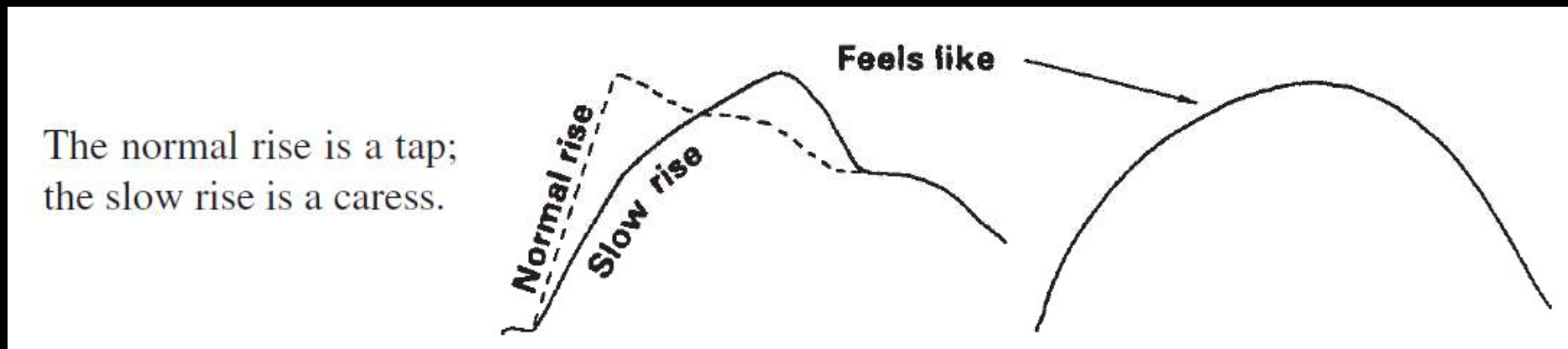


Pulsus parvus et tardus...

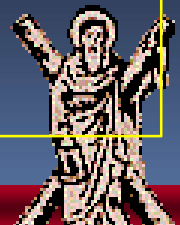
The first indication that the rise is slow is the absence of a tap.

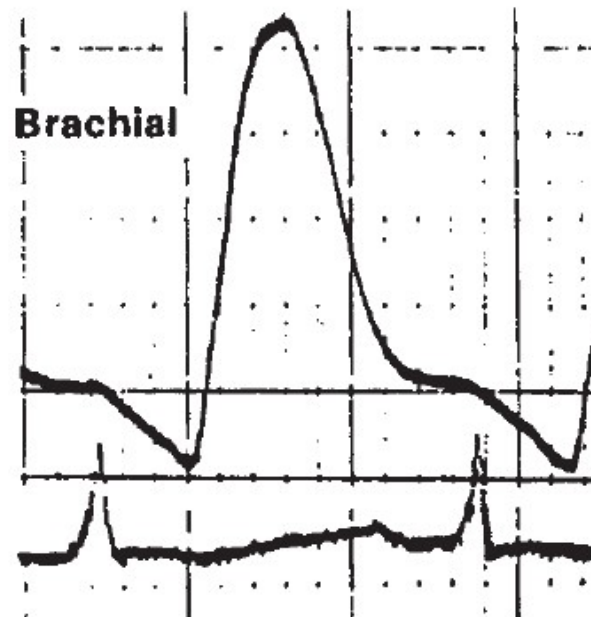
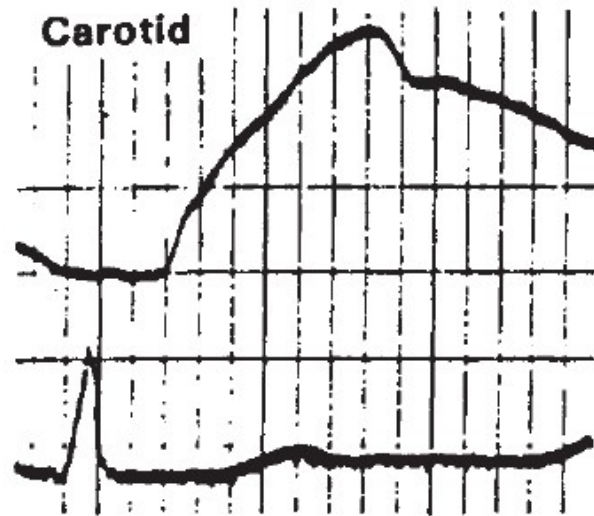
Then you may notice that the sensation is one of a caressing lift.



SOS: If you feel a tap followed by a push, then you may be feeling an anacrotic shoulder followed by a late slow-rising tidal wave

A lag between the onset of the apical impulse and the carotid impulse predicts a valve area $< 1 \text{ cm}^2$ (100% specific).





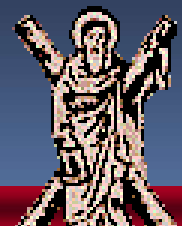
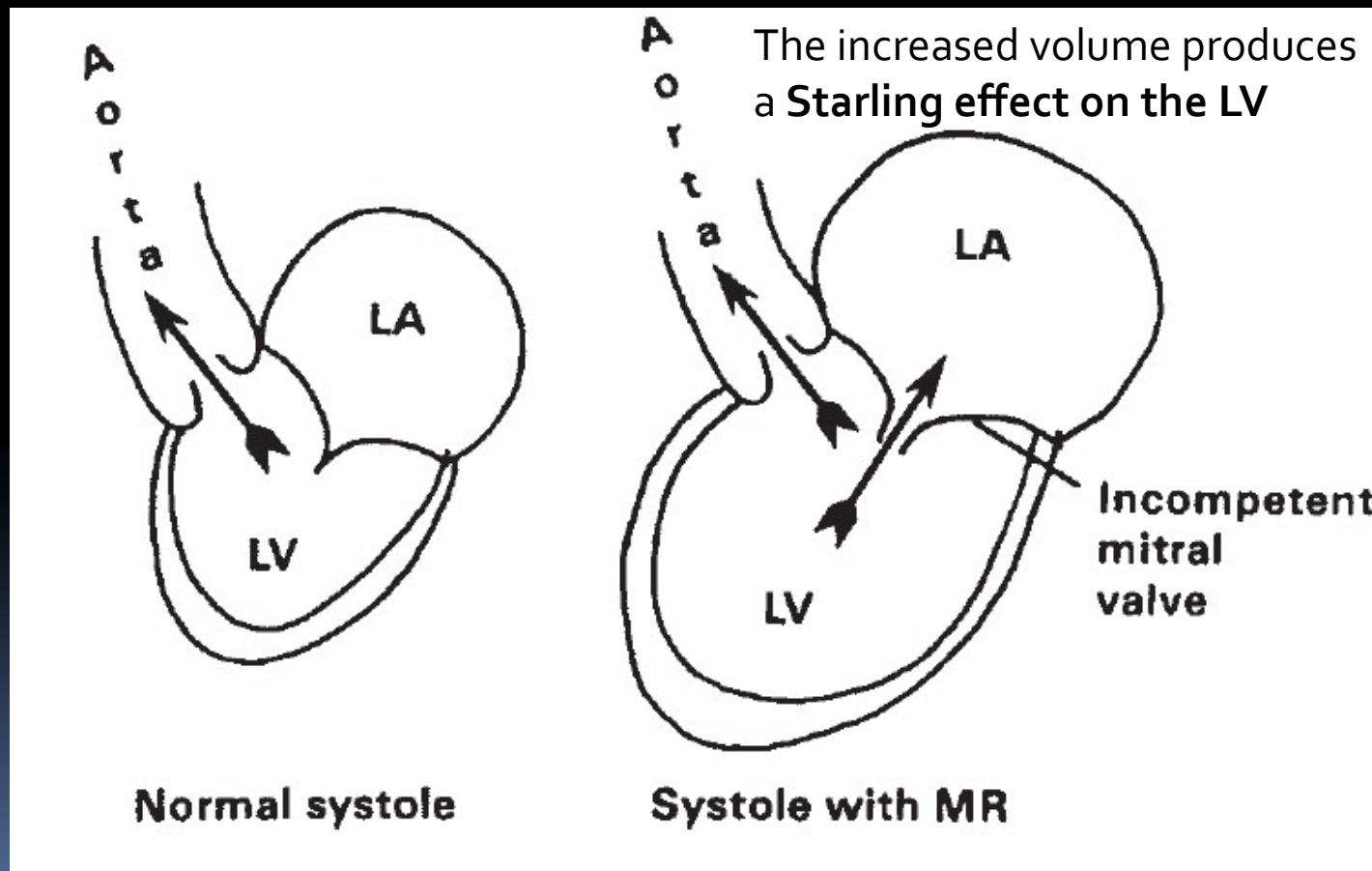
Carotid and brachial pulse contours in a patient with mild AS. By the time the pulse wave reached the brachials, it had become normal.



