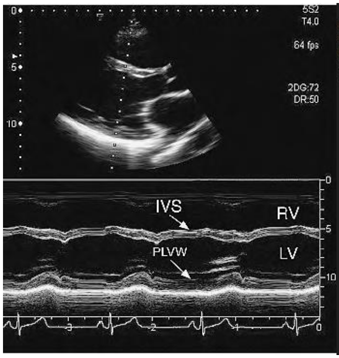
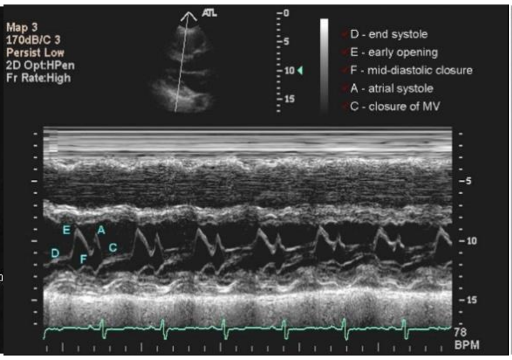
M-Mode

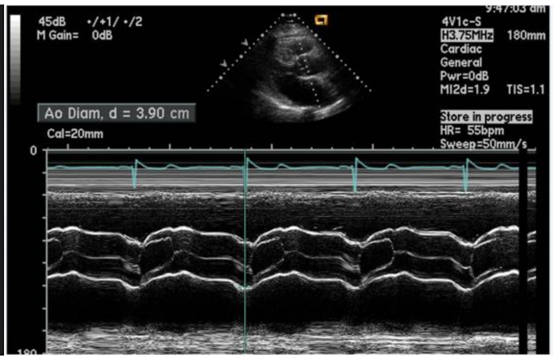
M-mode (or **m**otion-mode) imaging records motion along a single 'line of sight', selected by careful positioning of the on-screen cursor across a region of interest. Once the cursor is in place, activation of M-mode imaging produces a scrolling display of movement, as it occurs along the cursor line, plotted against time. The very narrow field of view of M-mode imaging – essentially a single scan line– means that a very high pulse repetition frequency can be used, giving a high sampling rate and high temporal resolution.

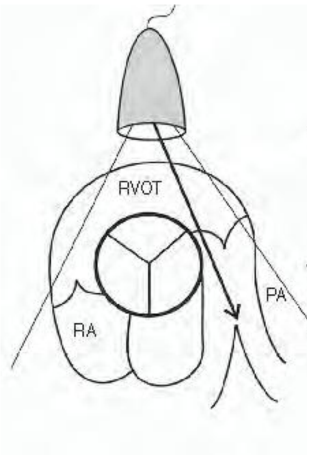
M-mode measurements are still performed, particularly the measurements of chamber dimension, LV wall thickness, and LV fractional shortening (normal 25-45%). Much of this has now been supplanted by two-dimensional echocardiography because M-mode may be inaccurate in evaluating chamber sizes and function if the beam is **oblique**, which will overestimate cavity size and underestimate function. Moreover, M-mode echocardiogram have the disadvantage of determining ventricular function only along a single interrogation line. They are, therefore, not indicative of the overall function in heart disease in which there is substantial **regional** variation in function (e.g. IHD)

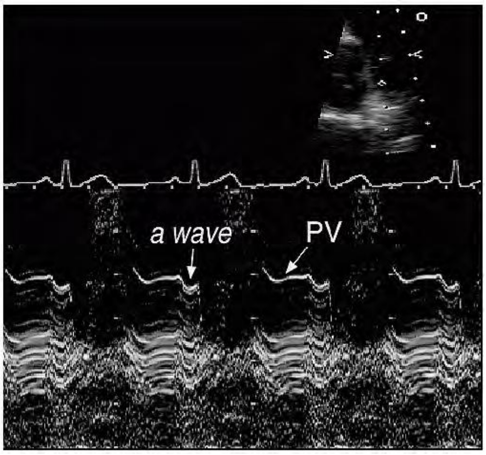
Normal M-mode echocardiography:

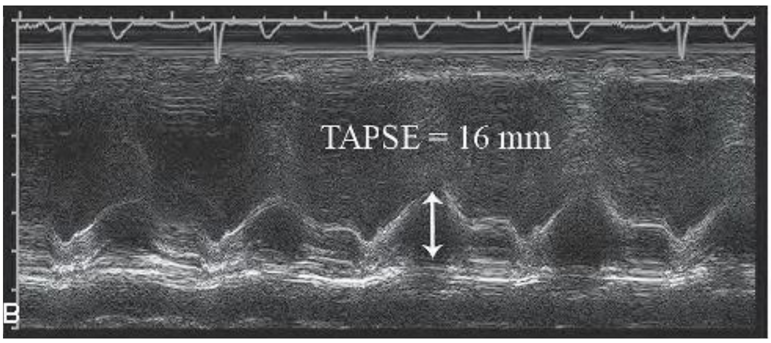


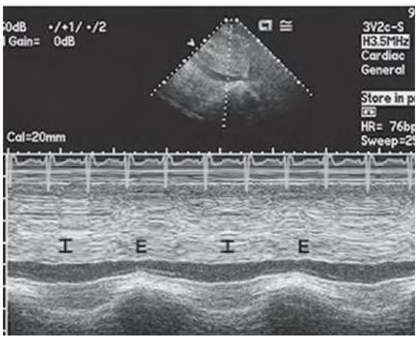




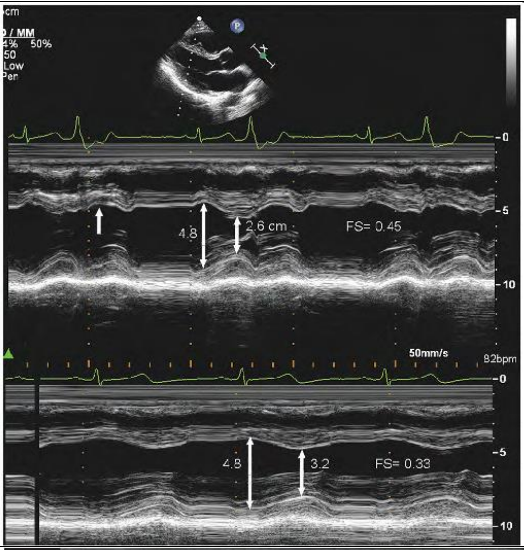


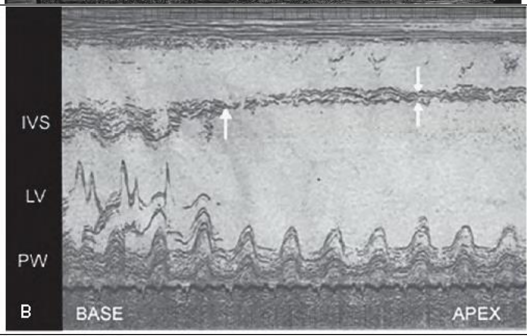




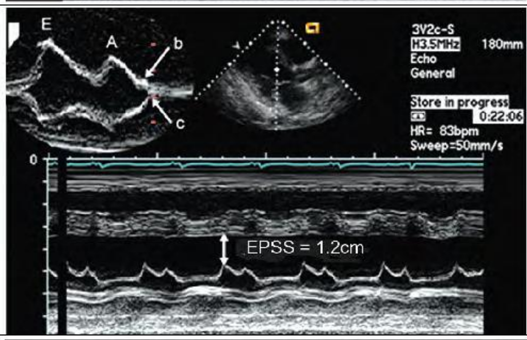


M-MODE IN QUANTIFYING CHAMBER SIZES AND FUNCTION *(dimensions, FS, EPSS, B-bump, rounded AV)*:

<table>
<tr><td>Ventricular bigeminy. The left panel was recorded during bigeminy and reveals an abnormal contraction pattern of the ventricular septum (arrow) coincident with the PVC. The internal dimension in diastole and systole for the post-PVC beat is noted from which a fractional shortening of 0.45 is calculated. The lower panel was recorded in the same patient during an arrhythmia free period. Note the normal contractile pattern of the septum and posterior wall and the consistent fractional shortening of 0.33. The increased fractional shortening in the post-PVC beat is related to hyperkinetic motion following a post-PVC pause.</td><td>


</td></tr>
<tr><td>Patient with an anteroseptal myocardial infarction and extensive areas of scar. At the base, the anterior septum has normal contraction but at the level of the mitral valve (upward-pointing arrow), there is an abrupt loss of wall thickness and endocardial motion (rightward arrows) of the anterior septum.</td><td>


</td></tr>
<tr><td>Decreased EF→ Increased MV E-point septal separation (EPSS) (normal 6mm) due to increased LVEDD &/or decreased the magnitude of opening of the mitral valve (due to decreased SV). EPSS is also increased with AR due to limited MV opening.

↑LVDP→ Interrupted (delayed) closure of MV with a B bump (top), indicating transient reopening of the MV due to atrial contraction against noncompliant LV</td><td>


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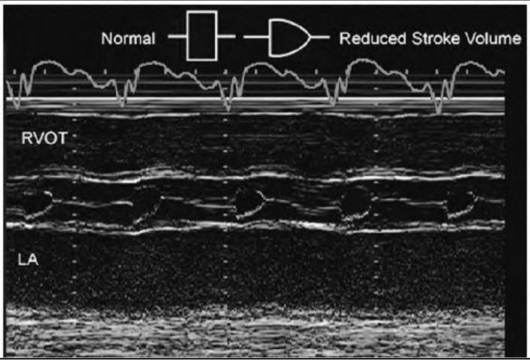
<tr><td>↓SV→ Gradual curved (rounded) closure of the AV at end-systole due to decreasing forward flow at the end of systole</td><td>


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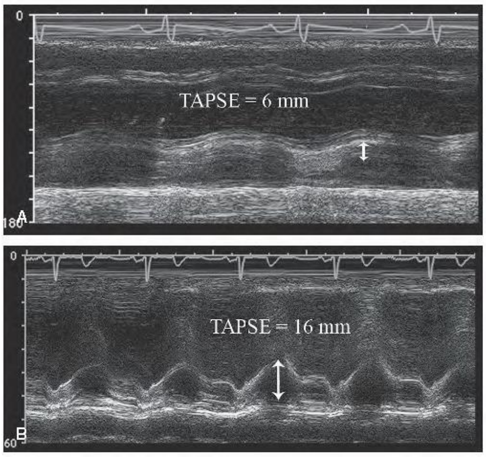
M-MODE IN EVALUATION OF RV FUNCTION (TAPSE)

Illustration of the tricuspid annular plane systolic excursion (TAPSE).

