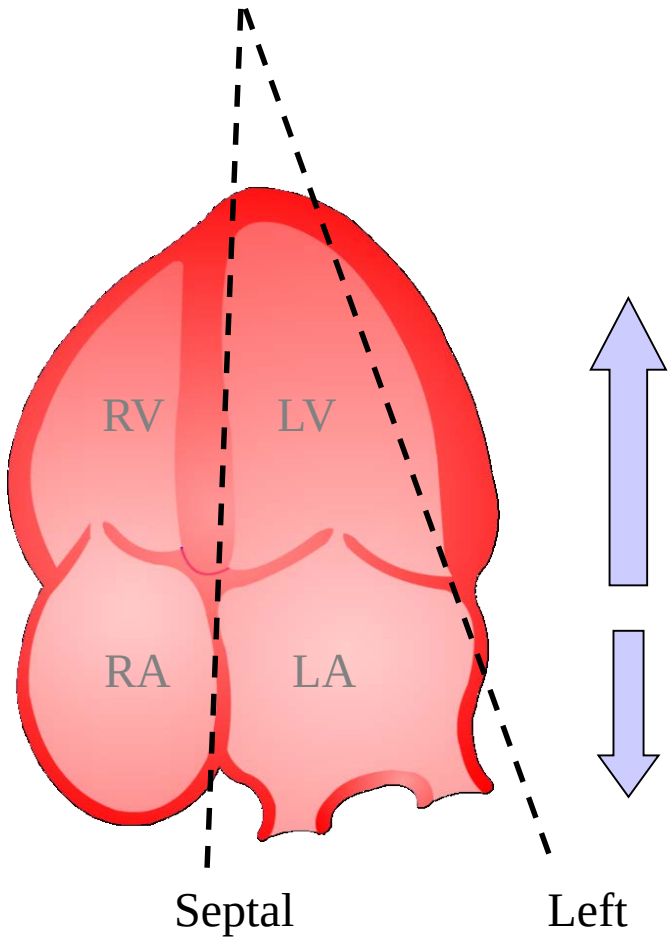

A
Normal coronaries, normal activation
Normal coronaries, LBBB
CAD, normal activation
CAD, LBBB
Cardiac output at stress (s/min)
Total isovolumic time at stress (s/min)
B
Percentage predicted peak VO2 (%)
Total isovolumic time at rest (s/min)