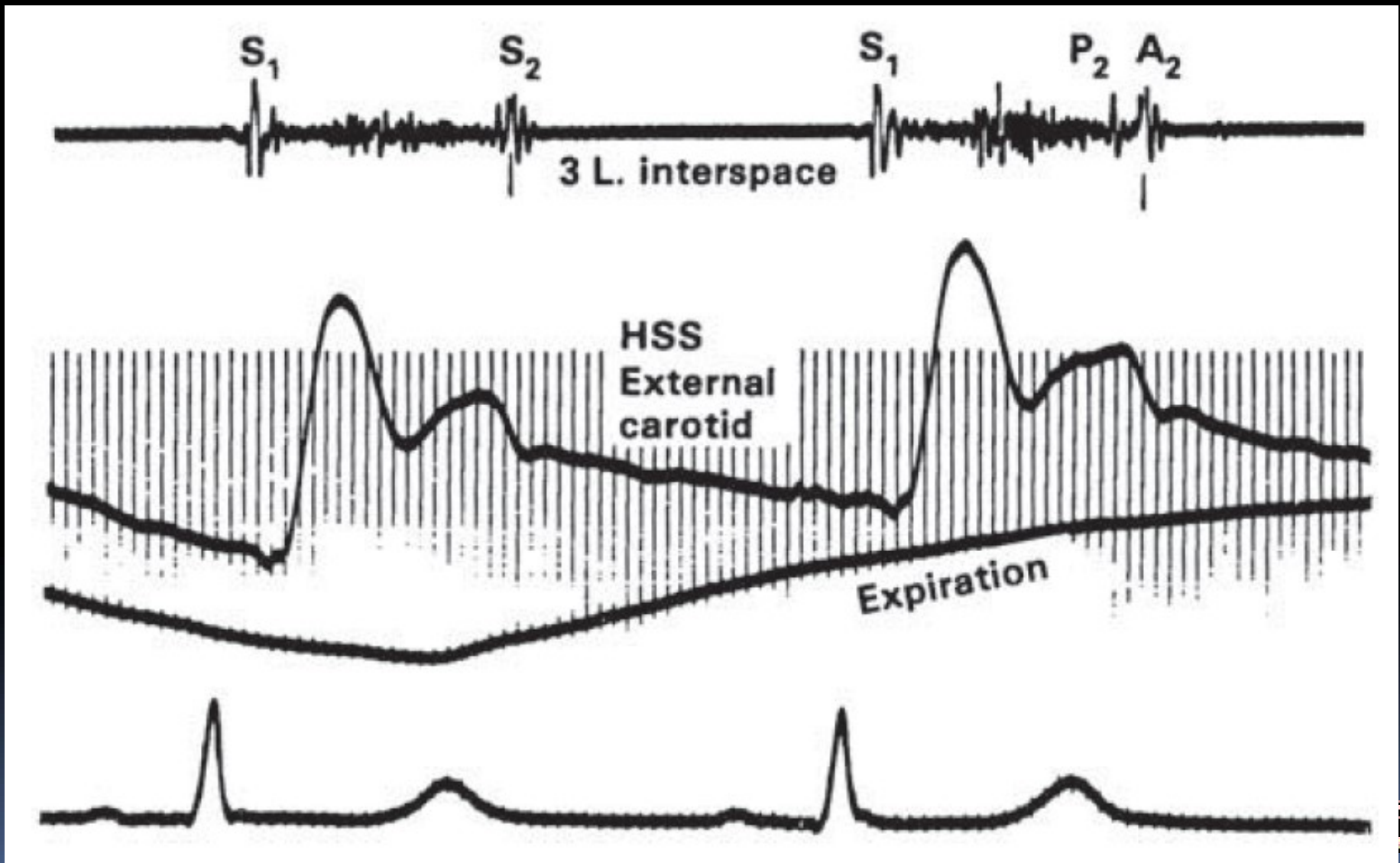
Rapid Rates of Rise (Brisk Pulse) with Normal Pulse Pressures

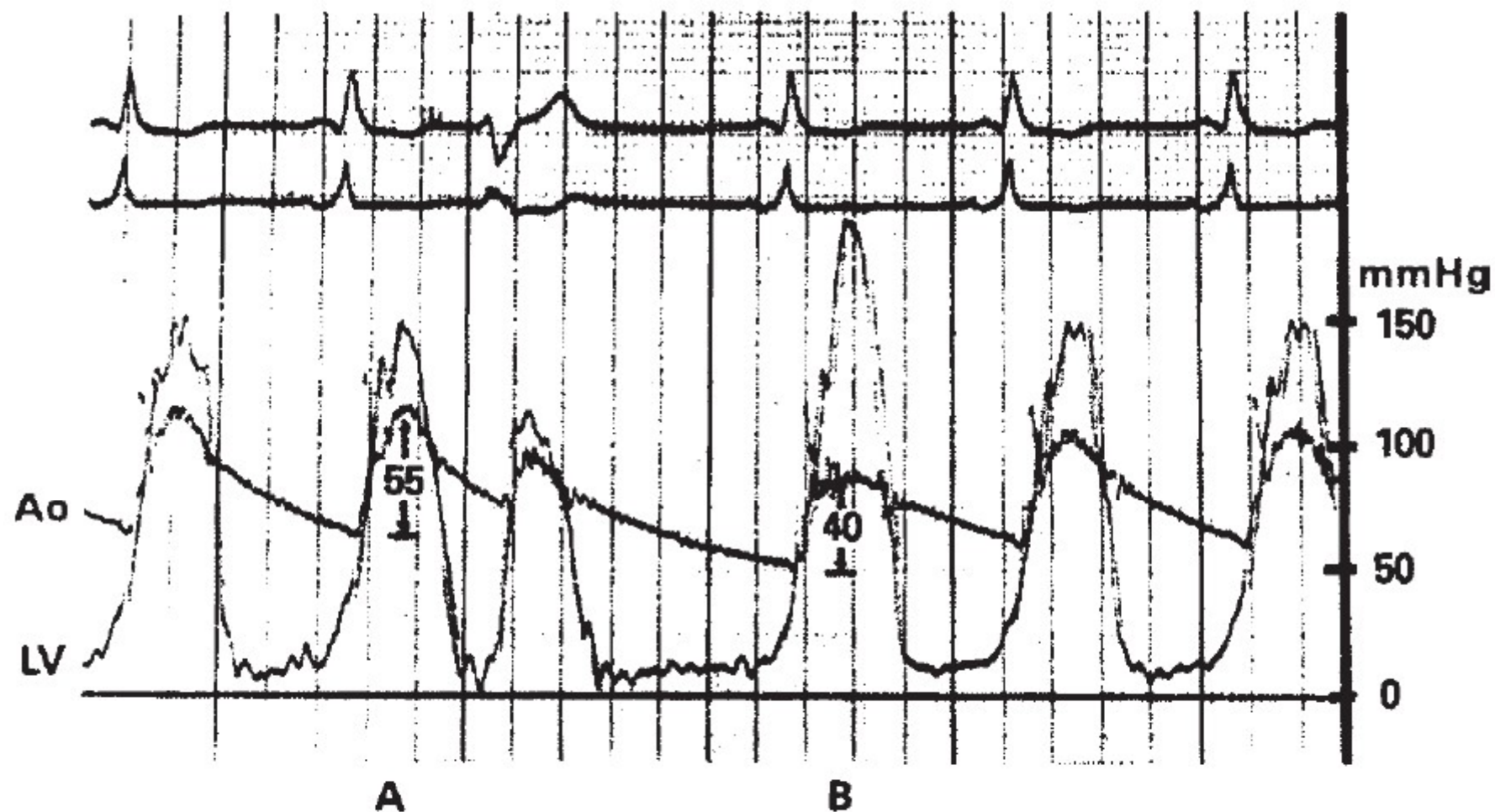
Pressures

- If there are two outlet orifices for ejection, as in MR or VSD



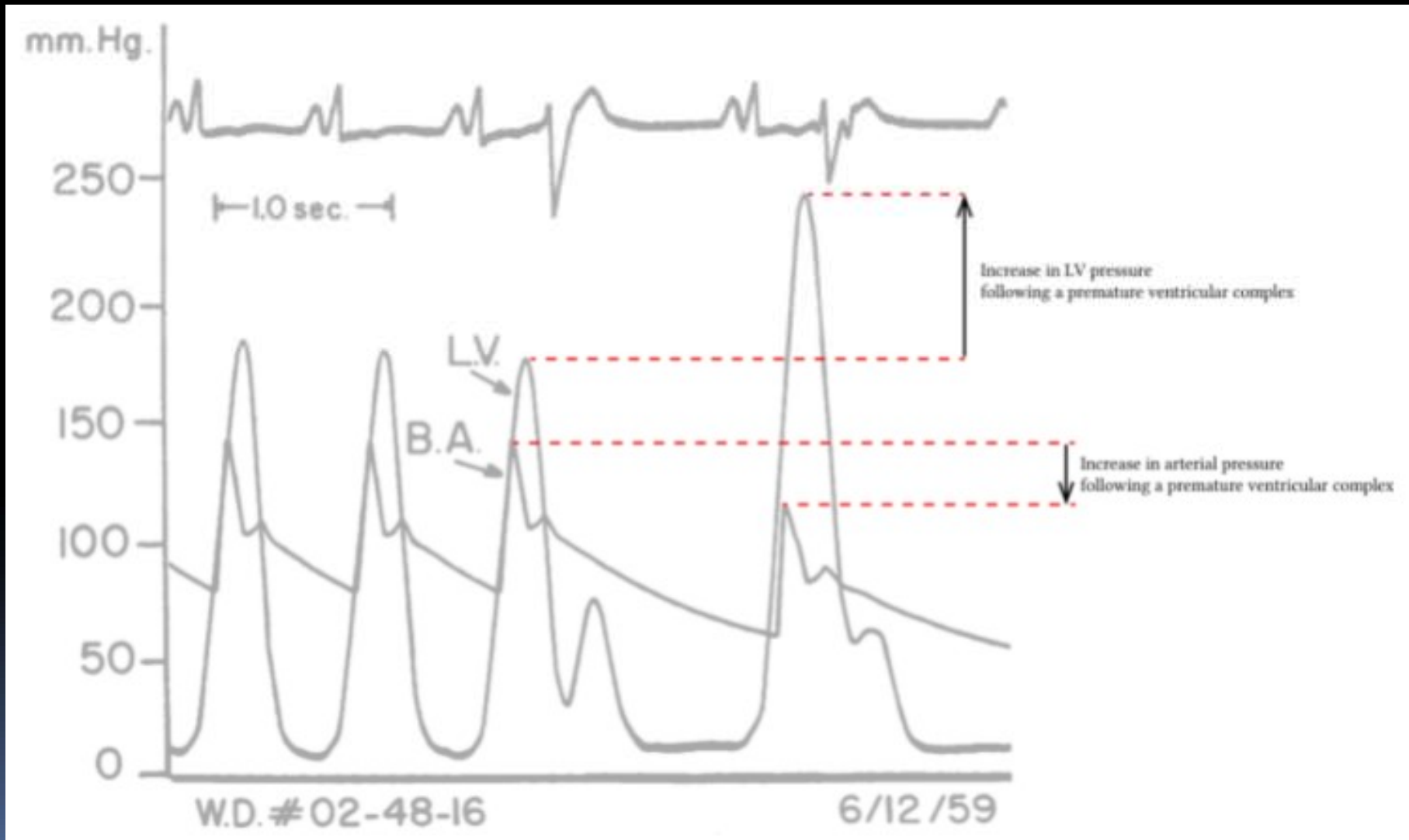
The rate of rise in HOCM is among the fastest in cardiology





The Brockenbrough effect is seen in the postextrasystolic beat B because the pulse pressure decreased to 40 mmHg from 55 mmHg during sinus rhythm at A.