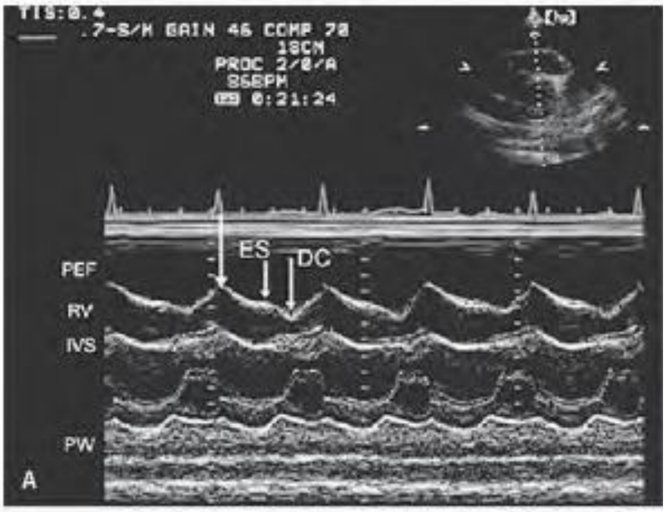
A: Recorded in a patient with long-standing, severe pulmonary hypertension and right ventricular systolic dysfunction. Note the reduced TAPSE of 6 mm.

B: Recorded in a normal, disease-free individual in which TAPSE is measured as 16 mm.

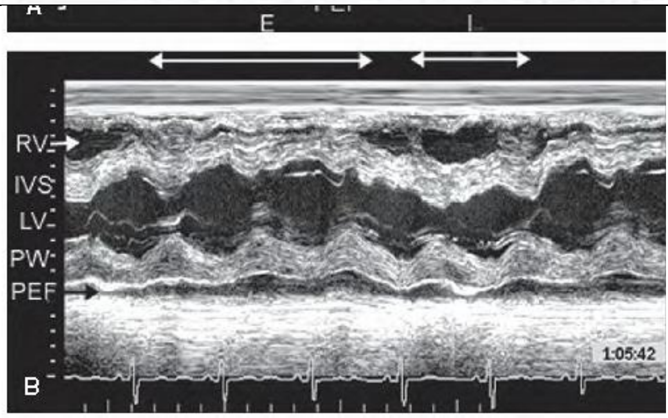


FEATURES OF M-MODE IN PERICARDIAL TAMPONADE *(diastolic collapse & respiratory variation)*

Tamponade**:** early diastolic collapse of the right ventricular free wall. The unlabelled *arrow* denotes the beginning of systole. The position of the right ventricular free wall at end-systole is also noted. Immediately after end-systole, the right ventricular free wall moves posteriorly, indicative of diastolic collapse. DC, diastolic collapse; ES, end-systole, PE, pericardial effusion.



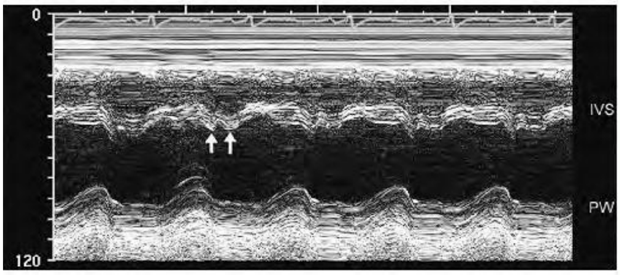
Tamponade: respiratory variation in right ventricular size and septal position.



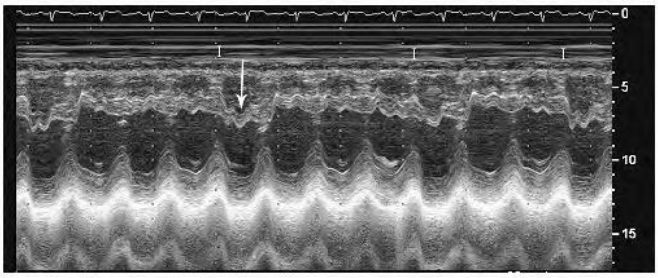
FEATURES OF M-MODE IN CONSTRICTIVE PERICARDITIS *(flat diastolic motion of PW, multiphasic diastolic motion of IVS & respiratory variation)*

Constrictive pericarditis:

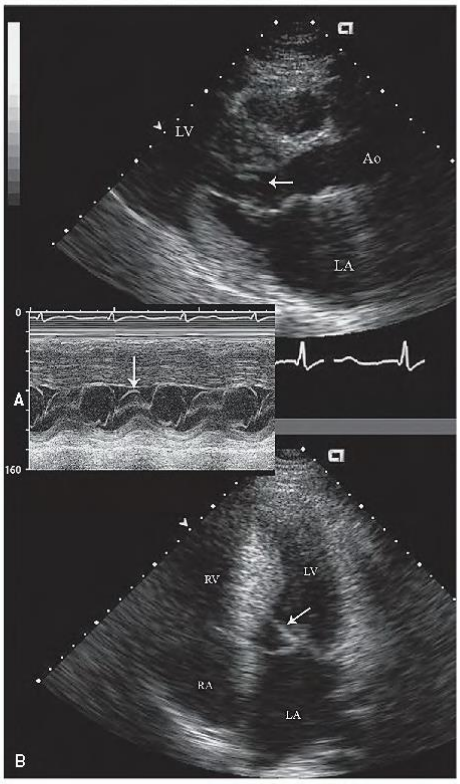
- Thickened posterior pericardial echoes.
- Multiphasic diastolic motion (second reverberation) of the septum (*abrupt posterior motion early in diastole, caused by rapid RV diastolic filling, followed by little motion in mid-diastole, caused by equalization of RV and LV pressures, followed by abrupt anterior motion at the end of diastole due to further RV filling after atrial contraction*)



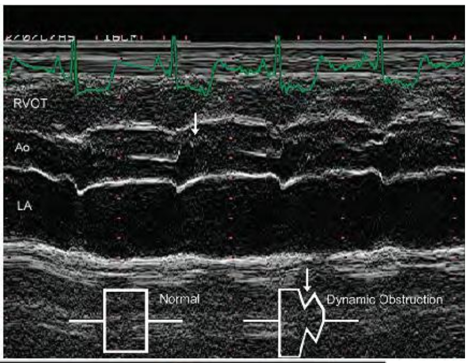
In elastic constriction (as opposed to classic calcific pericardial constriction), there is respiratory-dependent interaction of the right and left ventricular filling that manifests as exaggerated respiratory variation in septal position (inspiratory septal shift resembling the type of septal motion abnormality seen in cardiac tamponade). As the total intracardiac volume is limited by the constrictive pericardium, any inspiratory increase in right-sided filling must be accompanied by a reciprocal decrease in left-sided filling. Note that with inspiration (I), there is expansion of the right ventricular cavity with abrupt posterior motion of the ventricular septum (*arrow*).