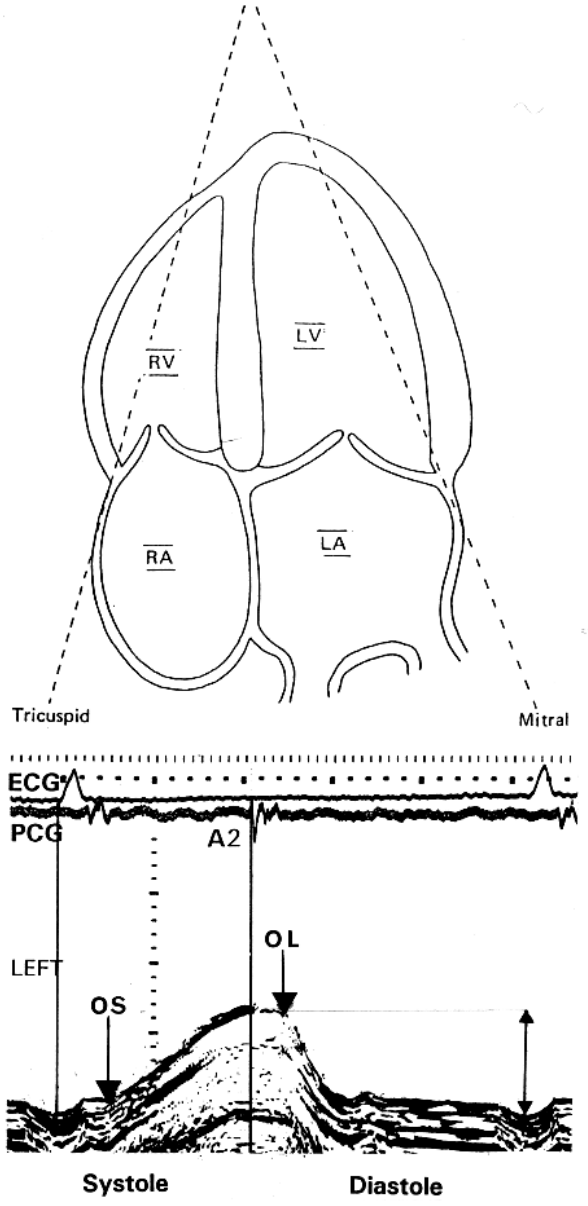


Assessment of long axis function

Longitudinal fibres

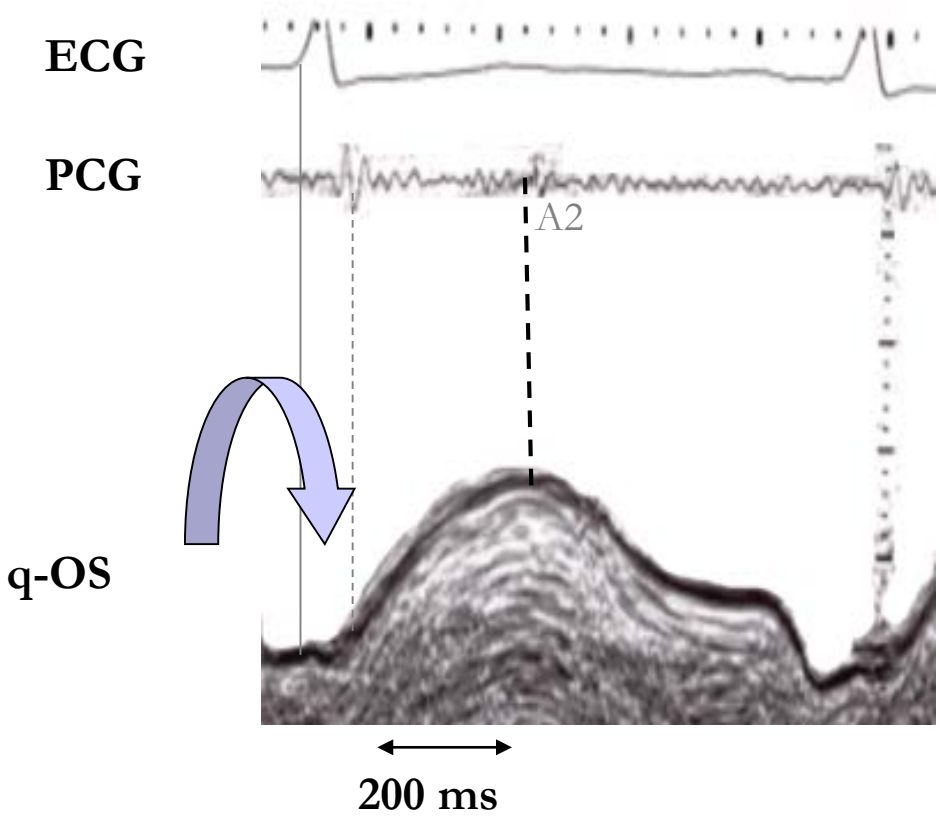
Long axis



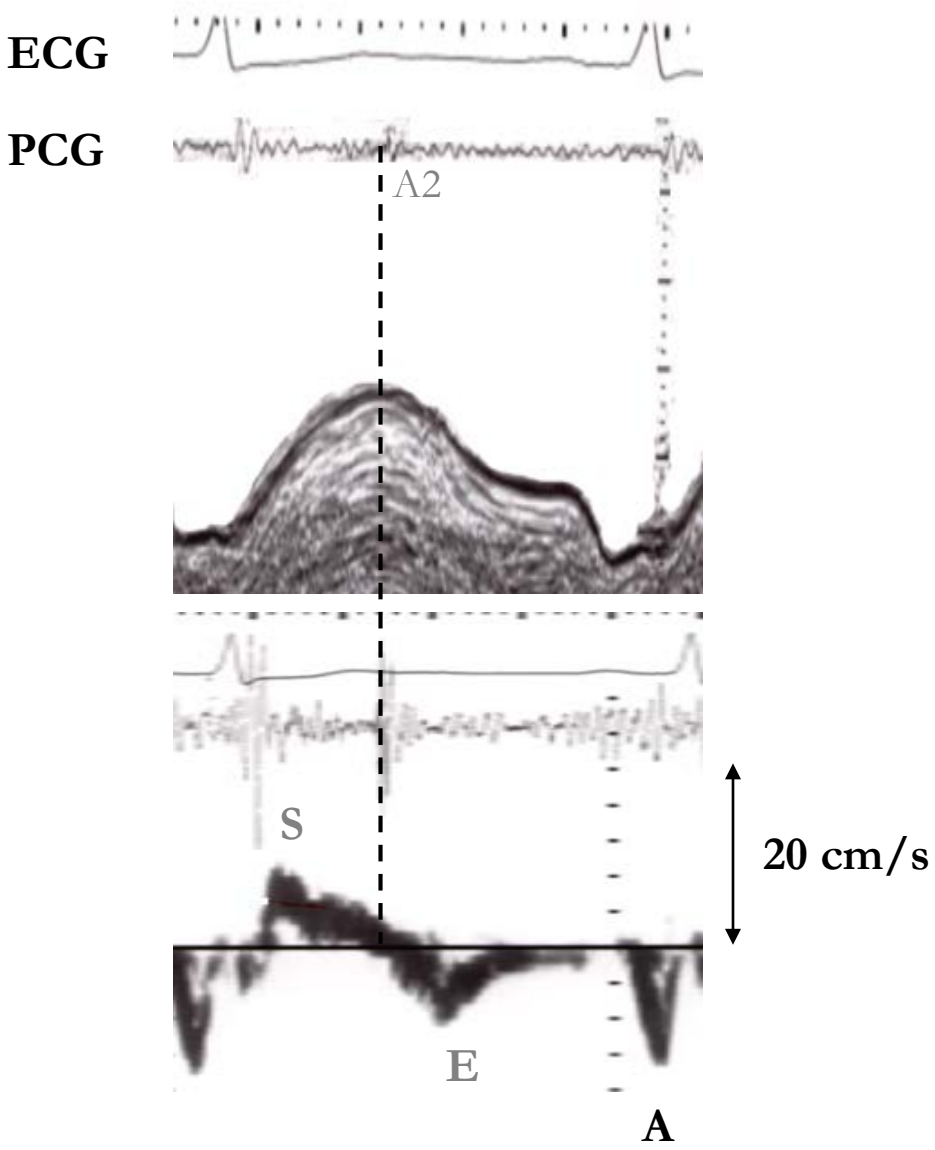

RV
LV
RA
LA
Tricuspid
Mitral
ECG
PCG
A2
LEFT
OS
OL
Systole
Diastole

Normal

Normal LV long axis



Normal LV long axis velocity

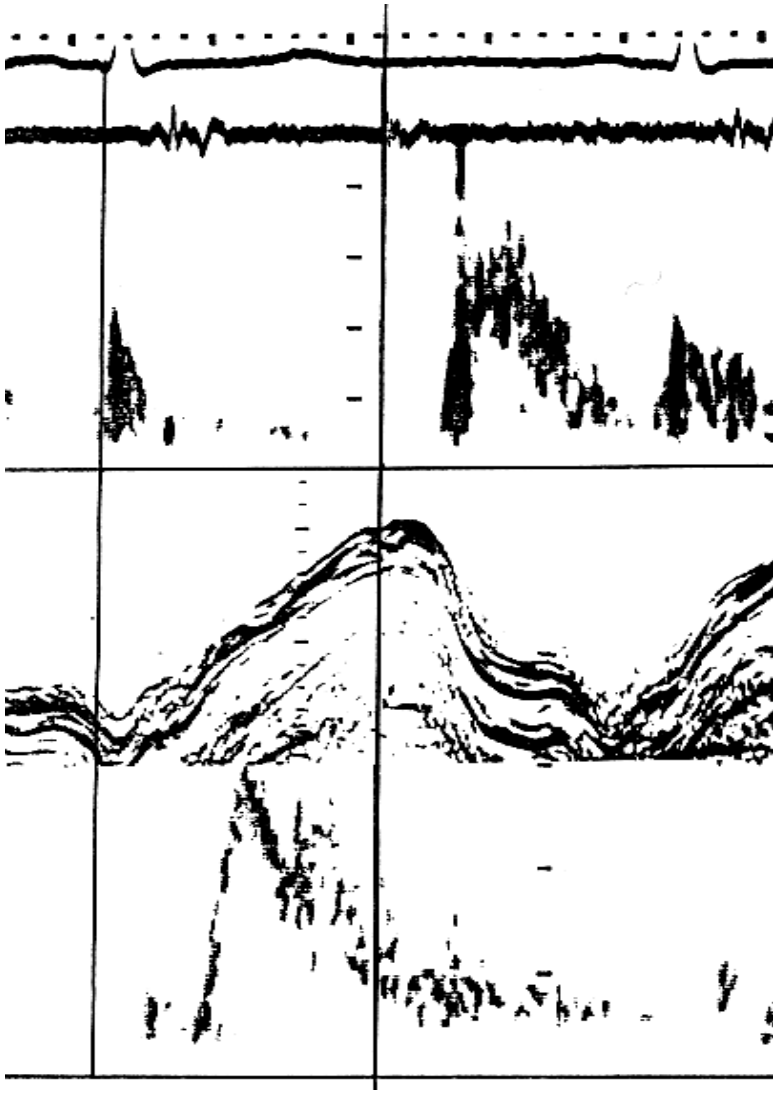


Relation between long axis and LA & LV filling

LV filling

LV long axis

LA filling



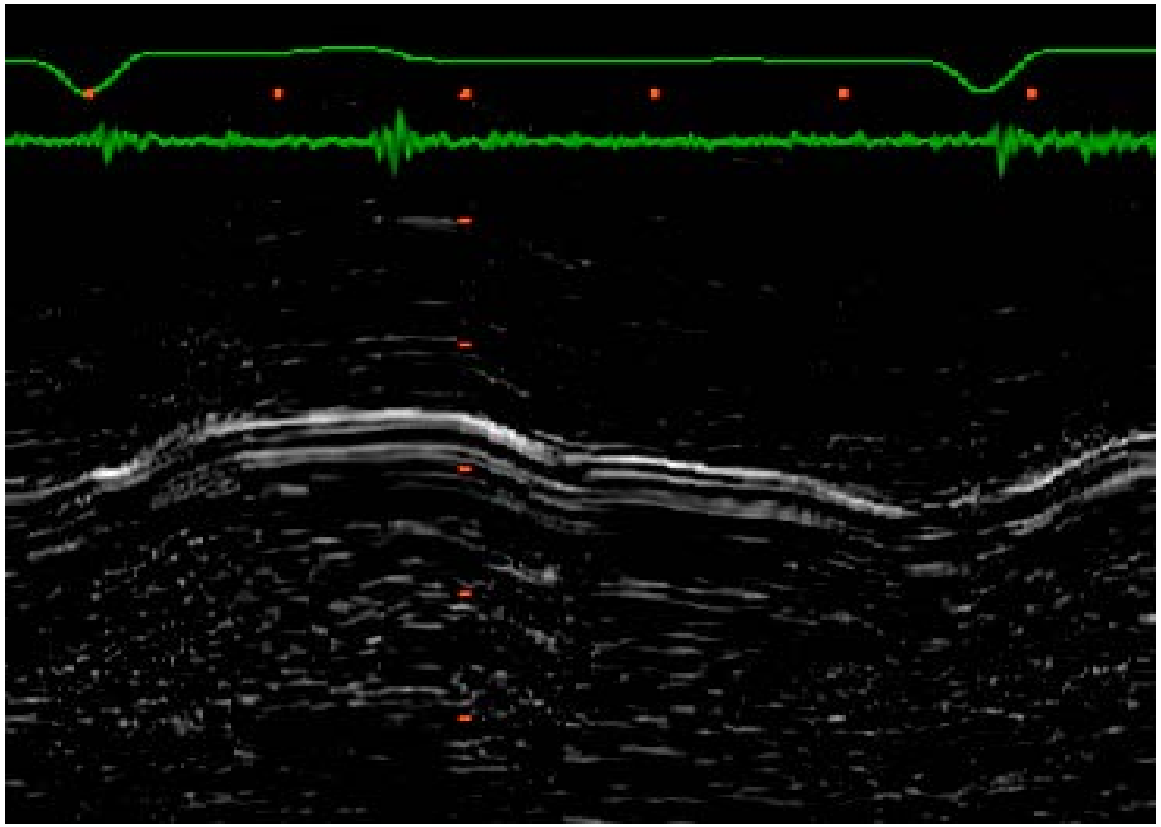
Level of…

Mitral valve

Mitral annulus

Pulmonary vein

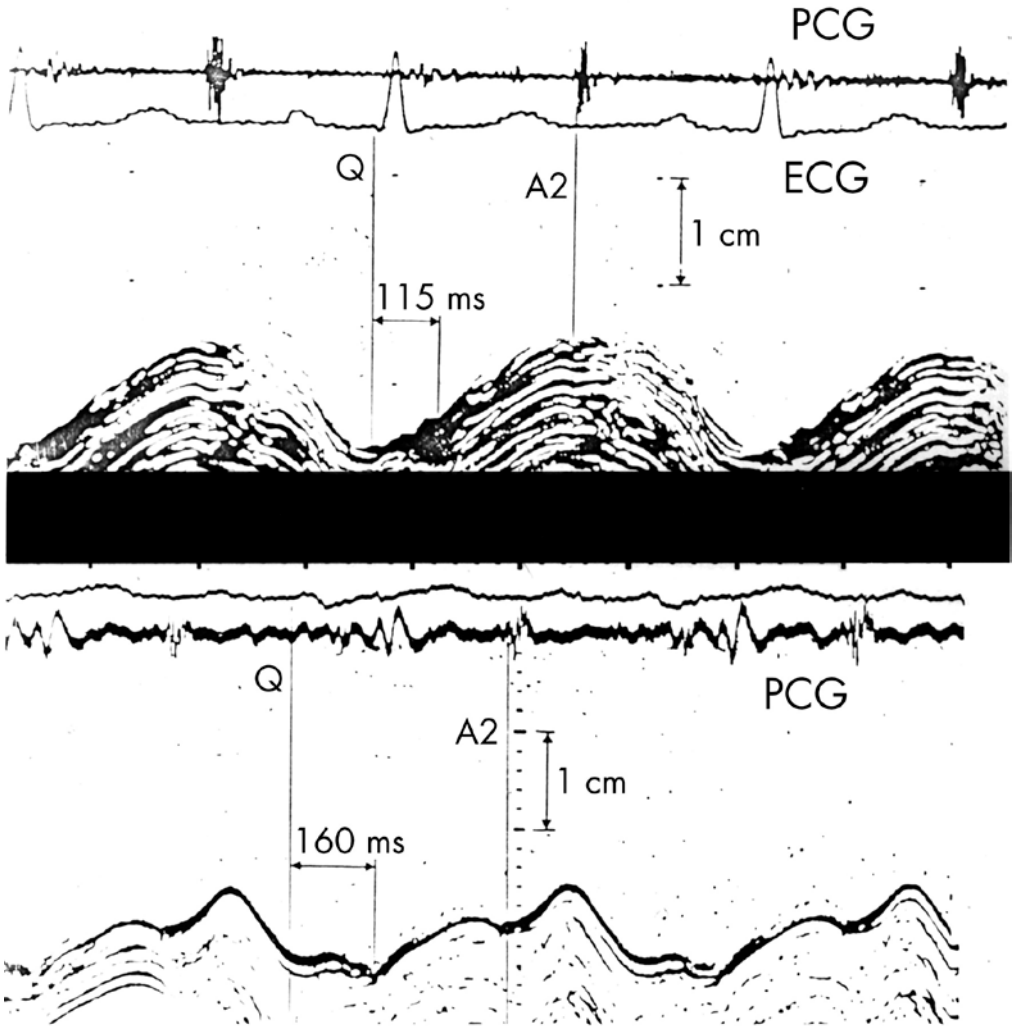
Restrictive LV disease



Intermittent LBBB

Normal activation

LBBB



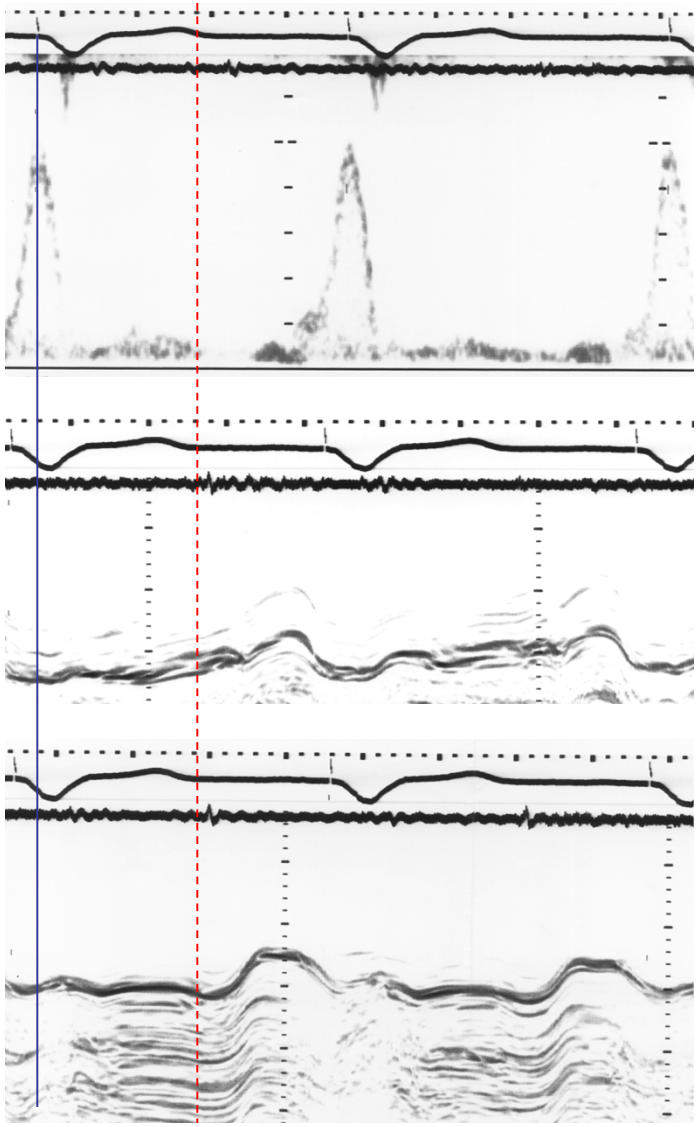
Xiao et al. Br Heart J 1991;66:443–7

Severe LV long axis asynchrony

LV filling

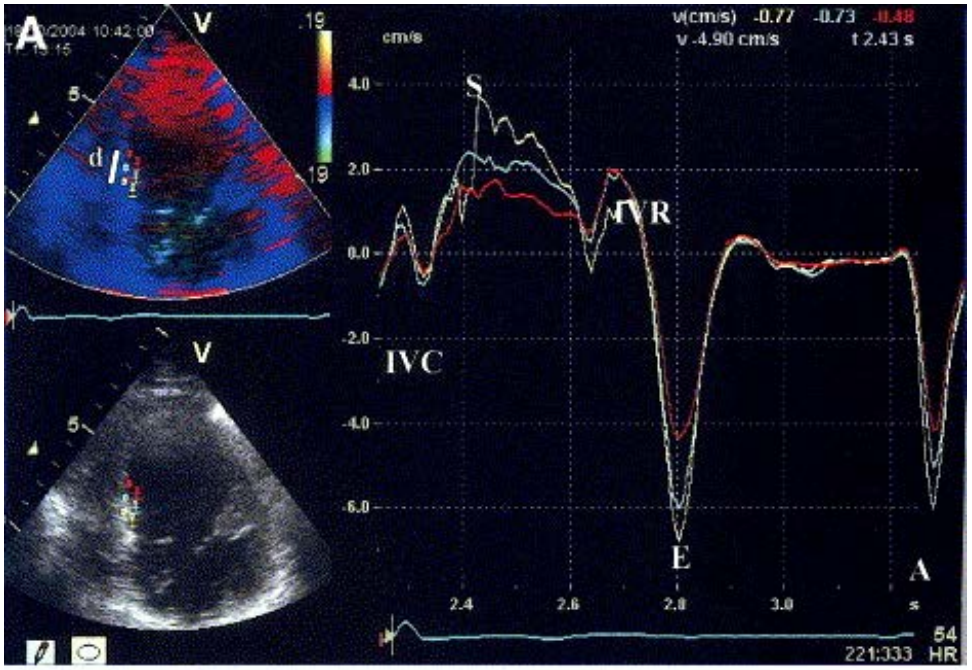
Free wall

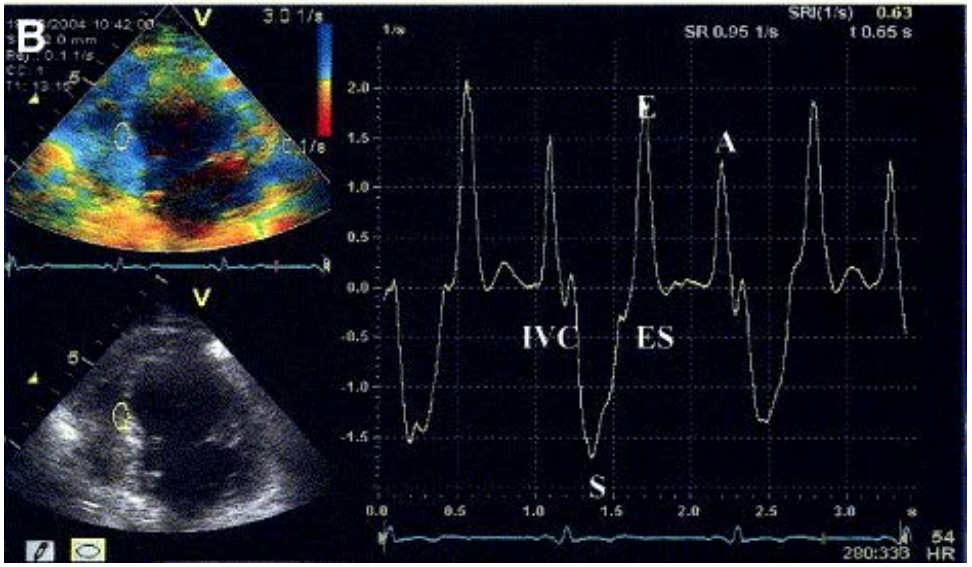
Septum



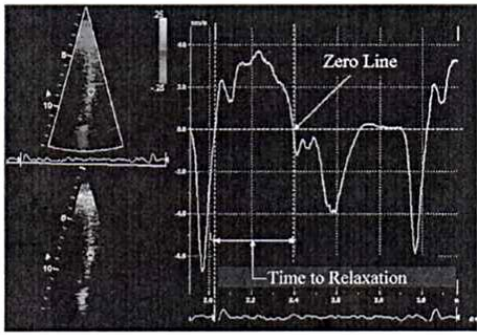
Strain and Strain Rate

- Measures of myocardial deformation
- Uses
  - Assessment of resting LV and RV function