Brockenbrough–Braunwald–Morrow



Rapid Rates of Rise with Increased Pulse Pressure

- Most common cardiac causes of a bounding pulse
 - Aortic regurgitation (AR), persistent ductus arteriosus, and coarctation.
- Most common noncardiac causes of a rapid rise with increased pulse pressure
 - Thyrotoxicosis, pregnancy, and severe anemia.



- **Bounding pulse/ water hammer pulse**

This type of pulse rises suddenly followed by a quick fall.

Quick rise is due to increased stroke volume, and the quick fall is due to quick passage of blood from aorta to ventricle.

Seen in aortic incompetence.



What is Corrigan's pulse?

ANS: It is the bounding carotid seen by eye.

2. What are the most common cardiac causes of a bounding pulse?

ANS: Aortic regurgitation (AR), **persistent ductus arteriosus**, and coarctation.

3. What are the most common noncardiac causes of a rapid rise with increased pulse pressure?

ANS: Thyrotoxicosis, pregnancy, and severe anemia.

4. Why is the pulse of AR bounding?

ANS: a. There is a high systolic pressure because a large volume is ejected. The large volume is from two sources: the diastolic AR flow plus the mitral diastolic flow. The Starling effect caused by stretching the LV creates the rapid rise.

b. There is a low diastolic pressure.



Corrigan pulse...

- The lower diastolic pressure in AR is only partly due to backflow into the LV during systole.
- It is mostly due to the reflex decrease in TPR caused by the large stroke volume stretching the carotid and aortic sinuses.
 - *Although sAR will generally have a diastolic pressure of about 50 mmHg or less, if the patient goes into heart failure the resultant reflex increase in peripheral resistance caused by low output may raise the diastolic pressure to normal values.*



Corrigan pulse...

- The loud sounds heard when the stethoscope is placed over the rapidly rising large pulsations of the femoral artery are called **Traube's sign**, or pistol-shot sounds



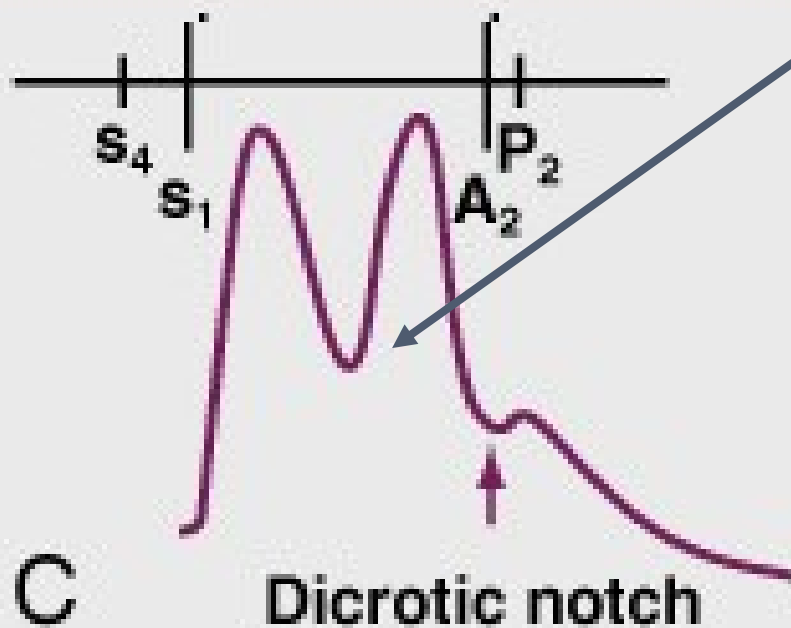
Duroziez double murmur...

- Duroziez' double murmur:
- 1st → systolic murmur heard by gradually compressing the femoral artery with a finger proximal to the stethoscope
- 2nd → diastolic murmur produced by gradually compressing the artery distal to the stethoscope (backflow in all the large arteries in diastole).
- *Note: Traube's sign and Duroziez' double murmurs are more of historical than practical interest because no more information is gained from them than by palpating the pulses or taking a blood pressure*



Δικόρυφος (Bisferiens) σφυγμός

- Μεγάλος όγκος παλμού που εξωθείται ταχέως
- Μεσοσυστολική έμφραξη



Bernoulli effect...or
Midsystolic LVOTO

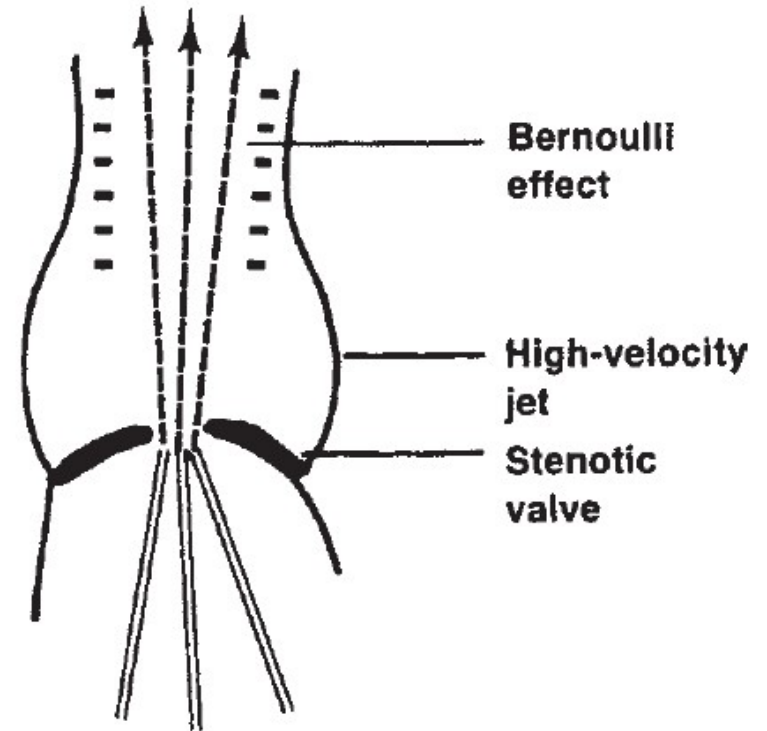
Δικόρυφος σφυγμός: Percussion
& tidal waves.

Αιμοδυναμικά σημαντική AR,
AR+AS, HOCM ...



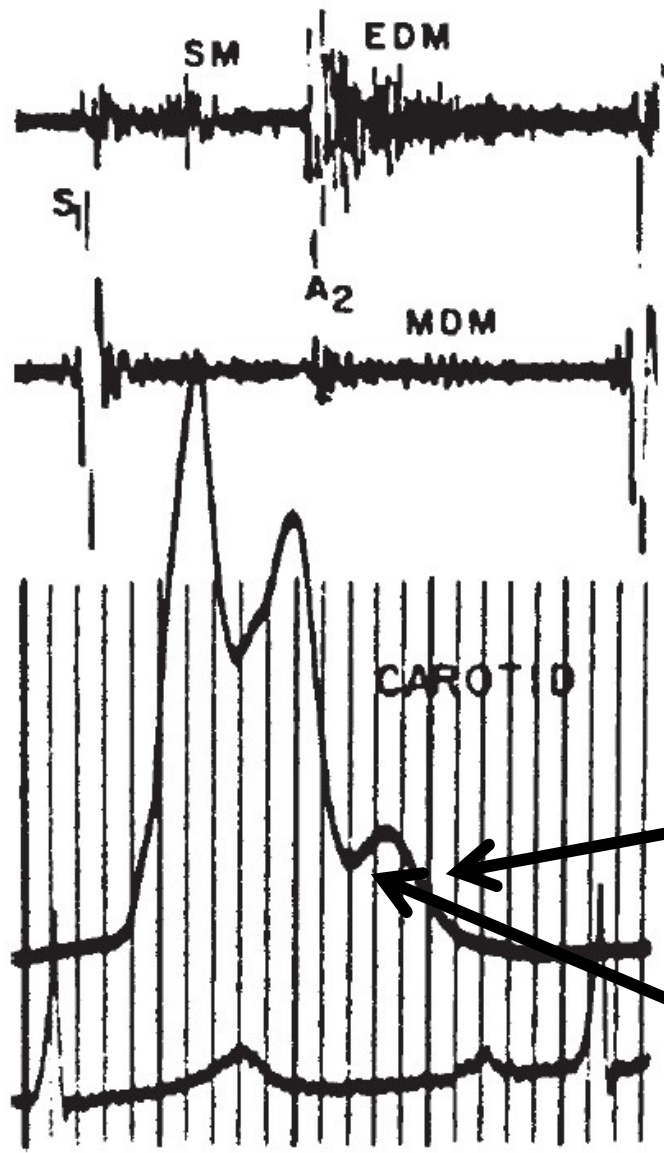
Δικόρυφος (Bisferiens) σφυγμός

The fall in lateral wall pressure during peak velocity requires a high velocity of ejection. This implies the presence of a relatively healthy myocardium.