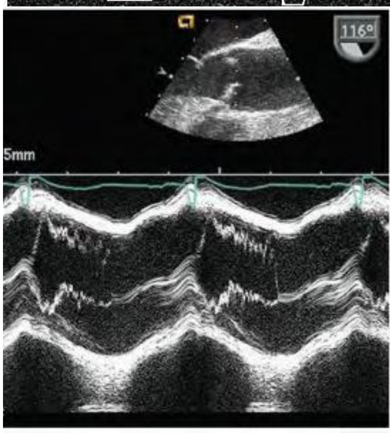


FEATURES OF M-MODE IN HCM & SUBAORTIC MEMBRANE *(SAM of the MV & notching of the AV)*



HCM: **SAM of MV** depicted in the parasternal long-axis view and in apical four-chamber view. In each systolic frame, note the motion of the mitral valve into the left ventricle outflow tract (*arrows*). The M-mode echocardiogram (small inset) also demonstrates systolic anterior motion of the mitral valve (*arrow*).

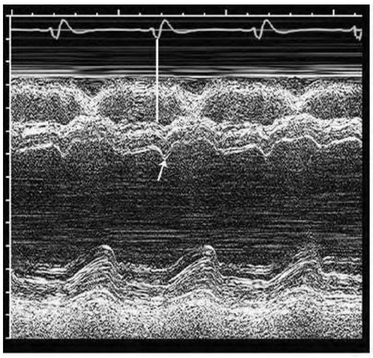




Top: **HCM**: **partial mid- systolic closure (notching) of the AV** (*arrow*).
Bottom: **Subaortic membrane**: **partial mid-systolic closure** and coarse **fluttering** of the AV cusps

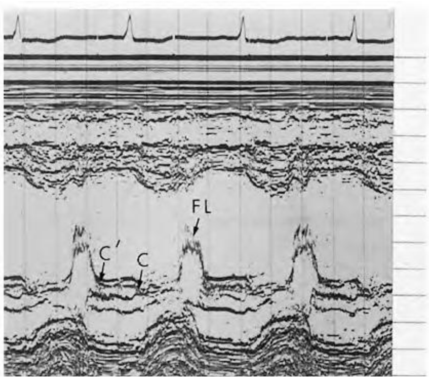
FEATURES OF M-MODE IN LBBB

LBBB: early systolic downward motion of the IVS (*arrow*), followed by anterior (paradoxical) septal motion throughout the remained of systole (sometimes called septal bounce).



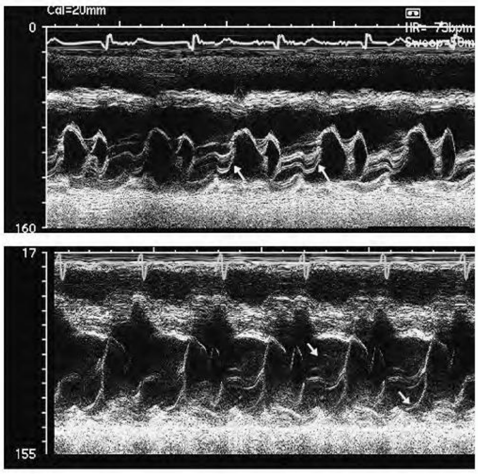
FEATURES OF M-MODE IN AORTIC REGURGITATION *(when the AV leaks, the MV flutters and closes early)*

Acute AR: early closure of MV in mid-diastole (C′), due to rapidly increasing diastolic LV pressure. The valve does not reopen with atrial systole and then closes completely with the onset of ventricular contraction (C). Fine fluttering of MV (FL) is due to the aortic regurgitant jet.



FEATURES OF M-MODE IN MITRAL VALVE DISEASE *(prolapse, regurgitation, rheumatic stenosis)*

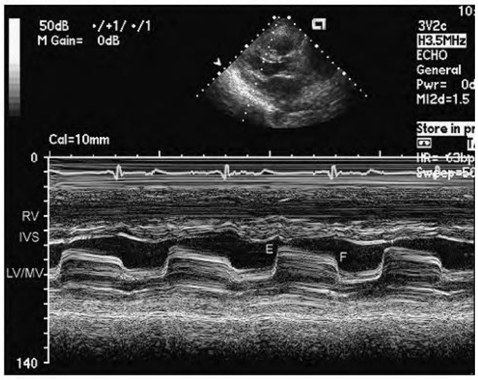
Two patients with mitral valve prolapse, showing
Distinct posterior motion (sagging) (buckling) (hammocking) of the mitral valve in mid to late systole (*arrow*).
Lower panel: Note the chordal systolic anterior motion (*upper arrow*), which may also be seen in mitral valve prolapse.