  - Myocardial viability during low-dose dobutamine infusion
  - Stress testing for ischaemia
  - Follow up of treatment response
- Limitations
  - Evidence base is limited
  - Technically challenging
  - Clinical availability
  - Susceptible to artefact

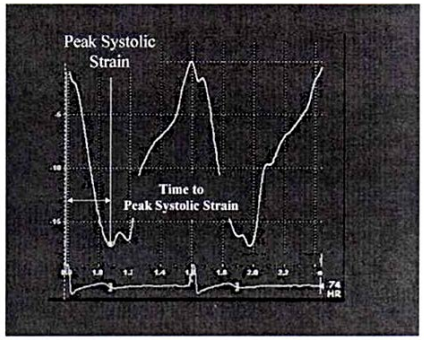

A
V
cm/s
4.0
2.0
0.0
-2.0
-4.0
-6.0
S
IVR
IVC
E
A
2.4
2.6
2.8
3.0
s
v(cm/s) -0.77 -0.73
v -4.90 cm/s
t 2.43 s
54
HR


B
V
SR 0.95 1/s
t 0.65 s
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
E
A
IVC
ES
S
0.0
0.5
1.0
1.5
2.0
2.5
3.0
s
54
HR

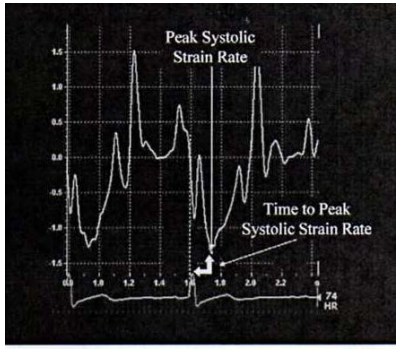
What to Measure?



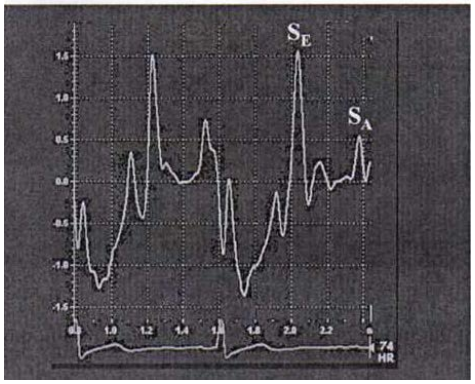
Time to "relaxation"



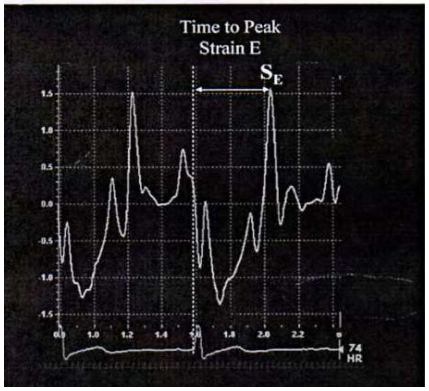
Peak systolic S and
time to peak systolic S



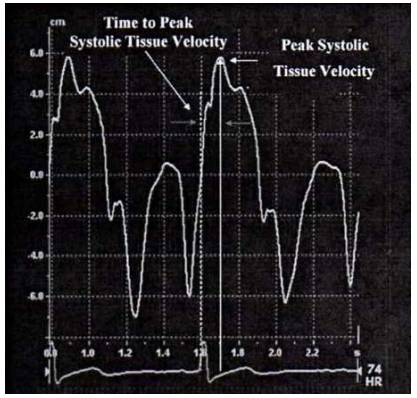
Peak systolic SR and
time to peak systolic SR



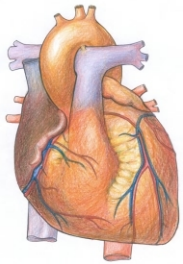
Peak E and A SR



Time to onset
peak E SR

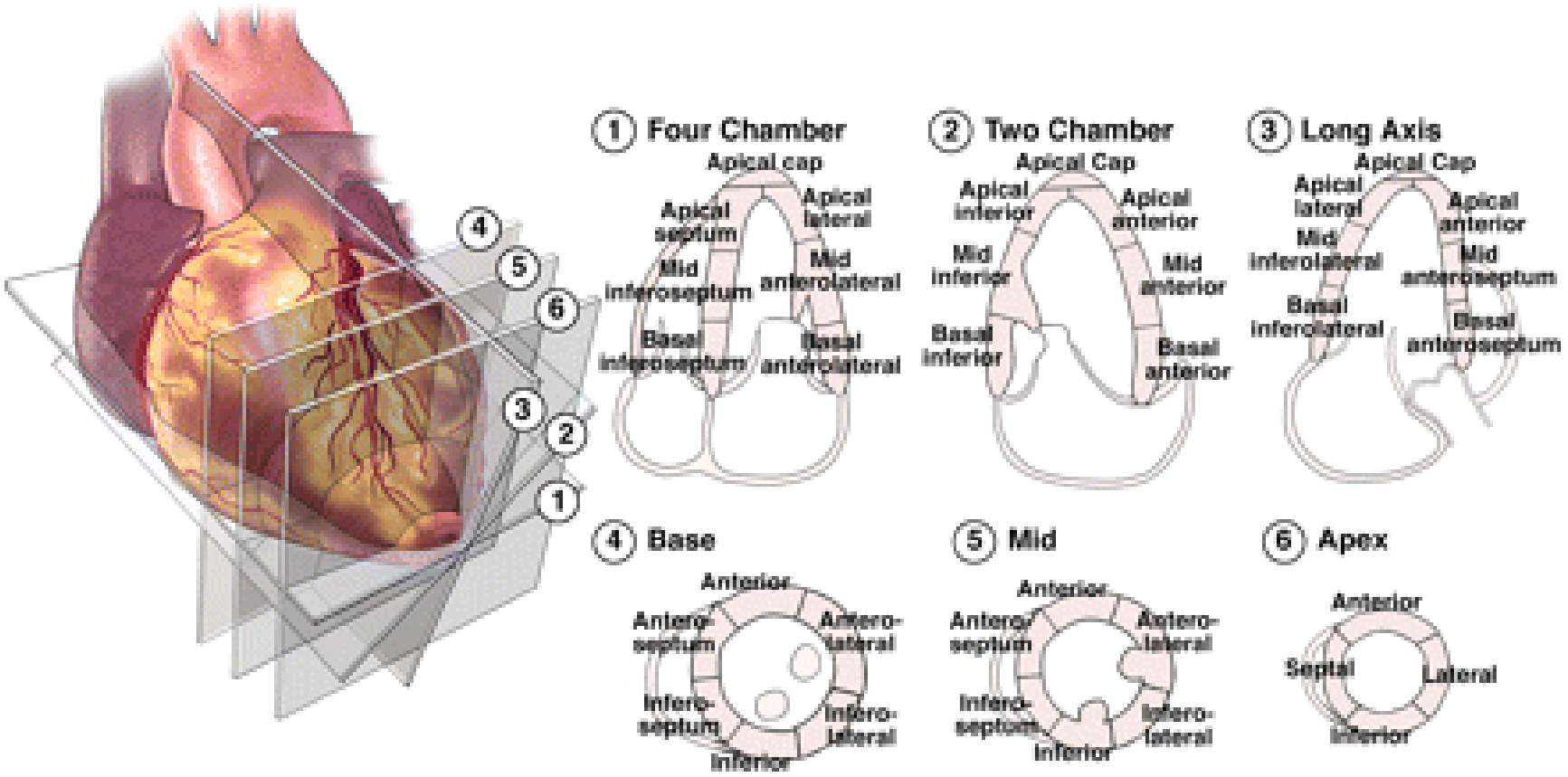


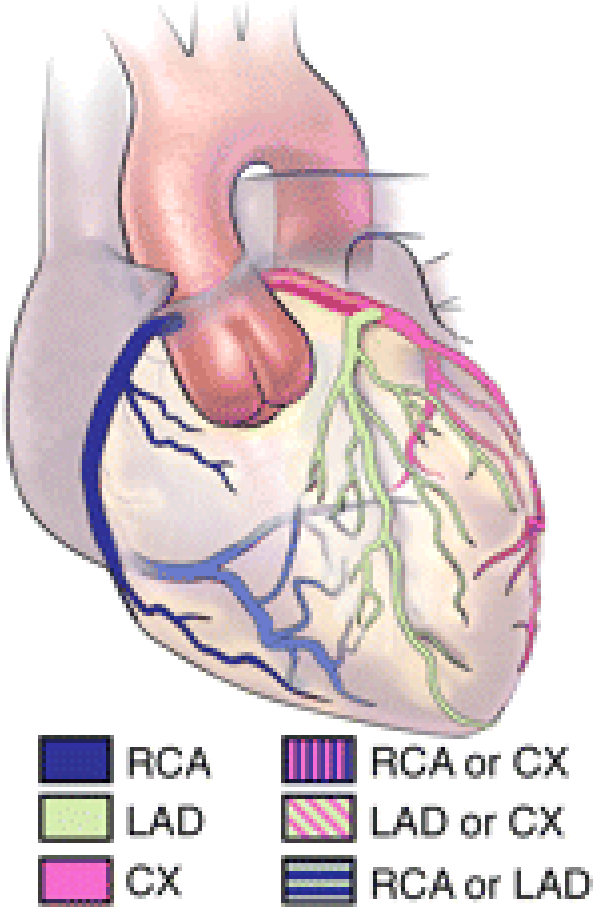
Peak systolic tissue velocity
and time to peak systolic TV