AS + AR



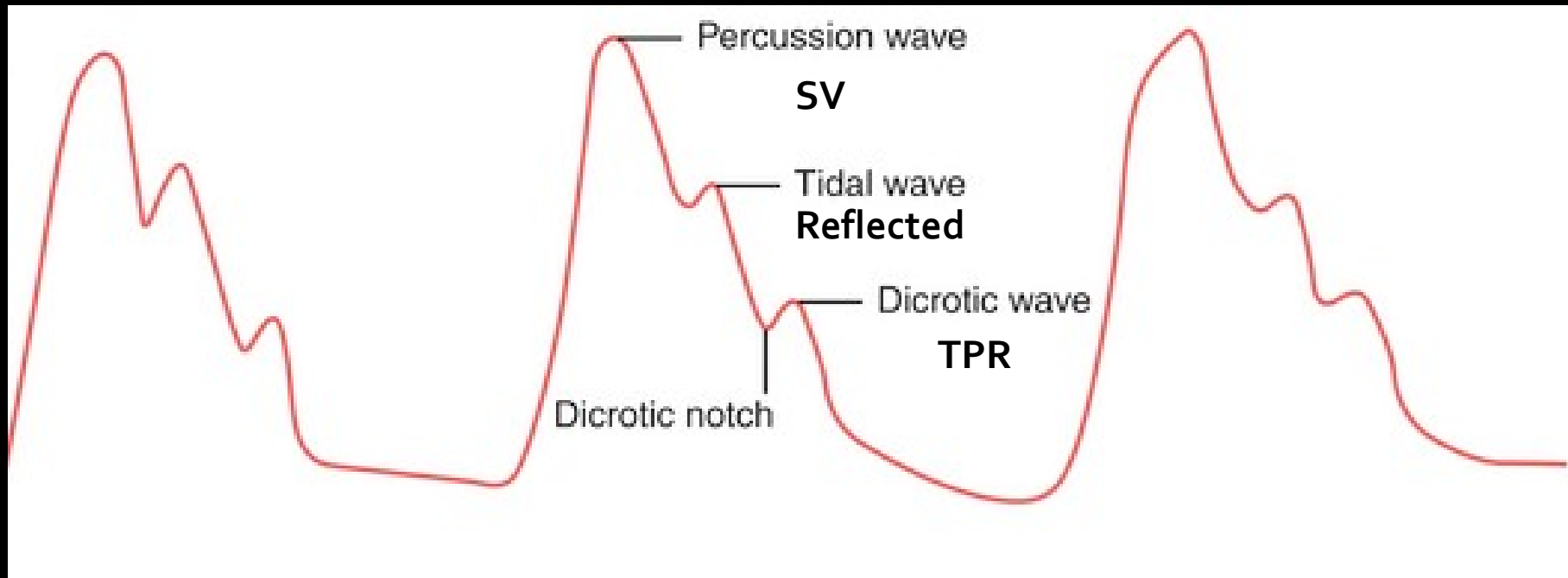


Bisferiens pulse in a patient with severe AR. (EDM = early diastolic murmur of AR at left sternal border; MDM = mid-diastolic murmur at apex [Austin Flint murmur]).

Δικροτικό κύμα

Δικροτική εντομή
Incisura



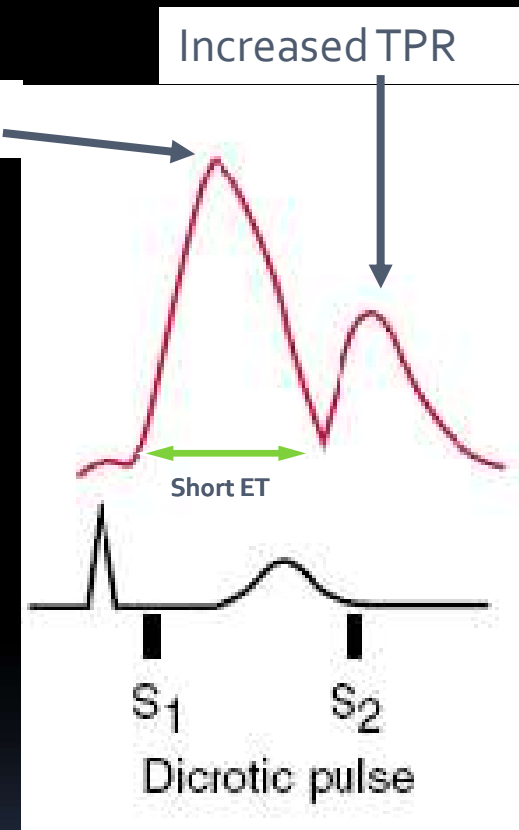


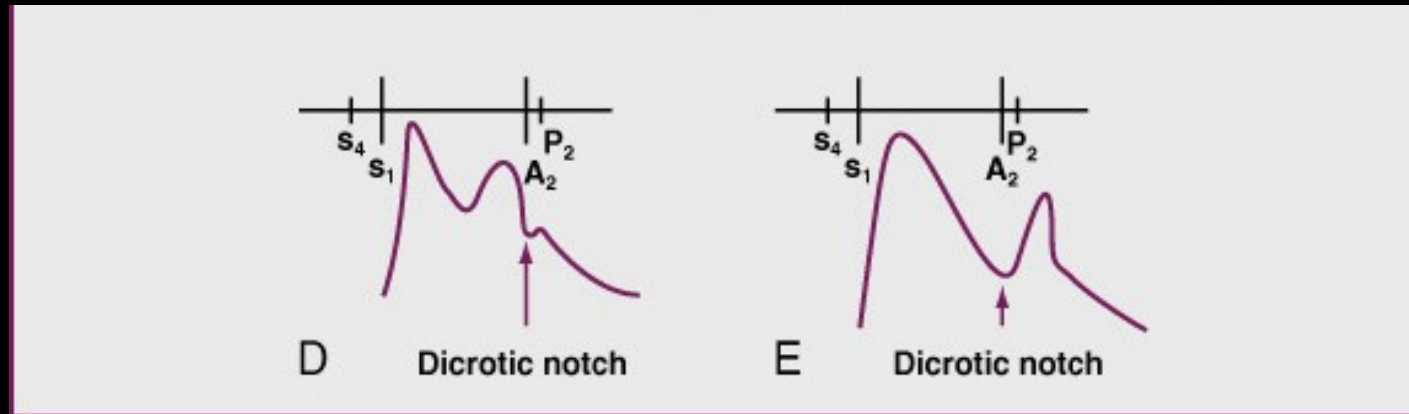
Percussion Wave = rise due to LV ejection;
Tidal Wave = echo of the percussion wave by the arterial system;
Dichrotic notch is the abrupt closure of the aortic valve; dichrotic wave is the reflected wave from the peripheral vasculature



Δίκροτος σφυγμός

- Η δεύτερη κορυφή στην διαστολή αμέσως μετά τον S_2 (υπόταση με αυξημένες αντιστάσεις όπως σε πυρετό, tamponade, σοβαρή οξεία καρδιακή ανεπάρκεια, υπογκαιμικό shock, post-AVR)





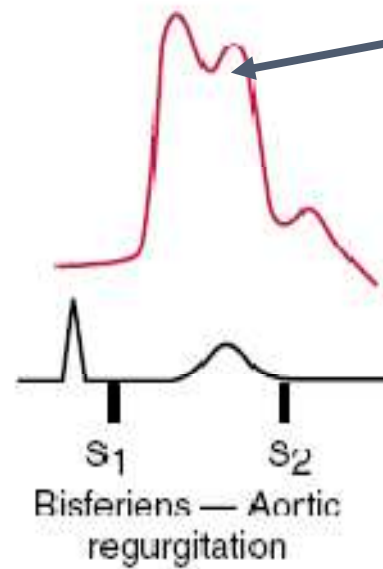
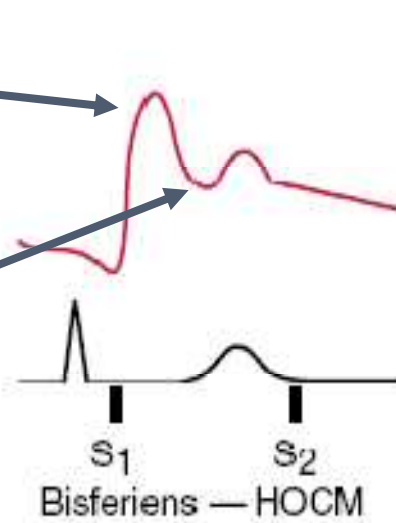
D, Δικόρυφος σφυγμός σε ΗΟCΜ. Σπάνια ψηλαφητός.

E, Δικροτικός σφυγμός: Ενισχυμένο δικροτικό κύμα όπως σε σήψη, σοβαρή ΚΑ, υπογκαιμικό shock, tamponade, AVR.



80% SV!

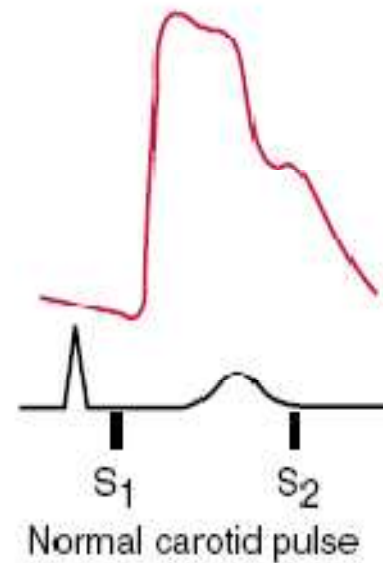
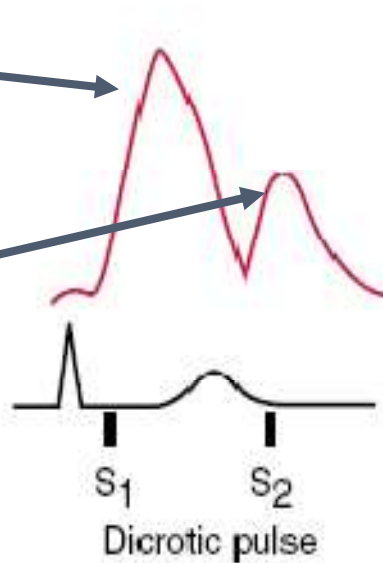
Midsystolic LVOTO



Bernoulli effect

Reduced SV

Increased TPR



Normal response of JVP and BP to Inspiration

JVP

Mean pressure falls .Wave forms become prominent

Mechanism

Inspiratory transmission of negative Intra thoracic, intra pleural , Intra-pericardial and Intra cardiac pressures help the right heart chambers to suck the blood from extra-thoracic venous reservoir IVC*