Rheumatic mitral stenosis, showing

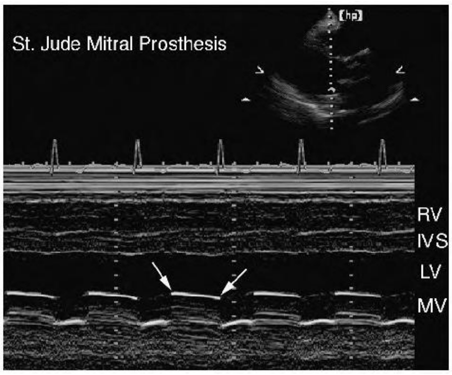
- Marked thickening of the mitral valve leaflets
- Flat E-F slope during diastole.
- Posterior leaflet appears to move anteriorly in diastole as well (both leaflets move in concert).

Note that The mitral leaflets open at early diastole.



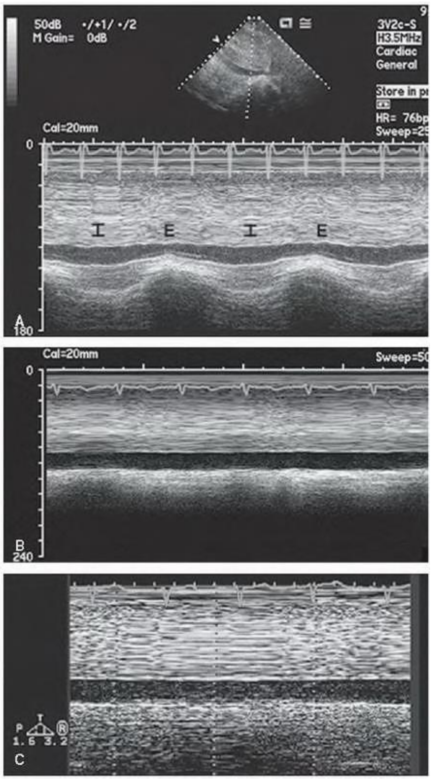
M-MODE IN RECORDING MOTION OF A DISK-TYPE PROSTHETIC VALVE

M-mode echocardiogram of a St. Jude mitral prosthetic valve. M-mode echocardiography is ideal to record the brisk opening and closing of the disks (*arrows*). N.B. rounding of the opening/closing points of the disks indicates Mechanical restriction to disc motion



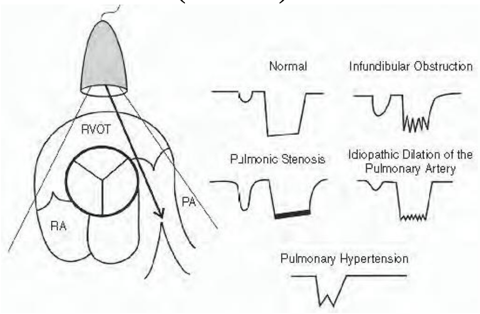
M-MODE IN EVALUATION OF IVC

M-mode echocardiograms from the subcostal transducer position of the IVC.
A**:** Image recorded in a normal patient. Note the respiration-dependent phasic variation in inferior vena cava size.
B: A normal inferior vena cava size but a loss of respiratory variation
C: a dilated inferior vena cava also without respiratory variation
I, inspiration; E, expiration.

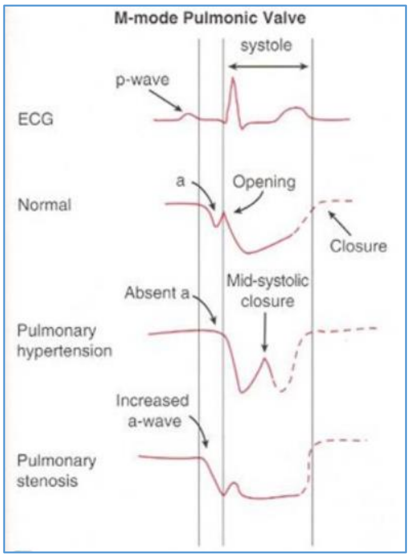


FEATURES OF M-MODE IN PULM HYPERTENSION AND PULM VALVE DISEASES *(PH: absent a & notching; valvular PS: exaggerated A)*

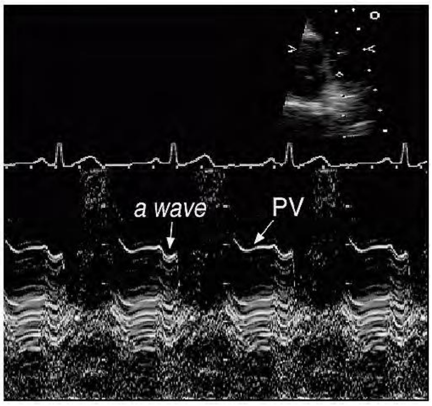
In most cases where motion is normal, only the anterior leaflet of the pulmonic valve can be depicted on M-mode. This leaflet moves posteriorly and remains opened during systole. At end diastole, with right atrial contraction, the right ventricular pressure approaches the pulmonary arterial end-diastolic pressure, resulting in posterior motion of the pulmonic valve (A-wave)



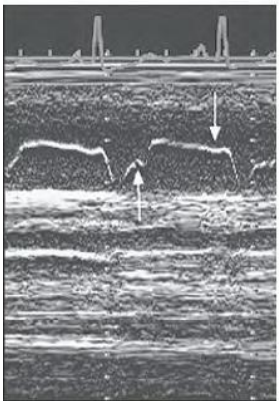
Schematic representation of M-mode echocardiograms of **normal and abnormal pulmonary valves**. In the normal schematic, note the normal A wave and boxlike opening of the valve



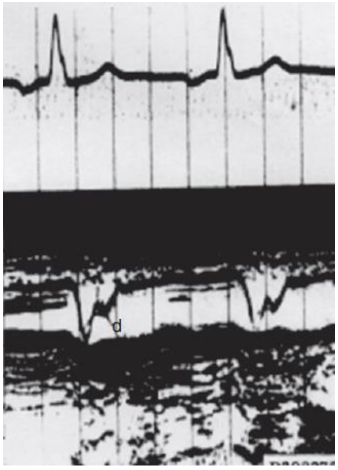
Schematic of the pulmonary valve in a **normal** individual, a patient with **pulmonary hypertension**, and a patient with **pulmonic stenosis**.