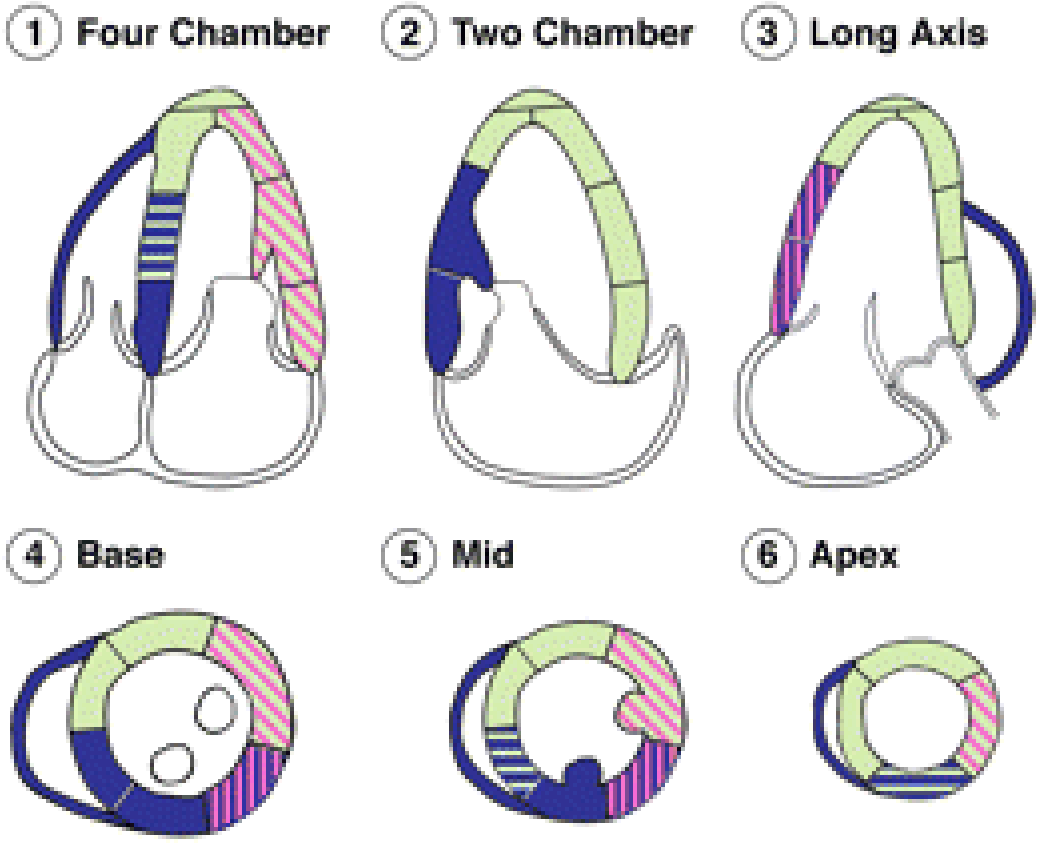


Assessment of regional wall motion abnormalities

17-segment model




RCA
LAD
CX
RCA or CX
LAD or CX
RCA or LAD


1 Four Chamber
2 Two Chamber
3 Long Axis
4 Base
5 Mid
6 Apex

Wall motion score analysis

ASE criteria

Schiller et al. J Am Soc Echocardiogr 1989;2:358-367

Wall motion score

1 normal (↑ systolic thickness >50%)

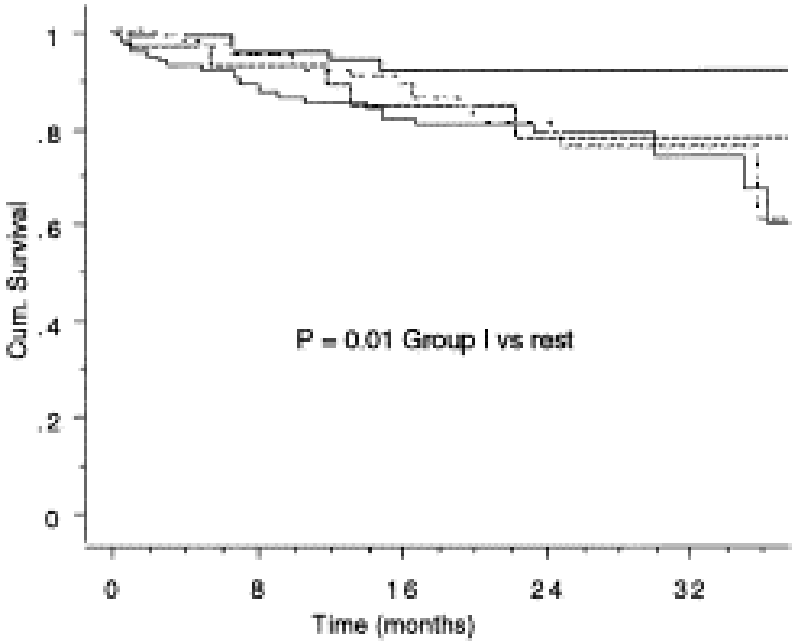
2 hypokinesis (↑ systolic thickness <40%)

3 akinesis (↑ systolic thickness <10%)

4 dyskinesis (outward systolic motion + wall thinning)

5 aneurysmal (outward systolic systole, wall thinning, diastolic deformation)

Viability During DSE Predicts Survival



Group I	85	57	43	24	9
Group II	119	92	70	32	11
Group III	30	23	18	8	4
Group IV	84	78	67	33	10