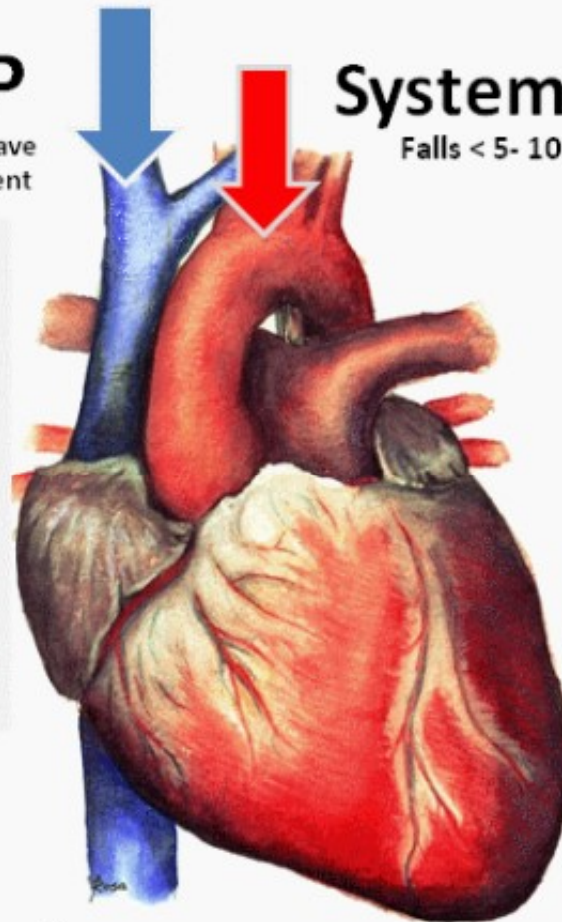
*(*Which is uninfluenced by swinging Intra thoracic pressure Hence a positive gradient towards the right heart is created.)*

Systemic BP

Falls < 5- 10mmhg

Mechanism

- During inspiration there is relative pooling of blood volume in lungs. (Note :Since both pulmonary circuit and the left heart are intra-thoracic structures Inspiratory gradient is not established between them unlike right side.)
- Septal movement towards LV cavity interferes with LV stroke volume (Reverse Bernheim effect/Ventricular interdependence) Pericardial restraint also augments this.
- Importantly , direct transmission of negative intra-thoracic pressure into the central arteries also contribute to momentary reduction Aortic afterload & BP by few mmhg.



Inspiration



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Pulsus paradoxus

Παλσός βαρυστόχος

- Tamponade, συμπιεστική ΠΚ, βρογχικό άσθμα, υπογκαιμικό shock, πνευμονική εμβολή...

1. Why do some asthmatic patients seem to have a marked inspiratory fall in blood pressure?

ANS: Bronchospasm may raise the intrathoracic pressure very high (similar to a Valsalva maneuver), and inspiration will, by contrast, seem to lower the systolic pressure excessively. Actually, it is an expiratory rise in blood pressure, not an inspiratory fall.



Pulsus paradoxus

When will there be no significant inspiratory fall in blood pressure despite marked tamponade?

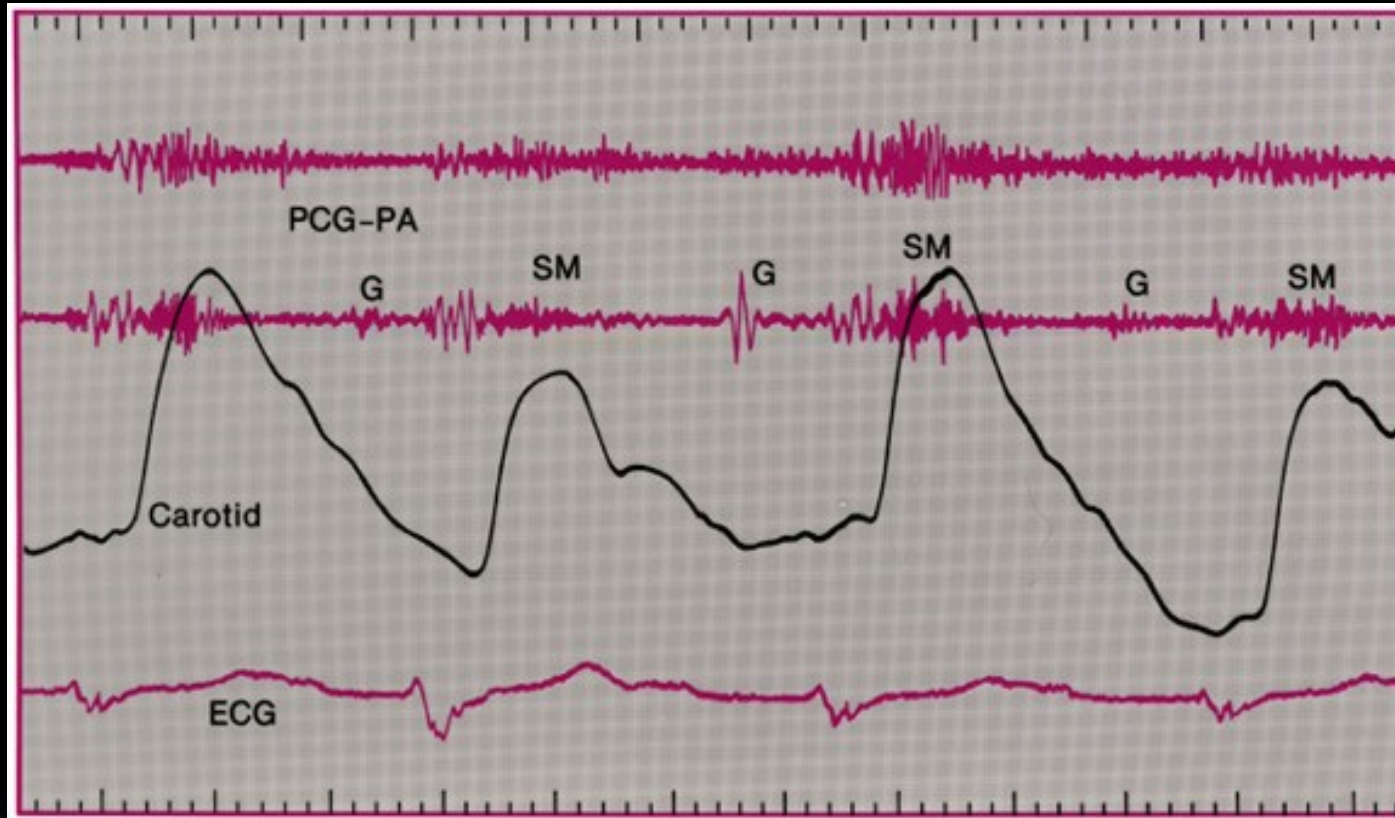
- ANS:
- a. If AR is present, the LV can fill from the aorta during inspiration.
 - b. In patients with a large atrial septal defect (ASD) the normal increase in systemic venous return to the RV on inspiration is almost balanced by a decrease in left-to-right shunt, so that the RV volume changes very little during inspiration.
 - c. If the LV diastolic pressure is very high.



Pulsus alternans

- Σοβαρή μυοκαρδιακή δυσλειτουργία, εκτακτοσυστολές (ΔΔχ σφυγμός διδυμίας pulsus bigeminus). Με πιεσόμετρο (<10 mmHg διαφορά)...
- Έκλυση με διούρηση, όρθια θέση...(μετατροπή σε ↓ output)

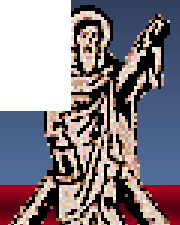
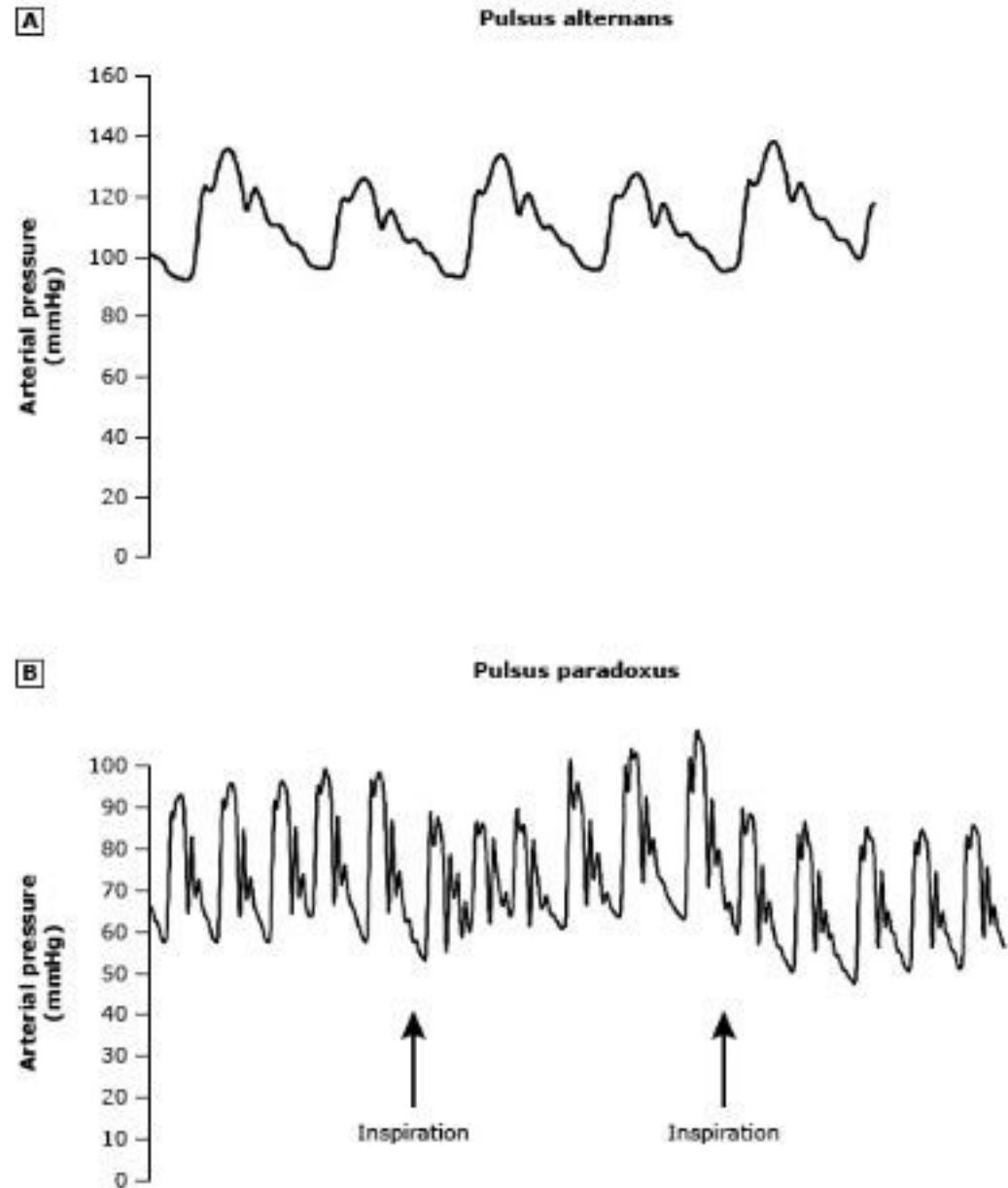