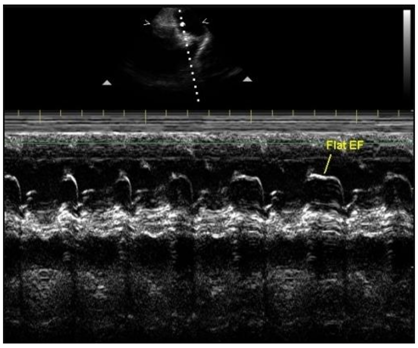
An M-mode recording of **normal pulmonary valve (PV) motion.** The A-wave, corresponding to right atrial systole, is indicated.



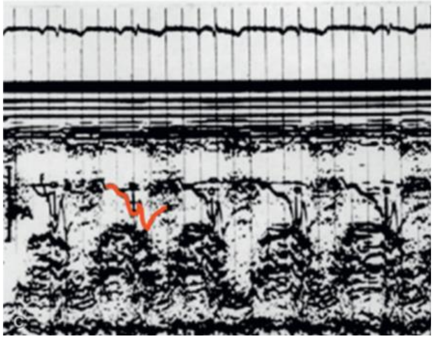
pulmonary hypertension: **loss of the pulmonic valve A wave** (*downward-pointing arrow*) and **mid-systolic notching,**
"flying W" sign (*upward-pointing arrow*) of the valve



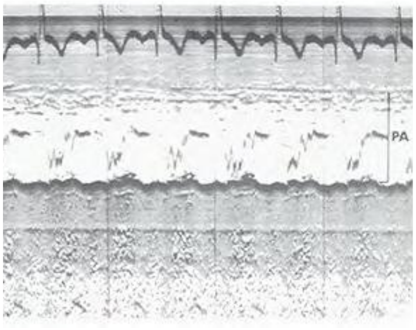
Severe pulmonary hypertension: "flying W" sign (mid systolic notching)



pulmonary hypertension: Flat EF slope on M-mode echocardiogram of pulmonary valve



Severe valvular pulmonic stenosis: **exaggerated atrial contraction motion (accentuated A wave)**



Infundibular obstruction: **coarse fluttering of the valve in systole**.

SUMMARY OF ABNORMALITIES OF M-MODE

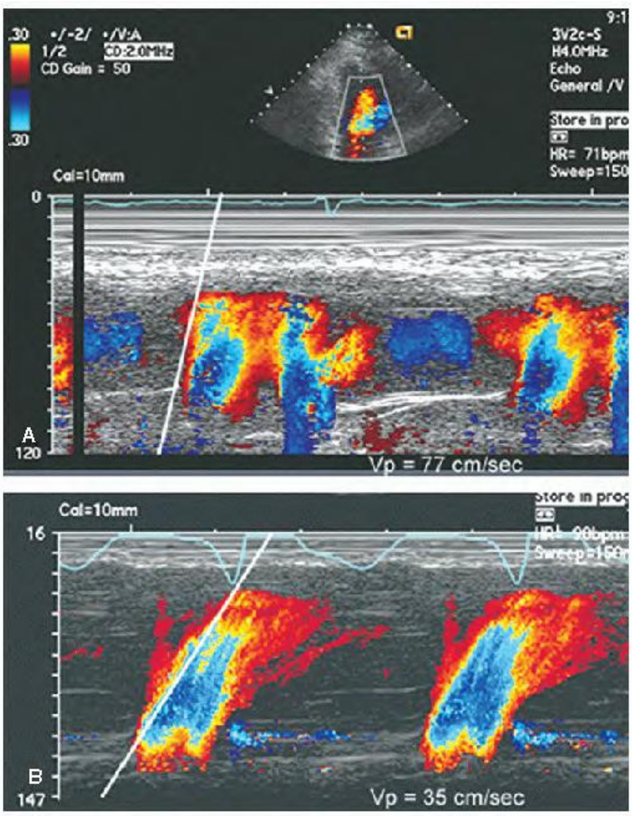
Abnormal Feature	Condition
LEFT VENTRICLE	
Decreased fractional shortening (normal 25-45%)	LV dysfunction (↓EF)
Increase fractional shortening	Hyperkinetic motion following a post-PVC pause
Loss of wall thickness and endocardial motion of the anterior septum	Anteroseptal myocardial infarction & scarring
Flat motion of the posterior LV wall after the initial rapid posterior motion	Constrictive pericarditis
EPSS	
Increased MV E-point septal separation (EPSS) (normal 6mm)	LV dysfunction due to increased LVEDD (due to increased diastolic volume) &/or decreased the magnitude of opening of the mitral valve (due to decreased stroke volume) or AR → limited MV opening
RIGHT VENTRICLE	
Early diastolic collapse of the RV free wall	Pericardial tamponade
Respiratory variation in right ventricular size and septal position	
↓ tricuspid annular plane systolic excursion (TAPSE) (normal >16 mm)	RV dysfunction
IVS	
Early systolic downward motion (beaking) of the IVS, often followed by anterior (paradoxical) septal motion throughout the remained of systole (sometimes called septal bounce)	LBBB
Exaggeration of the normal early diastolic septal dip and an overall increase in the amplitude of septal motion compared with the posterior left ventricular wall	AR → LV volume overload due to unequal filling and stroke volume of the ventricles
Multiphasic diastolic motion (second reverberation) of the septum (*abrupt posterior motion early in diastole, caused by rapid RV diastolic filling, followed by little motion in mid-diastole, caused by equalization of RV and LV pressures, followed by abrupt anterior motion at the end of diastole due to further RV filling after atrial contraction*)	Constrictive pericarditis
Ventricular septal 'bounce' during inspiration: a shift in the ventricular septum towards the LV with inspiration and towards the RV with expiration due to ventricular interdependence.	
Inspiratory septal shift toward the LV	Constrictive pericarditis or pericardial tamponade
AORTIC VALVE	
Gradual curved (rounded) closure of the AV at end-systole due to decreasing forward flow at the end of systole	LV dysfunction (↓LV SV)
Partial mid- systolic closure (notching) of the AV	HCM or subaortic membrane
Fluttering of the AV cusps	Subaortic membrane
MITRAL VALVE *(delayed closure in LVF, **early closure and fluttering** in AR, and **moves anteriorly** in HCM)*	
Interrupted (delayed) closure of the MV (B-bump)	↑LVPD →Transient reopening of the MV due to atrial contraction against noncompliant LV
Premature (early) closure of the MV in mid diastole (→ functional MS)	AR, often acute and severe → rapidly increasing diastolic LV pressure
Diastolic fluttering of the MV	Cascade of AR jet
SAM of the MV (→ functional MR)	HCM → blood flowing through narrowed LVOT → a Venturi (suction) effect → drags the MV towards the septum during systole (recently SAM is thought to be due to abnormal geometric relationship of papillary muscles and the mitral supporting apparatus combined with hyperdynamic LV contraction)