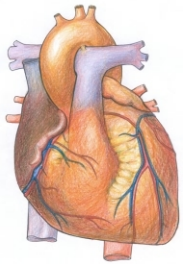
Group I — viability + revascularisation

Group II — viability and no revascularisation

Group III — no viability + revascularisation

Group IV — no viability, no revascularisation

Afridi et al. JACC 1998;32:921-6

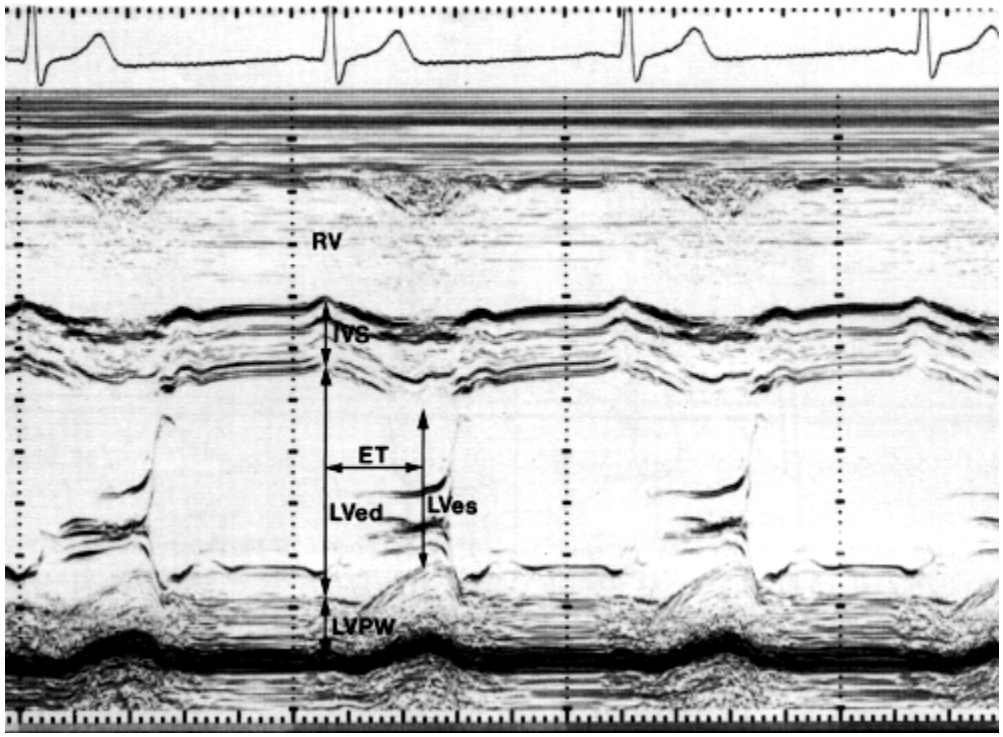


M-mode assessment of LV function

M-mode assessment of LV function

- Amplitude
- Velocities (shortening and lengthening)
- Timing
- Incoordination

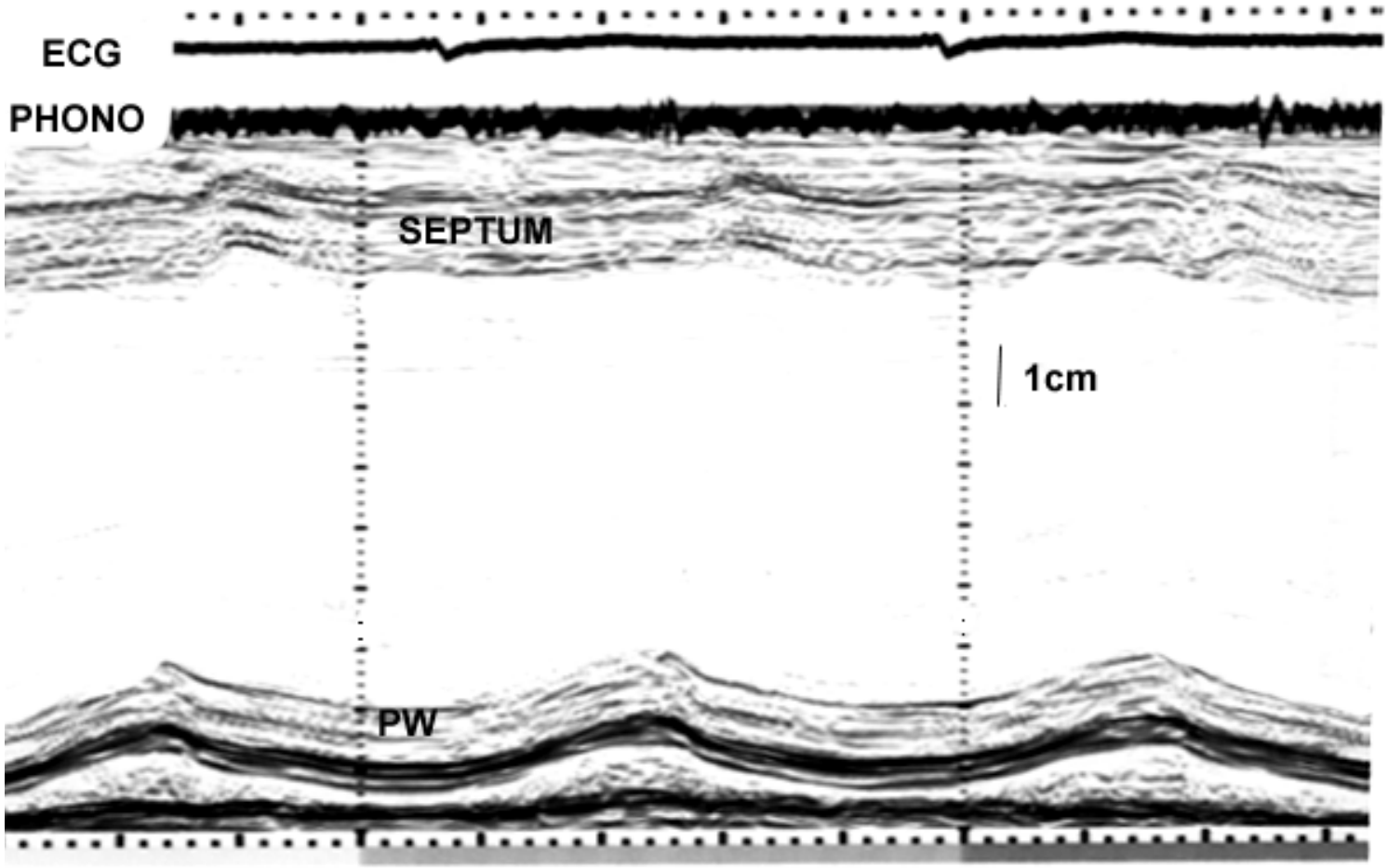
Minor axis



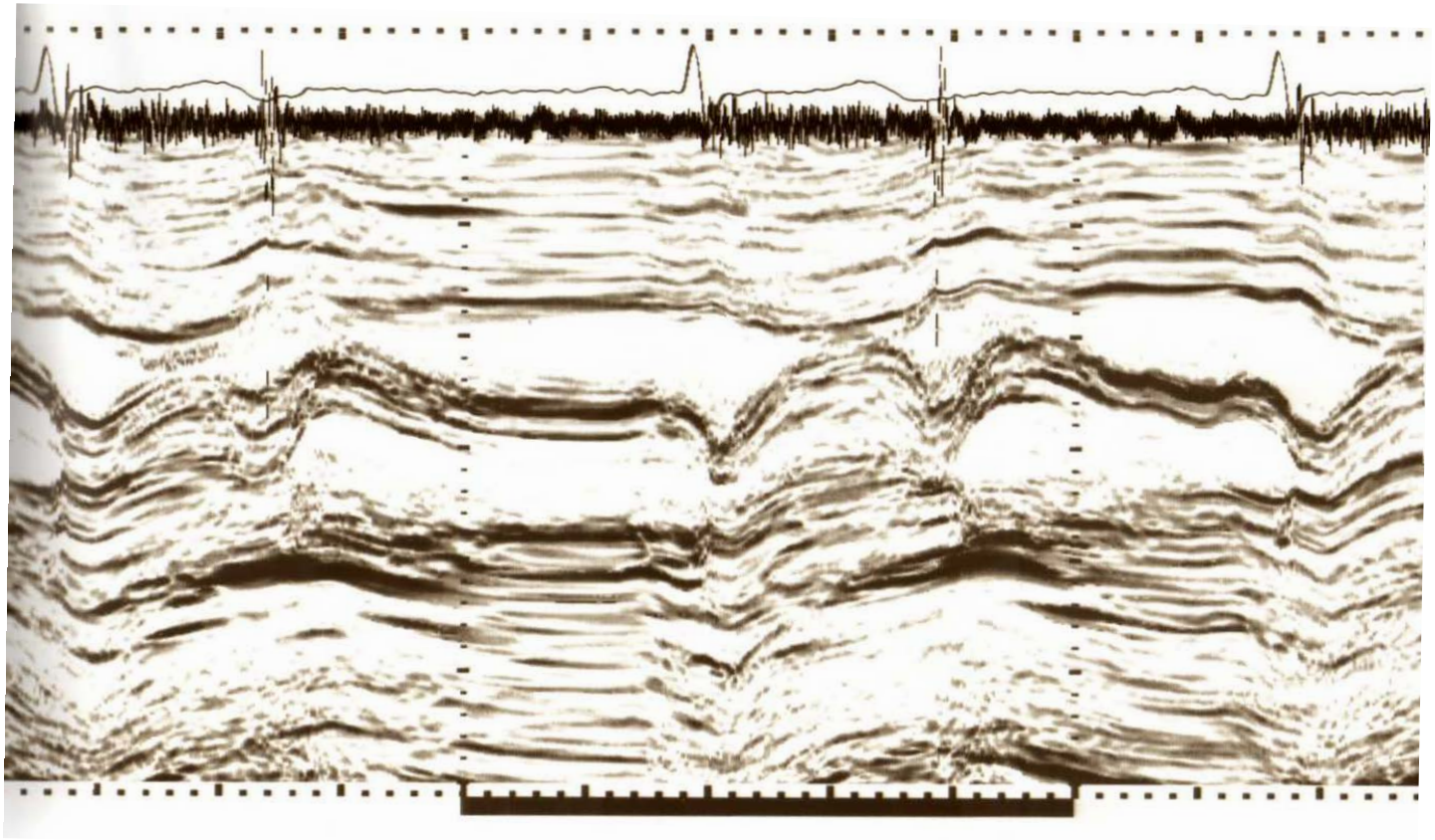
Normal values for cardiac chambers

M-mode parameter	Range
LV EDD (cm)	4.0 - 5.6 cm
LV ESD (cm)	2.0 - 4.0 cm
IVS diastole (cm)	0.7 – 1.2 cm
PW diastole (cm)	0.7 – 1.2 cm