Pulsus alternans σε άνδρα με AS & συστολική δυσλειτουργία.
Ο διαστολικός ήχος (G) είναι αθροιστικός S₃ & S₄, λόγω
ταχυκαρδίας και παρατεταμένου P-R



Pulsus alternans (q2 beats, LV systolic failure) versus Pulsus paradoxus (lower during inspiration)



Παθολογικός σφυγμός

NAMES

1. **PULSUS PARVUS** (Weak pulse) low output failure
2. **PULSUS TARDUS** (Anacrotic pulse): Aortic stenosis (AS).
3. **PULSUS BISFERIENS** (Bifid pulse): Aortic insufficiency (AI).
4. **PULSES ALTERNANS**: With severe L-heart failure.
5. **PULSUS PARADOXUS**: SBP > 10 mm Hg with inspiration. Tamponade
6. **WATERHAMMER PULSE**: Wide pulse pressure. AI
7. **SPIKE AND DOME PULSE**: Double systolic peaks. HCM outflow obst.
8. **DICROTIC PULSE**: 2 (systole/diastole).-Myocardial disease hypovolemic
9. **BIGEMINAL PULSE**: Alternating normal and PVC's PAC'S.



Παθολογικός σφυγμός

- **Pulsus tardus:** Fixed obstruction to left ventricular outflow (valvular aortic stenosis, congenital fibrous subaortic stenosis). Βραδεία άνοδος, ροίζος, βραδύς και παρατεταμένος με μικρό ύψος. Anacrotic notch & acrotic pulse.
- **Pulsus parvus:** σφυγμός μικρού ύψους λόγω ελαττωμένου όγκου παλμού.
- **Pulsus parvus et tardus:** σοβαρή στένωση αορτής.
- **Έντονος σφυγμός:** Υπερκινητική κυκλοφορία & LV volume loading (VSD, MR, AR)



Παθολογικός σφυγμός

- **Corrigan or water-hammer pulse:** σοβαρή AR; Αιφνίδια άνοδος, ταχεία πτώση χωρίς dicrotic notch. (χαμηλή αντίσταση αορτής και μεγάλος όγκος παλμού). Στην οξεία AR, πρόωμη σύγκλιση της MV παρεμποδίζει αυτά τα φαινόμενα.
- **Bounding arterial pulses:** PDA, AV fistulas, thyrotoxicosis, pregnancy, fever, and anemia, severe bradycardia, arteries proximal to CoA.
- **Hill's sign:** AR (ή καταστάσεις με αυξημένο όγκο παλμού) η συστολική πίεση στα κάτω άκρα είναι μεγαλύτερη από τα άνω άκρα > 20 mm Hg.
- **Καταστάσεις με αυξημένο όγκο παλμού:** Becker's sign (ορατές σφύξεις στον αμφιβληστροειδή) and Mueller's sign (ορατές σφύξεις σταφυλής).



Παθολογικός σφυγμός

- **AV dissociation:** διακύμανση σφυγμού (επί ταχυκαρδίας, υποψία κοιλιακής ταχυκαρδίας)
- **Bisferiens pulse:** μεγάλος όγκος παλμού που εξωθείται ταχέως, ή μεσοσυστολική απόφραξη (AR, AR & AS, σπανίως σε νεαρούς ενήλικες, HOCM).
- **Dicrotic pulse:** Η δεύτερη κορυφή στην διαστολή αμέσως μετά τον S₂ (υπόταση με ελαττωμένες αντιστάσεις όπως σε πυρετό, tamponade, σοβαρή καρδιακή ανεπάρκεια, υπογκαιμικό shock)
- **Pulsus alternans:** Σοβαρή μυοκαρδιακή δυσλειτουργία, εκτακτοσυστολές (ΔΔχ σφυγμός διδυμίας pulsus bigeminus)
- **Pulsus paradoxus:** tamponade, συμπιεστική ΠΚ, βρογχικό άσθμα, υπογκαιμικό shock, πνευμονική εμβολή.



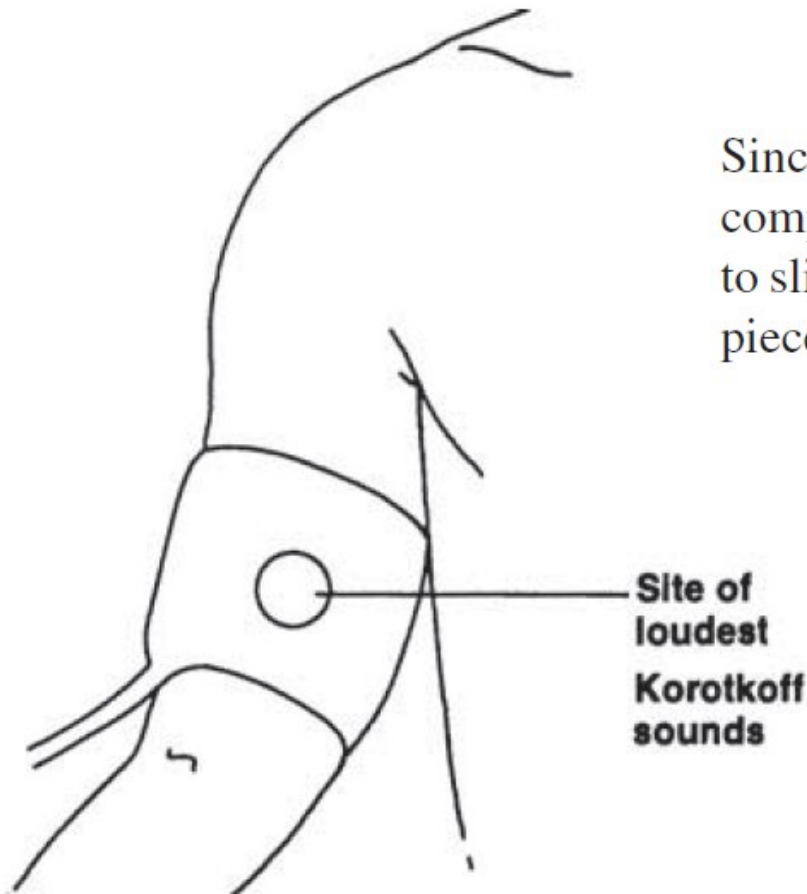
Quick Diagnoses Possible from the Carotid Pulse

- Feel for a gentle tap → carotid with a normal amplitude and rate of rise.
- If you feel no tap but only a “push” you should assume that AS is probably present.
- If you feel a sharp tap (brisk pulse) due to a rapid rate of rise, consider MR, VSD, or HCM if the pulse volume or pressure is normal.
 - If the pulse amplitude is increased, consider AR, PDA, or CoA



Where are Korotkoff sounds loudest? (a) In the center of the cuff, (b) at the edge of the cuff, or (c) a few centimeters distal to the cuff edge?

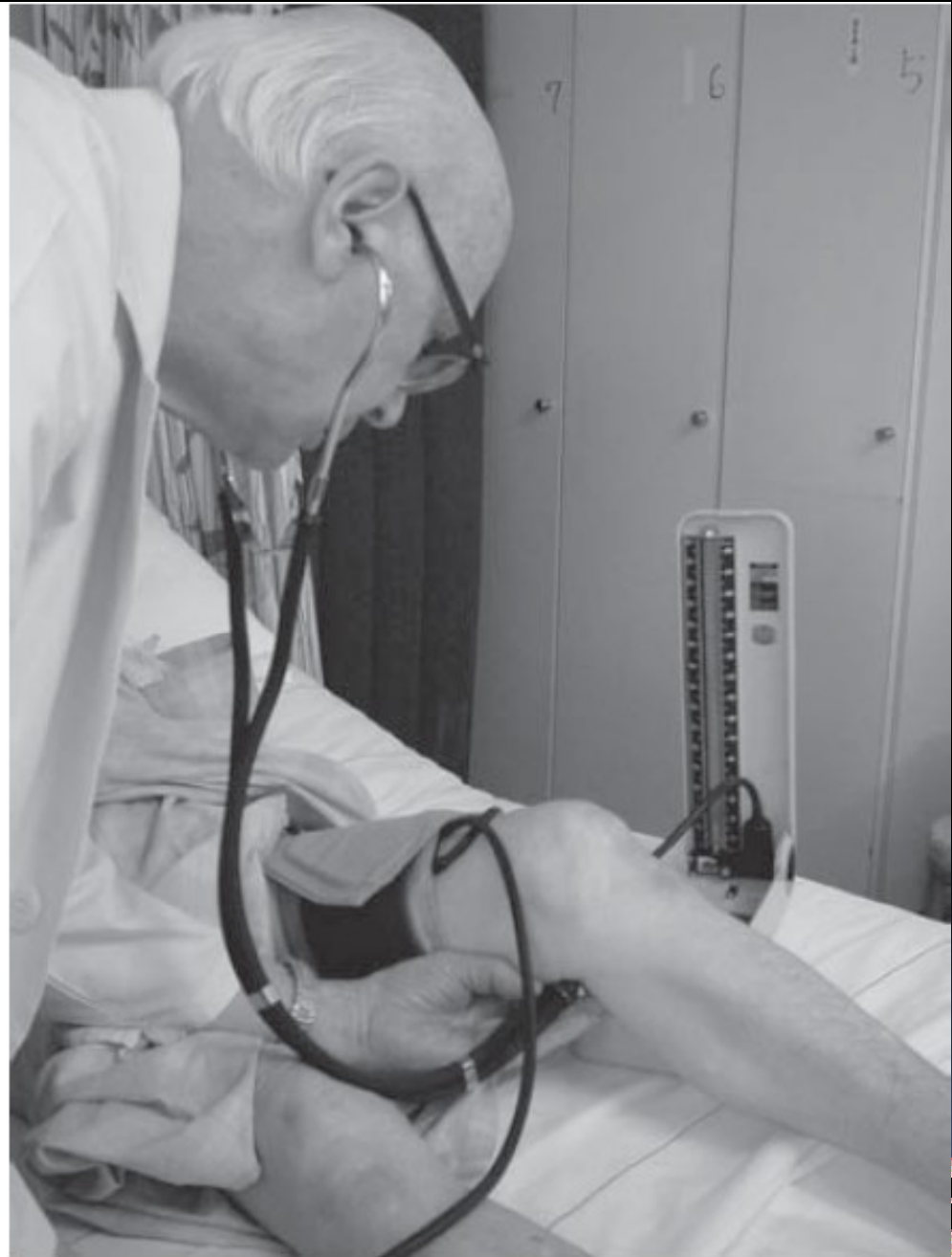
ANS: In the center of the cuff.