Mid to late systolic posterior motion (sagging) (buckling) (hammocking) of the MV.	Mitral prolapse
Chordal systolic anterior motion	
Flat mitral E-F slope during diastole and marked thickening of the mitral valve leaflets	Mitral stenosis
Posterior leaflet appears to move anteriorly in diastole as well (both leaflets move in concert).	
Mitral leaflets open at early diastole	
DISK TYPE PROSTHETIC VALVE	
Rounding of the opening/closing points of a disk type prosthetic valve	Mechanical restriction to disc motion
IVC	
Dilated IVC (normal) &/or loss of respiratory variation	↑ RAP
PULMONARY VALVE	
Absent "A" wave of the pulmonary valve, in spite of normal sinus rhythm	Severe pulmonary hypertension →↑ the PA diastolic pressure → ↑ the RV diastolic pressure → the RA contraction will have no effect on the pulmonic valve end-diastolic position
Mid-systolic notching of the pulmonary valve (flying "W" sign)	Pulmonary hypertension → early closure of pulmonary valve because of high PVR
Flat pulmonic EF slope of the pulmonary valve	Pulmonary hypertension
Exaggerated pulmonary valve A wave	Valvular pulmonary stenosis → exaggerated atrial contraction motion
Systolic fluttering of the pulmonary valve	Infundibular pulmonic valve obstruction

COLOUR M-MODE

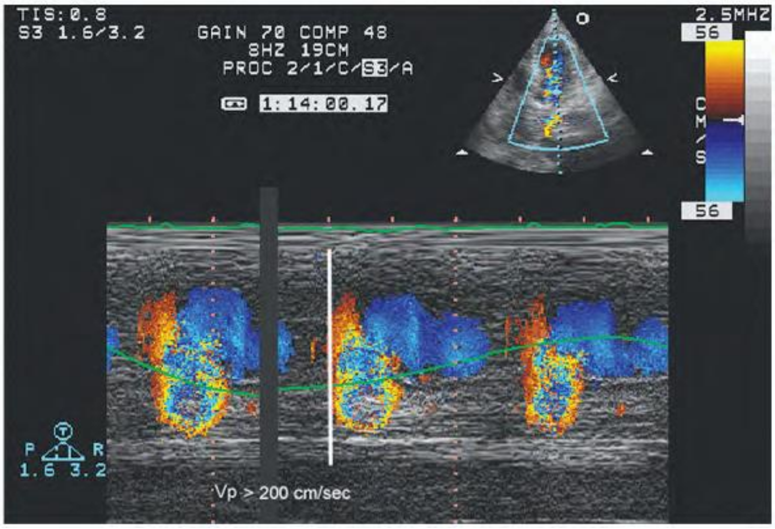
Colour Doppler M-mode- uses the same principles as colour Doppler, but instead of overlaying the colour data on a 2-D display it instead overlays it on an M-mode display. It can be useful for precisely timing the occurrence of colour jets, and is commonly used for measuring the width of a jet of aortic regurgitation in relation to the diameter of the LVOT.

Assessment of Diastolic dysfunction- Colour M-mode of mitral inflow is another approach to the assessment of diastolic function. Using routine colour flow imaging for orientation, the M-mode cursor is placed at the centre of the inflow jet. The M-mode display reveals the acceleration of blood in early diastole through the mitral valve toward the apex. The slope of the red-blue interface represents the propagation velocity (Vp) of left ventricular inflow and correlates with the rate of myocardial relaxation or elastic recoil of the chamber in early diastole. Thus, impaired relaxation will slow the propagation of blood and thereby reduce the slope of the line.
N.B: with normal **LV systolic function**, colour M-mode of the MR jet should produce a near vertical slope, correlating with the rapid rate of rise in ventricular pressure (dP/dt) during systole.