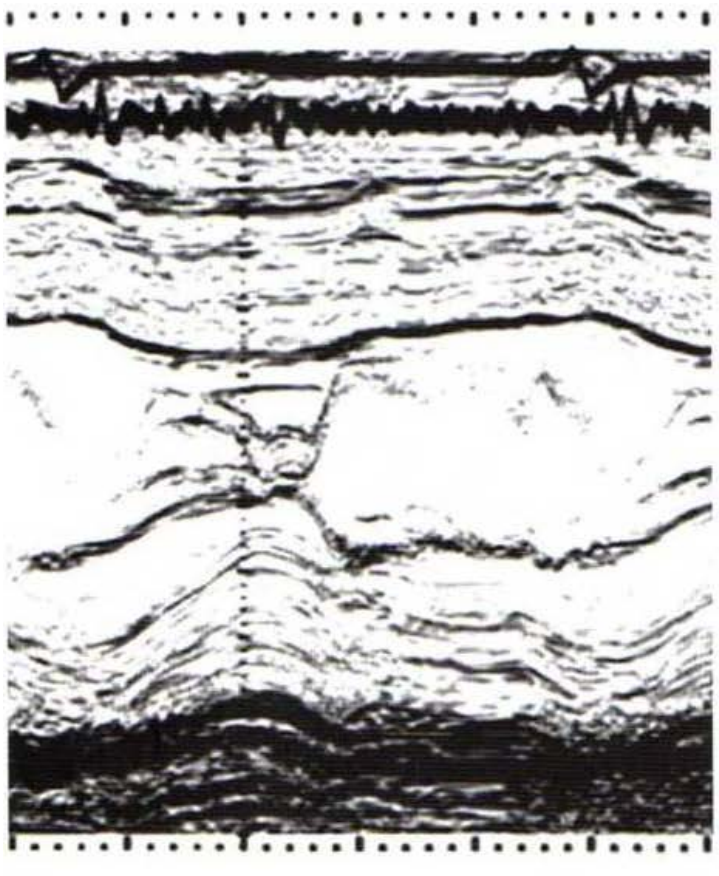
DCM



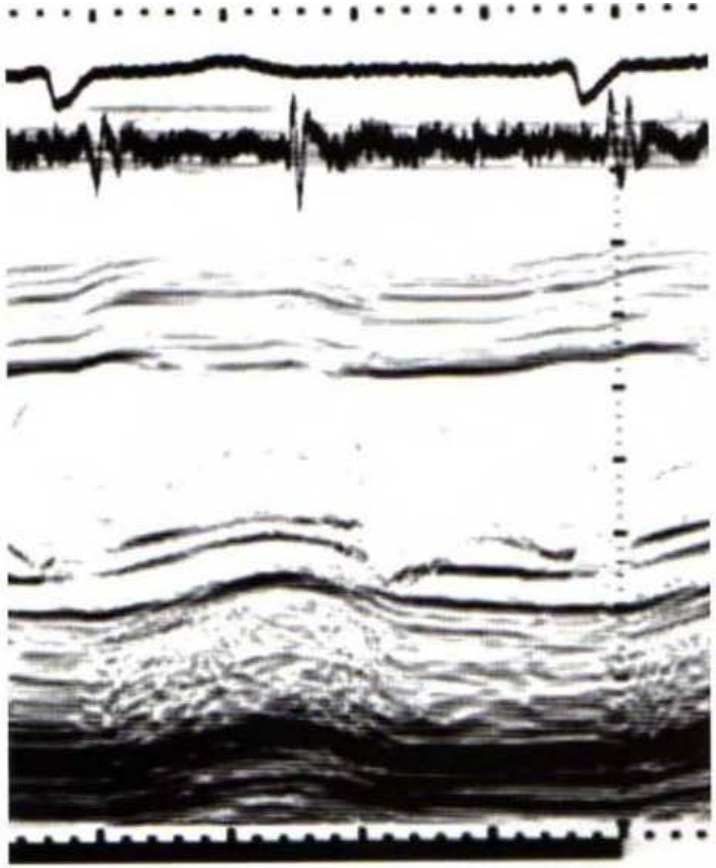
SAM



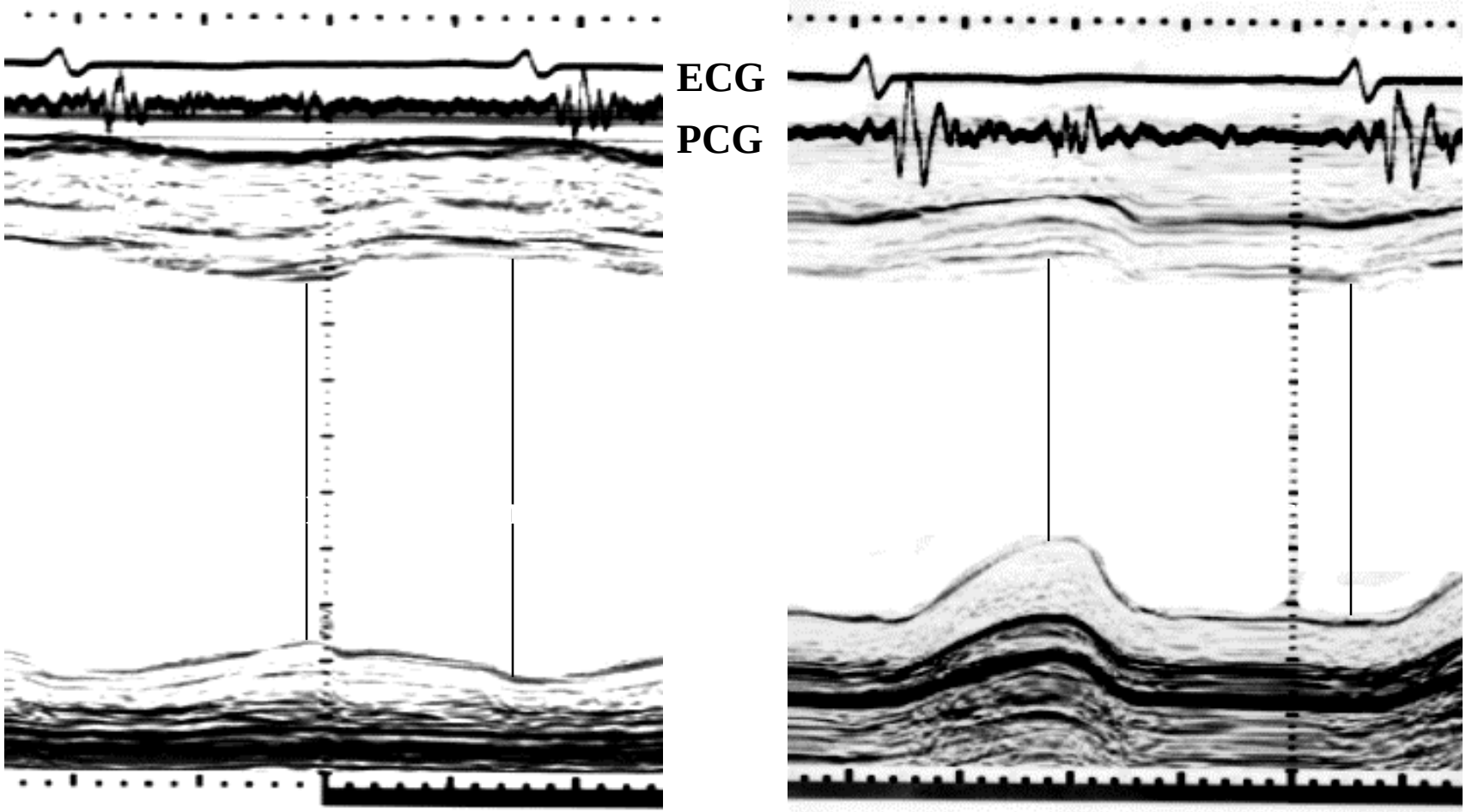
HCM



Amyloid



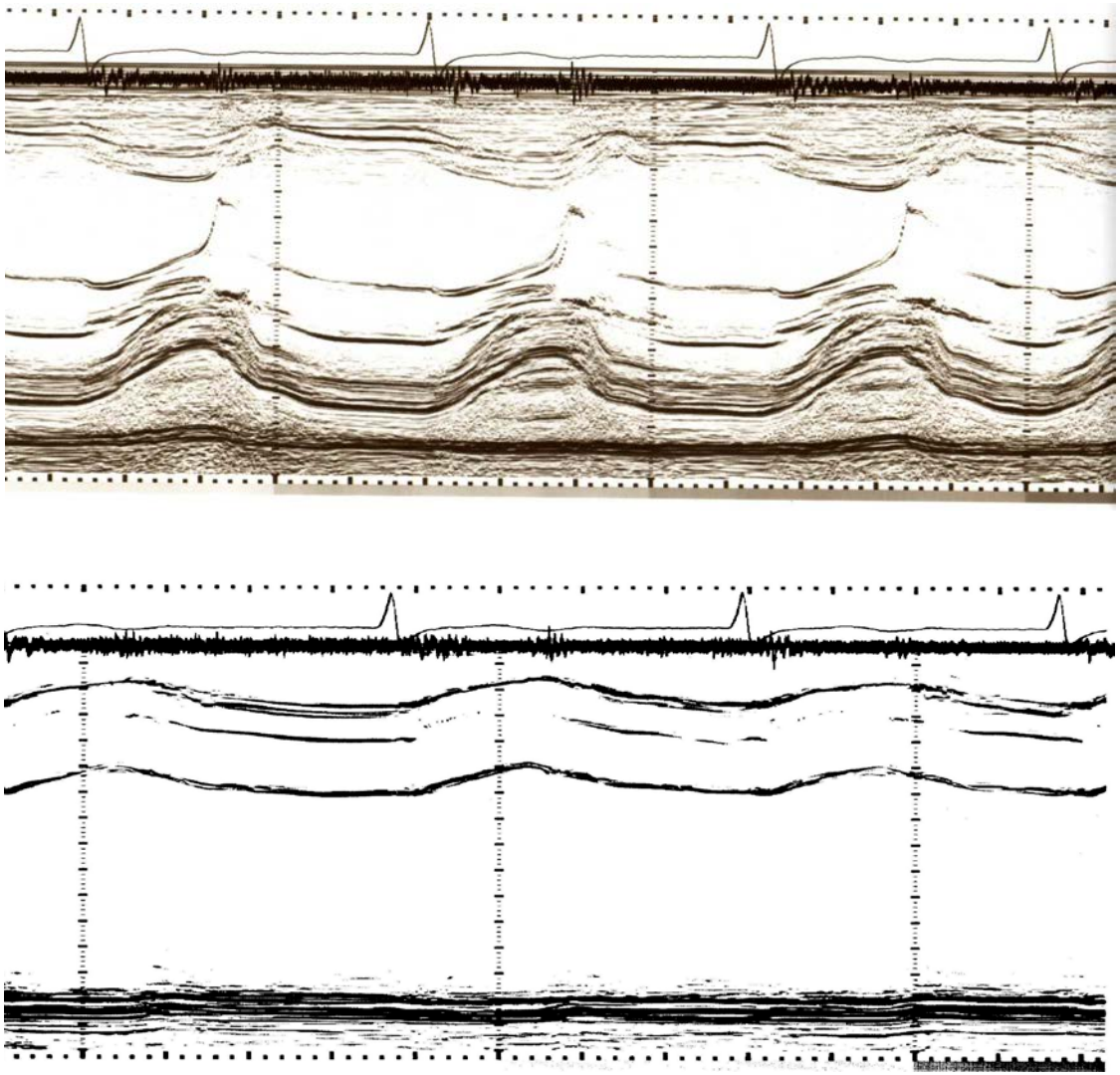
CABG for ischaemic DCM



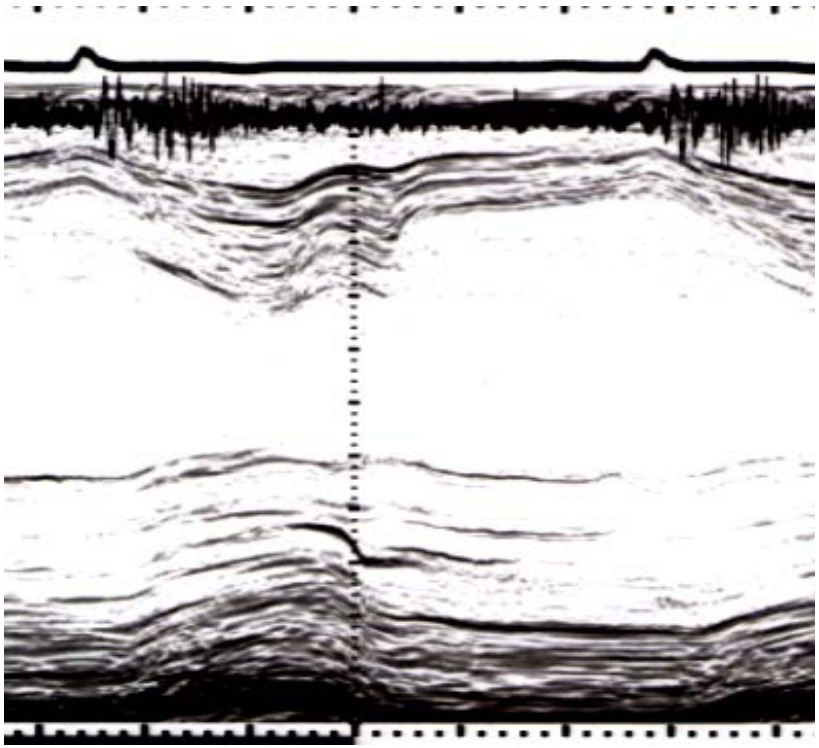
Pre-op

Post-op

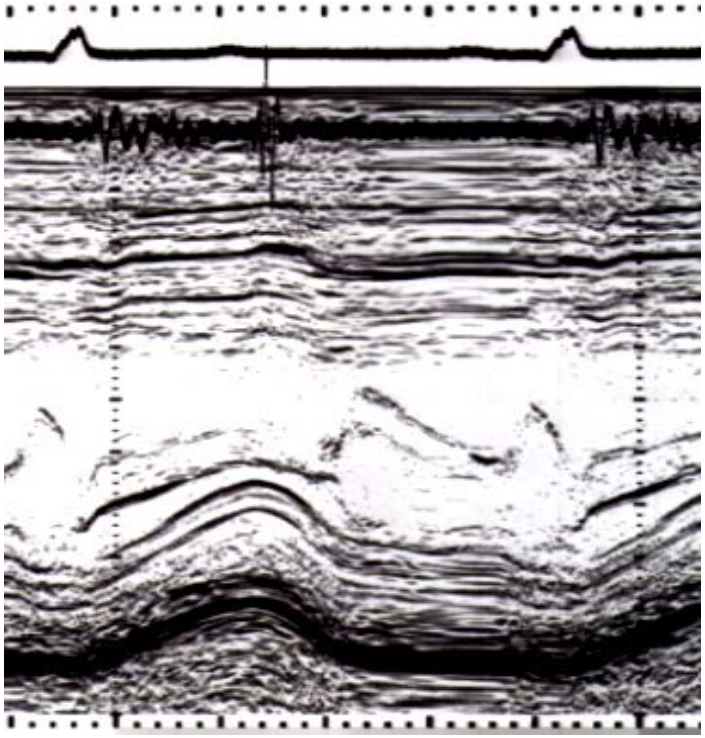
Severe MR



MV repair for MR

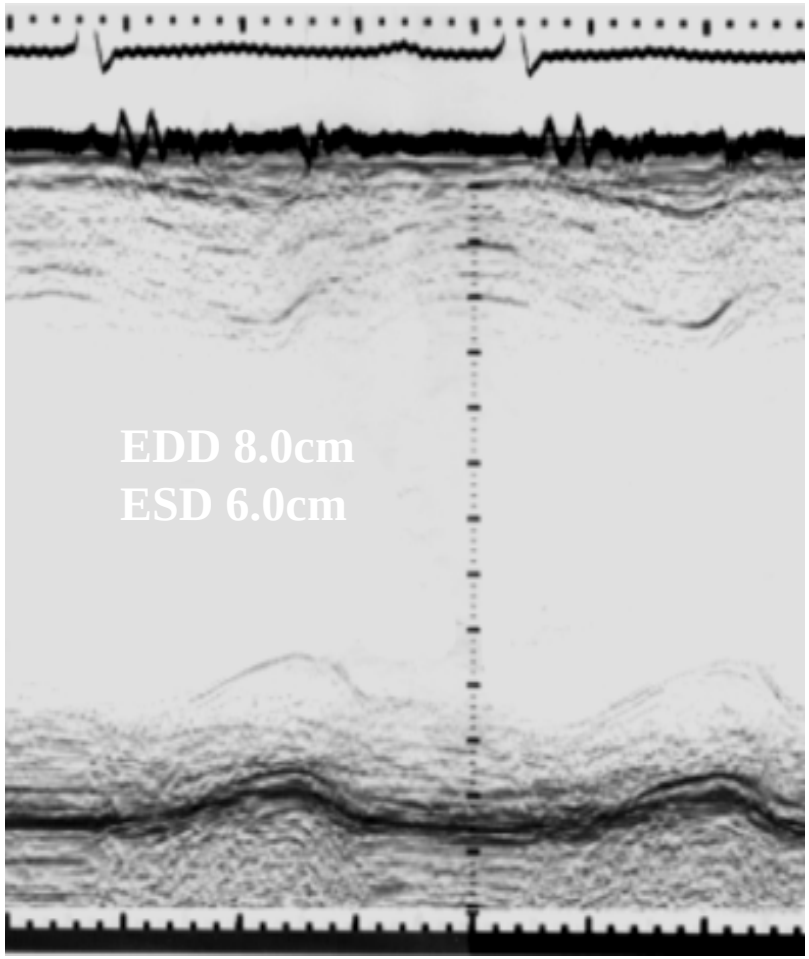


Pre-op

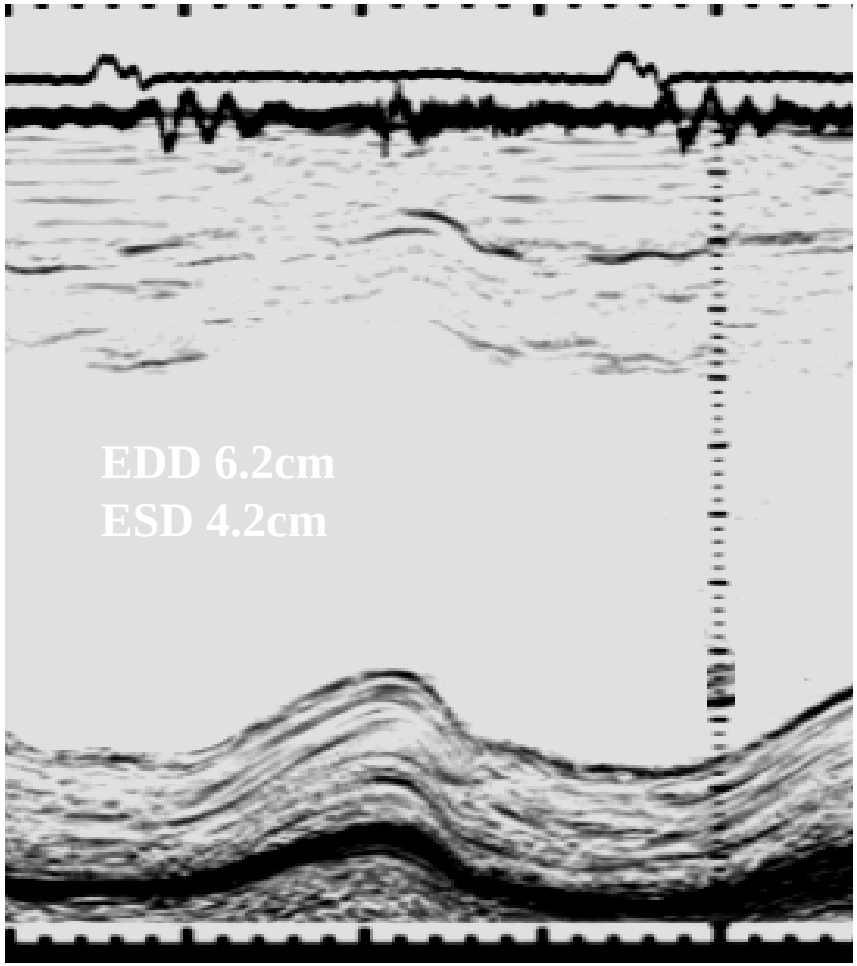