Since a stethoscope chest piece cannot be placed completely under a cuff, the best compromise is to slip as much as possible of the diaphragm chest piece under the distal edge of the cuff.

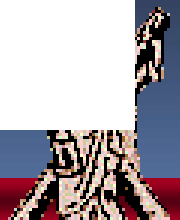


The usual commercial leg cuff, such as that shown here, must be rolled diagonally around the thigh, to keep the edges snug against the skin. The systolic blood pressure in the legs should not be over 20 mmHg higher than in the arms





A convenient method of taking a leg pressure if you do not have a thigh cuff. A pediatric bell should be used to achieve an easy air seal behind the medical malleolus.



Leg Blood Pressure in Aortic Regurgitation

1. How does AR affect the blood pressure in the legs in comparison with that in the arms? What is this sign of AR called?

ANS: AR exaggerates the tendency for the leg systolic pressure to be higher than that in the arms. If the difference is greater than normal, i.e., more than 20 mmHg, it is known as a positive Hill's sign [7].

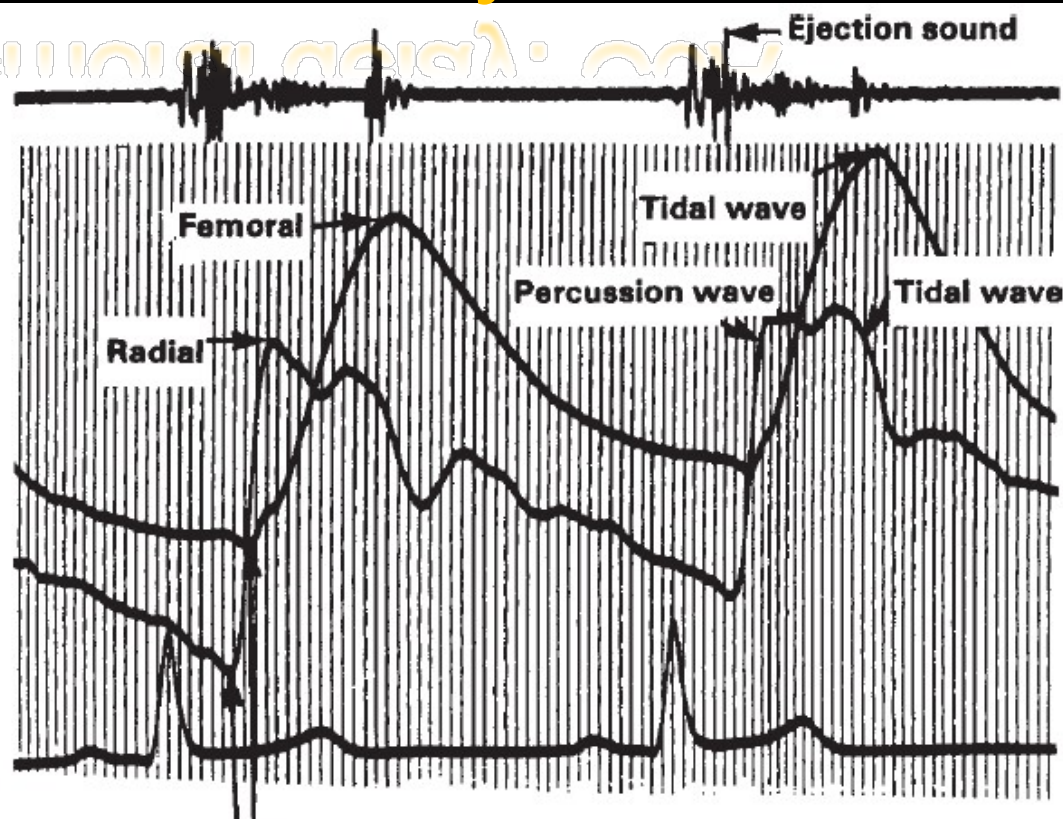
Note: It is easy to remember because blood pressure increases, i.e., goes “uphill” in AR as the examiner goes down the body.

2. Why is the cuff systolic pressure in AR higher in the legs than in the arms?

ANS: One theory is that reflected waves from the periphery sum with forward waves. These summed waves are known as standing waves.



Radio-Femoral delay: CoA



Onset almost simultaneous

Intra-arterial pressure tracings in a patient with coarctation of the aorta show that the onsets of the femoral and radial pulses remain almost simultaneous. In coarctation, a delay in the femoral is felt on palpating both arteries simultaneously because the percussion wave distal to an obstruction is obliterated by an **anacrotic shoulder**, which is imperceptible. Thus only the tidal wave is felt in the femoral artery, whereas the earlier percussion wave is felt in the unobstructed radial artery.



Radio-Femoral delay: CoA

By placing the patient's wrist over his or her femoral artery as you palpate both, you can best perceive the obvious delay of the femoral pulse peak over that of the arm. In using the radials rather than the brachials to test for differences between the arm and leg, you take advantage of the increased rapidity of pulse rise as you palpate more peripherally down the arm.

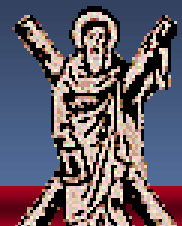
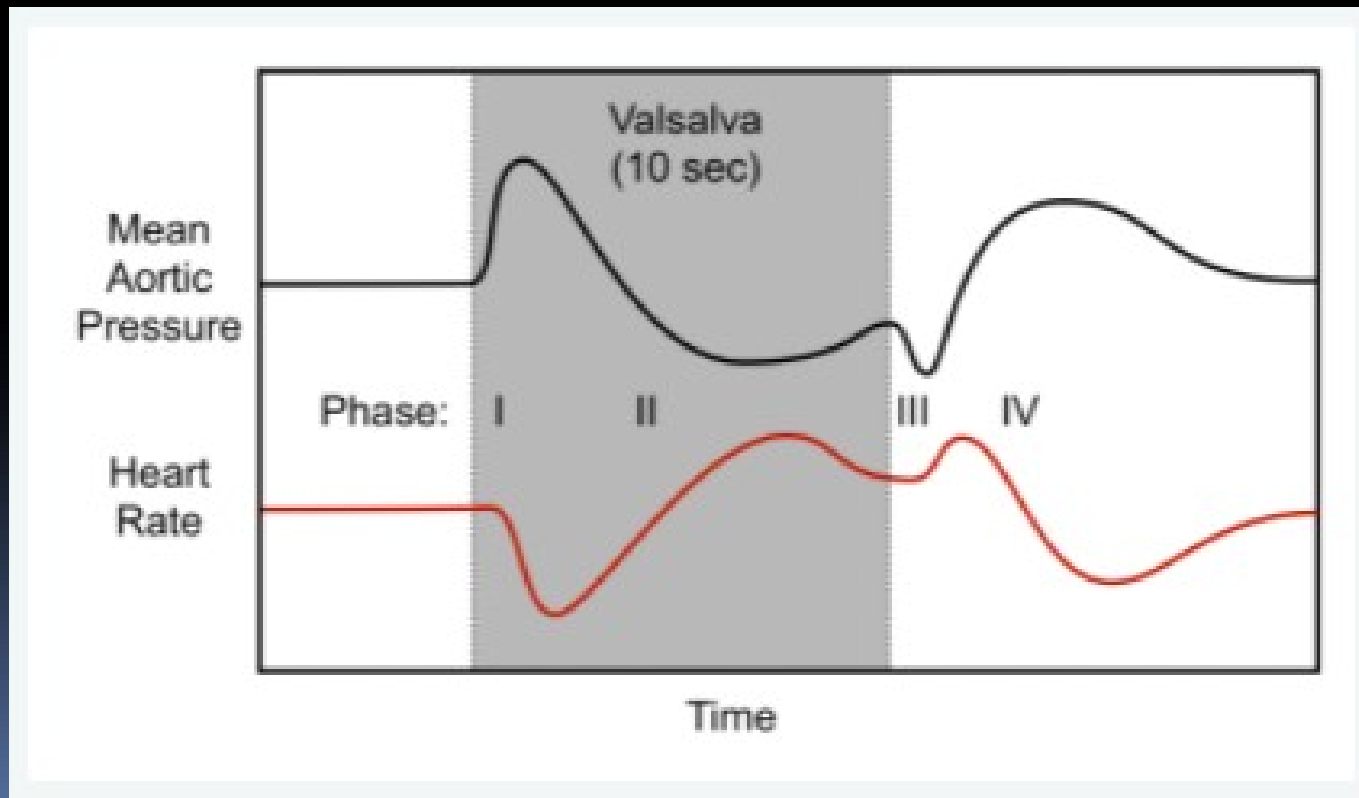
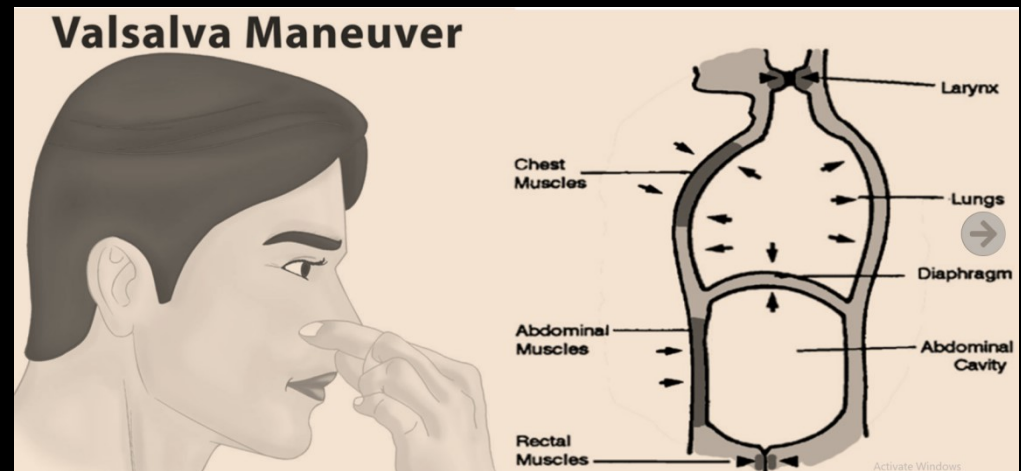