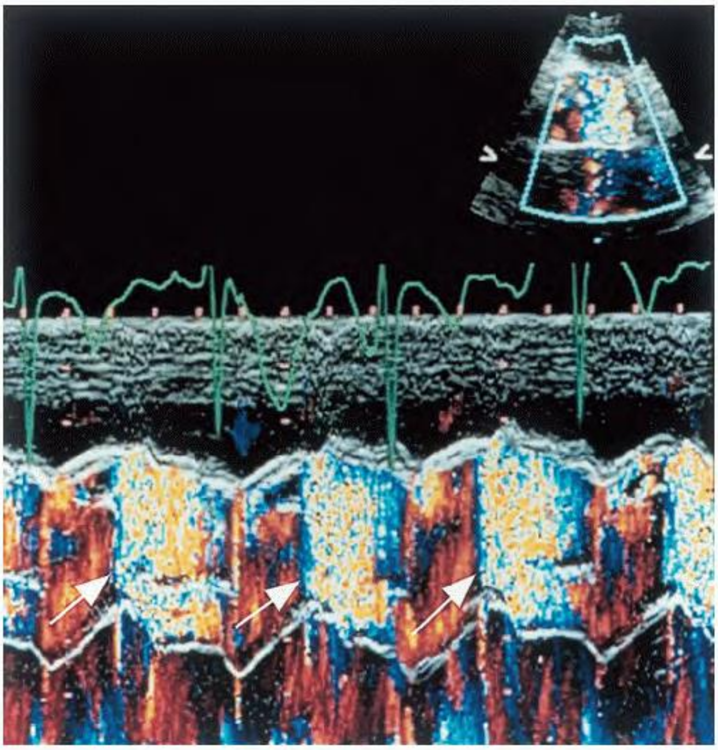


A colour Doppler M-mode image recorded from the apical four-chamber view. ***A:*** *Normal flow propagation velocity (Vp = 77 cm/sec) is demonstrated as evidenced by the steep slope of the early diastolic valve-to-apex contour.* ***B:*** *The reduced slope and lower velocity (Vp = 35 cm/sec) is consistent with decreased chamber compliance.*

Separation of Constrictive Pericarditis from Restrictive Cardiomyopathy

	Constriction	**Restriction**
Colour M-mode mitral valve *Vp*	Increased (≥55 cm/sec)	Reduced
	 *Colour Doppler M-mode recording in a patient with constrictive pericarditis. Note the very steep velocity of propagation (Vp), averaging more than 200 cm/sec in this example. Mitral inflow Vp with this technique may assist in distinguishing constrictive from restrictive physiology.*	

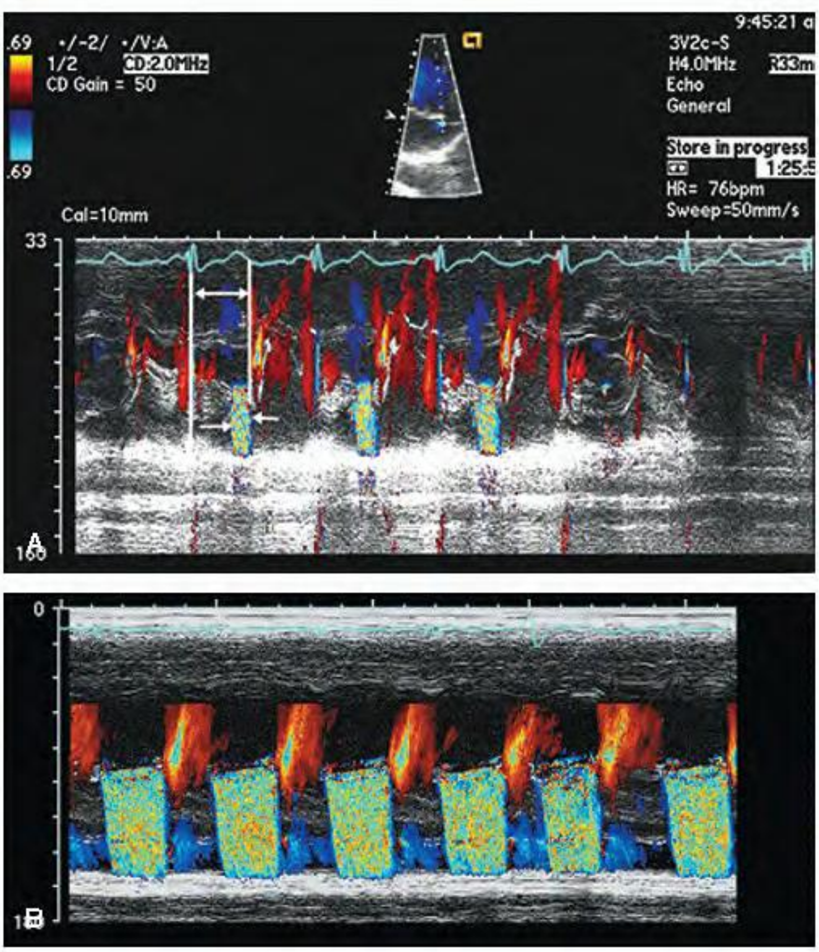
Establishing a Diagnosis of Aortic Regurgitation



A colour M-mode imaging example of aortic regurgitation. The mosaic flow signal during diastole (arrows) identifies the aortic regurgitation jet.

Assessing MR

Mitral regurgitation confined to late systole is overestimated by simple assessment of maximal jet area and is most common in patients with mitral valve prolapse.



Colour Doppler M-mode images recorded in patients with mitral regurgitation. Both tracings were recorded from the left ventricular apex. ***A:*** *Recorded in a patient with mitral valve prolapse and regurgitation confined to the latter 40% of systole. The two vertical lines indicate the duration of mechanical systole (double-headed arrow).* ***B:*** *Recorded in a patient with holosystolic mitral regurgitation.*