Post-op

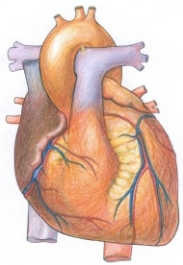
AVR for AR



Pre-op

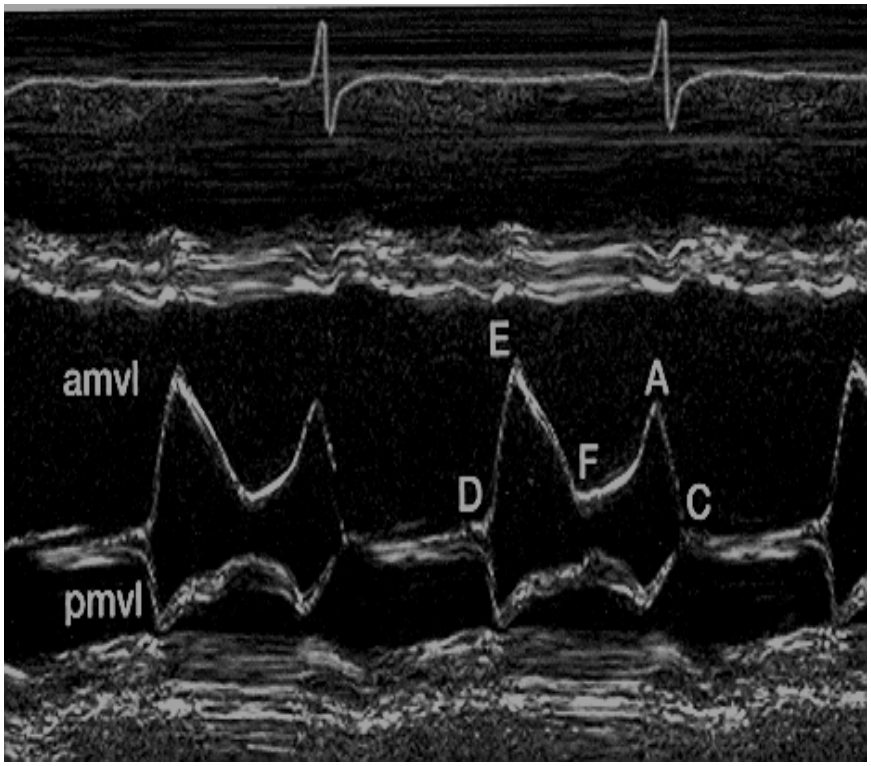


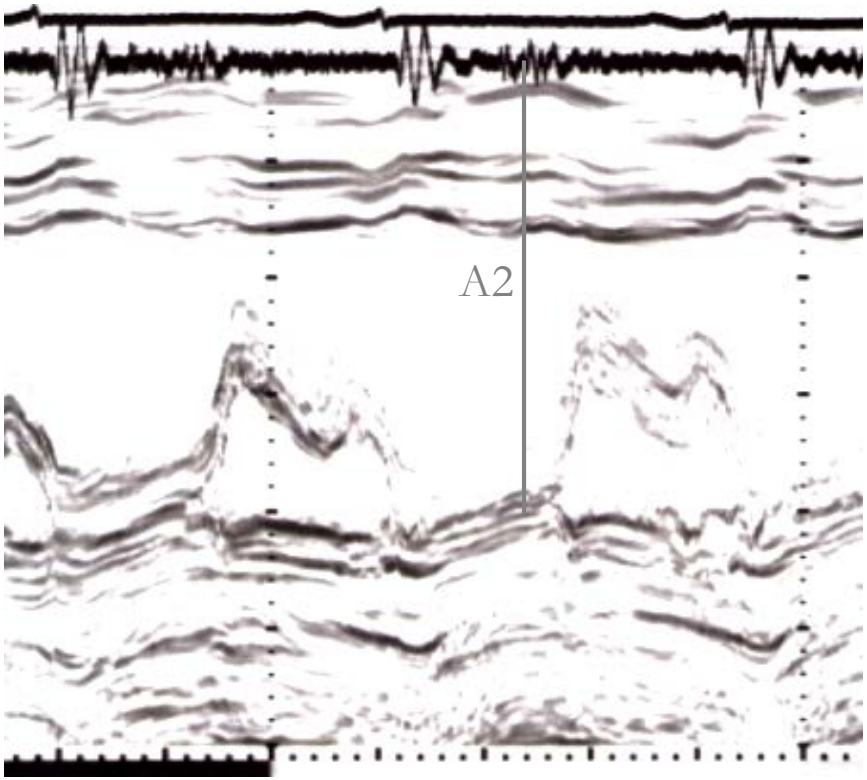
Post-op



M-mode mitral echogram for assessing LV function

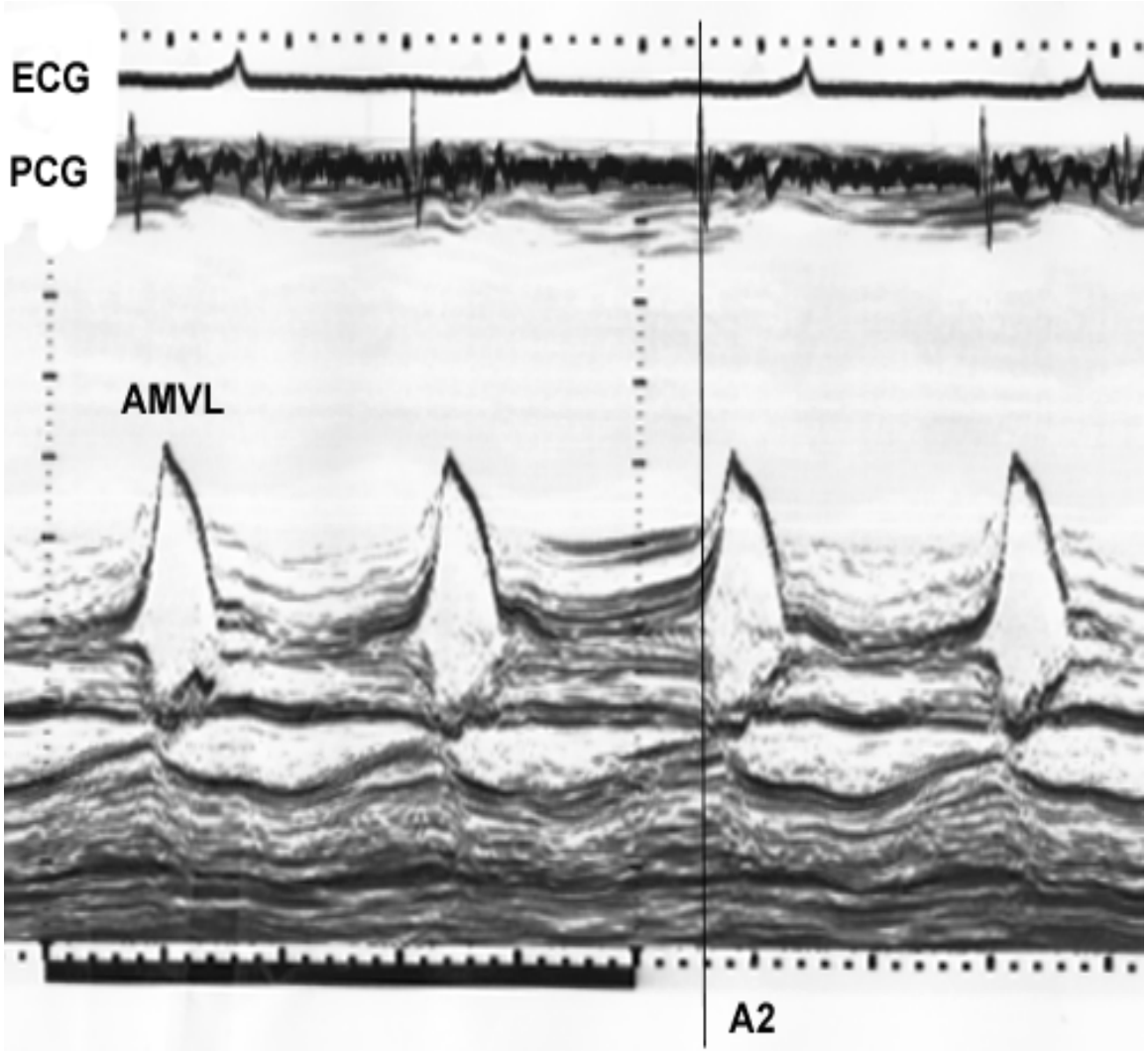
Normal MV echogram



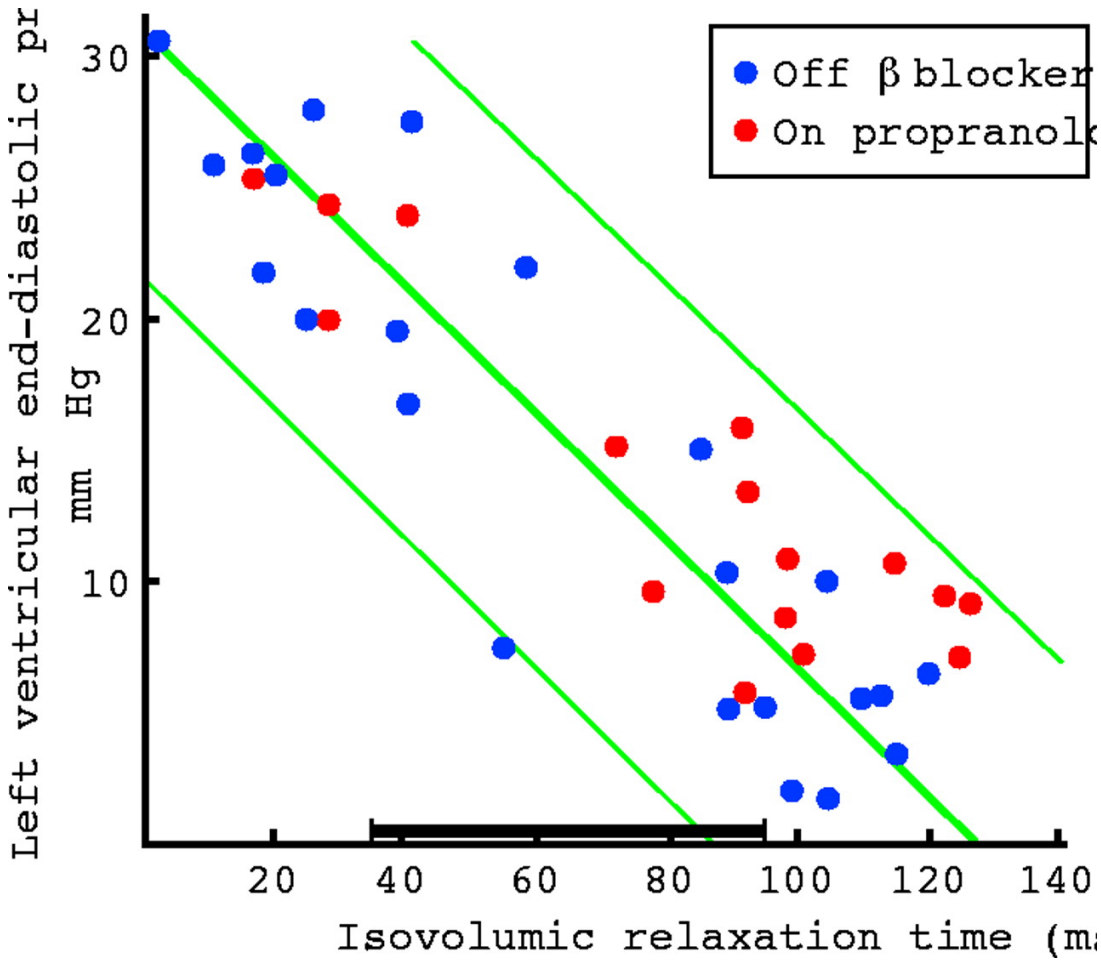


A2: aortic valve closing
MVO: mitral valve opening
IVRT: isovolumic relaxation time (from A2 → MVO)

Restrictive filling

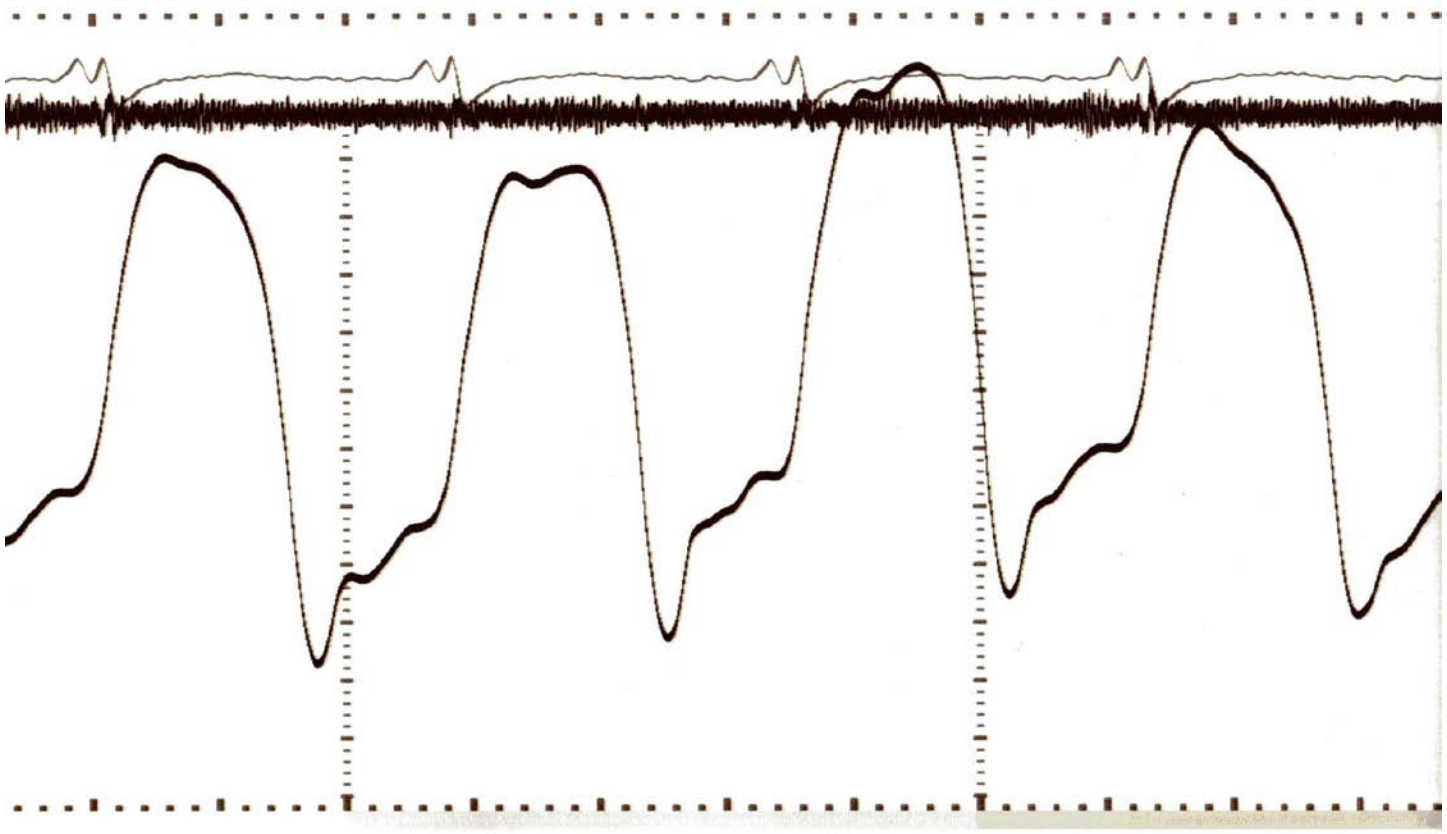


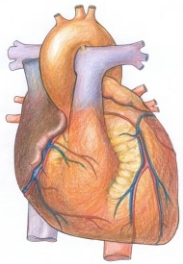
Relation between IVRT and LVEDP



Gibson ***et al. Heart 2003;89:231-238***

Apexcardiogram

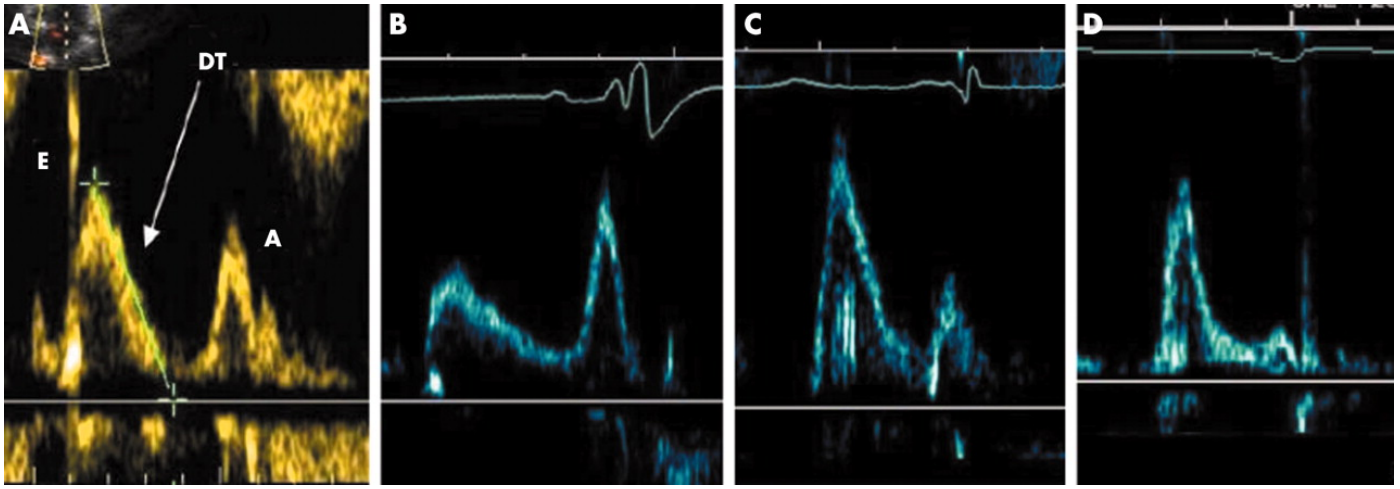




Assessing LV function: diastolic filling

Examples of different LV filling patterns

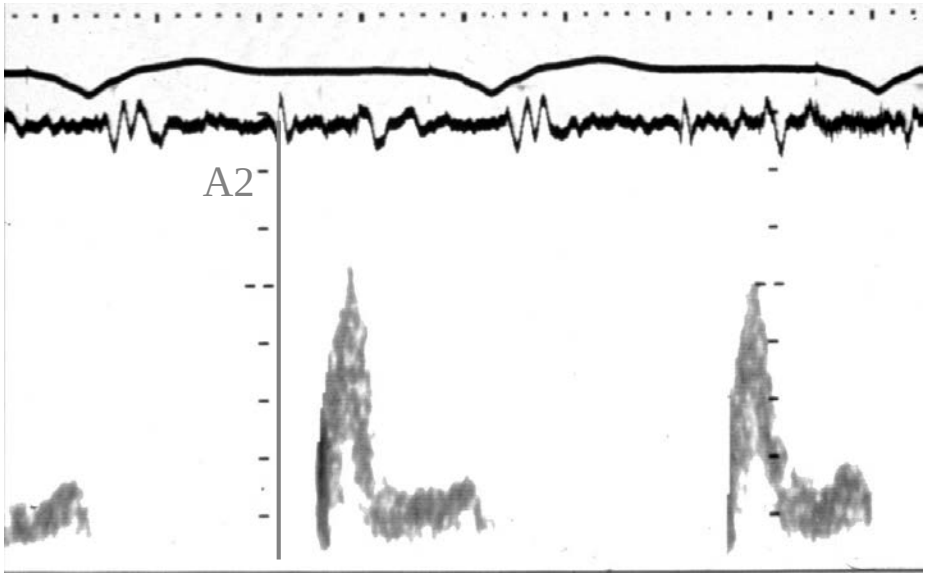
Normal	Dominant A	Pseudonormal	Restrictive



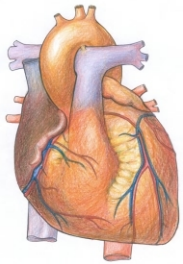
E:A >1 EDT 150-220ms IVRT <90ms	E:A <1 EDT >250ms IVRT >90ms	E:A1.0-1.5 EDT 150-220ms IVRT <90ms	E:A >2 EDT <150 IVRT <70ms

Worsening diastolic function

Restrictive filling pattern



- dominant E wave
- deceleration time <120 ms
- short (<70ms) or even zero isovolumic relaxation time
- reduced or absent A wave
- S3 is present, whose onset coincides with peak of the E wave
- acceleration and deceleration of the E wave are both increased



Assessing LV ventricular function: BSE guidelines

Descriptive terms and statements

Assessing LV function….	
1. Cavity size	Normal, dilated, small
2. Wall thickness	Normal, concentric LVH, asymmetric LVH
3. Ventricular mass	Normal, borderline, increased
4. Ventricular shape	Normal, aneurysmal, pseudoaneursymal
5. Global systolic function	Normal, low normal, decreased (mild, moderate, severe)

Descriptive terms and statements

Assessing LV function….	
6. Regional systolic function	Normal, hyokinetic, akinetic, dyskinetic, scar, asynchronous
7. Diastolic filling	Normal, abnormal (impaired relaxation, pseudonormal, restrictive), elevated LA / end-diastolic pressure
8. LVOT	No obstruction, septal hypertrophy, sub-aortic membrane, SAM
9. Thrombus	Present / absent
10. Mass (tumour)	Present / absent

Diagnostic statements

Appearances suggestive of….

- Myocardial infarction
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Restrictive cardiomyopathy
- Hypertensive heart disease
- Infiltrative heart disease
- LV volume overload
- Other

Measurements and calculations

	Measure	*Calculate*
1. LV cavity size and systolic function	LVEDD, LVESD, LVEDV, LVESV	FS, EF
2. LV wall thickness	IVSd, IVSs, PWd, PWs	
3. LVOT	LVOT diameter	LVOT area
4. LVOT outflow	Vmax, VTI	SV
5. LV filling	IVRT, EDT, E, A	E:A ratio

Conclusion

- In the assessment of LV function….
- LV systolic *and* diastolic function are important
- Forget not that the LV has both a minor axis and a long axis!