Orthostatic hypotension

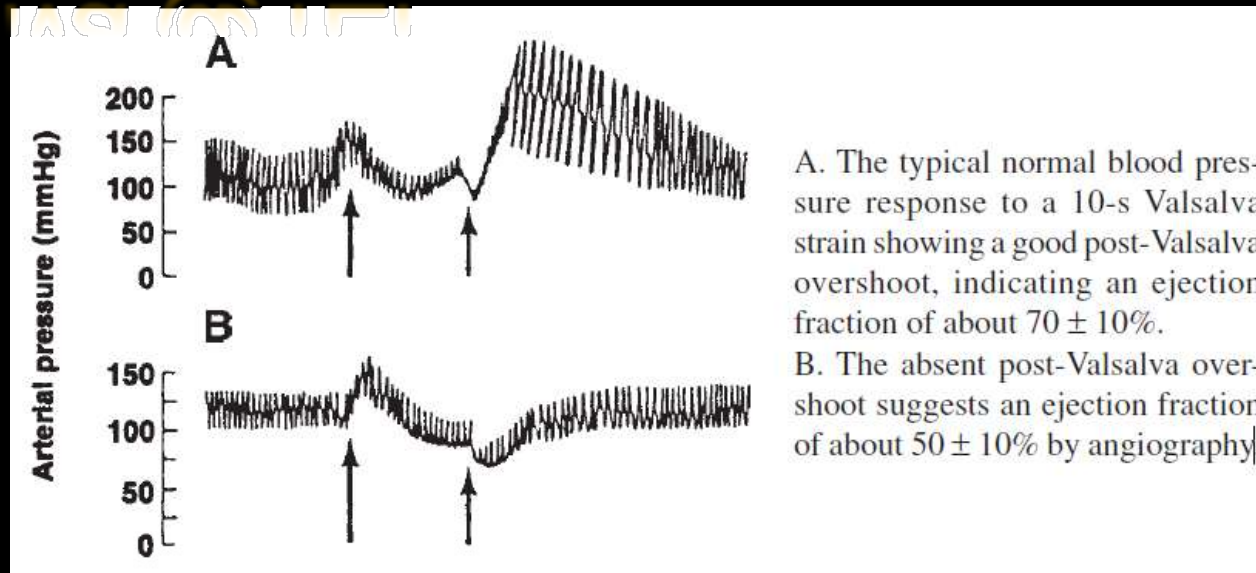
- If a patient has a history of presyncope or syncope on standing (orthostatic hypotension), how long should the patient stand before checking for a fall in blood pressure?
- ANS: If the blood pressure does not fall immediately, you should recheck after 3–5 min of standing.
- *Note: A drop of more than 15 mmHg in systolic pressure or any fall in diastolic pressure suggests hypovolemia or autonomic dysfunction...*



The Valsalva maneuver is credited to Antonio Maria Valsalva(1666-1723), an Italian anatomist, as a technique for expelling pus from ear by expiration against a closed nose and mouth,through an open glottis...



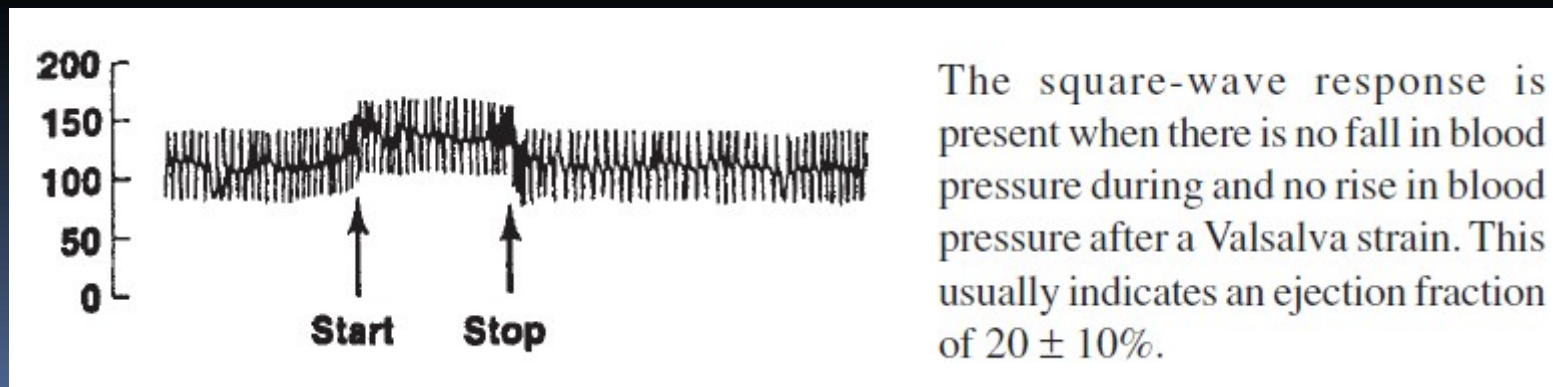
Valsalva @ rEF



A. The typical normal blood pressure response to a 10-s Valsalva strain showing a good post-Valsalva overshoot, indicating an ejection fraction of about $70 \pm 10\%$.

B. The absent post-Valsalva overshoot suggests an ejection fraction of about $50 \pm 10\%$ by angiography.

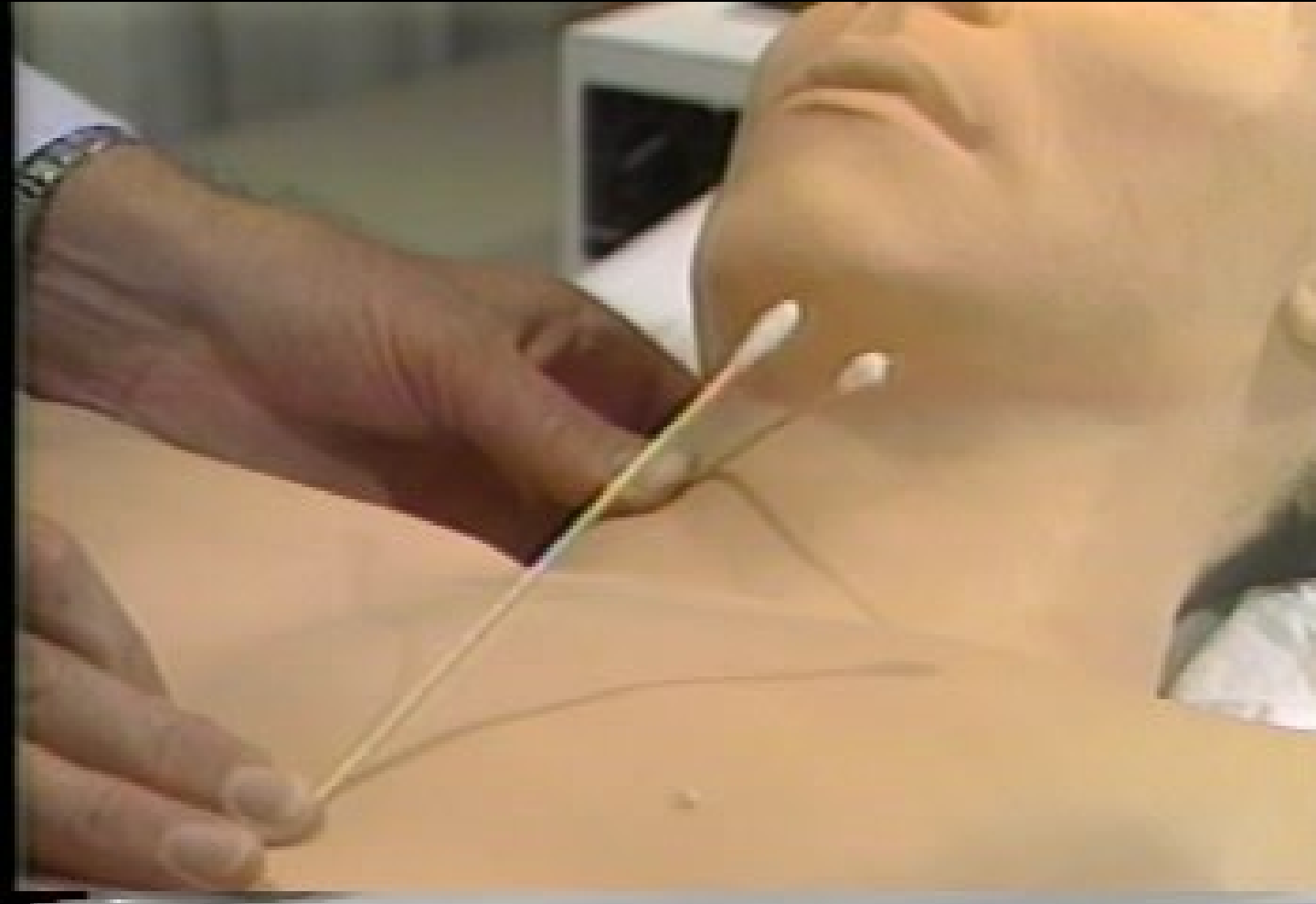
This is partly due to the excess lung blood volume in the congested lungs, which continues to empty into the LV during the entire 10 s of strain



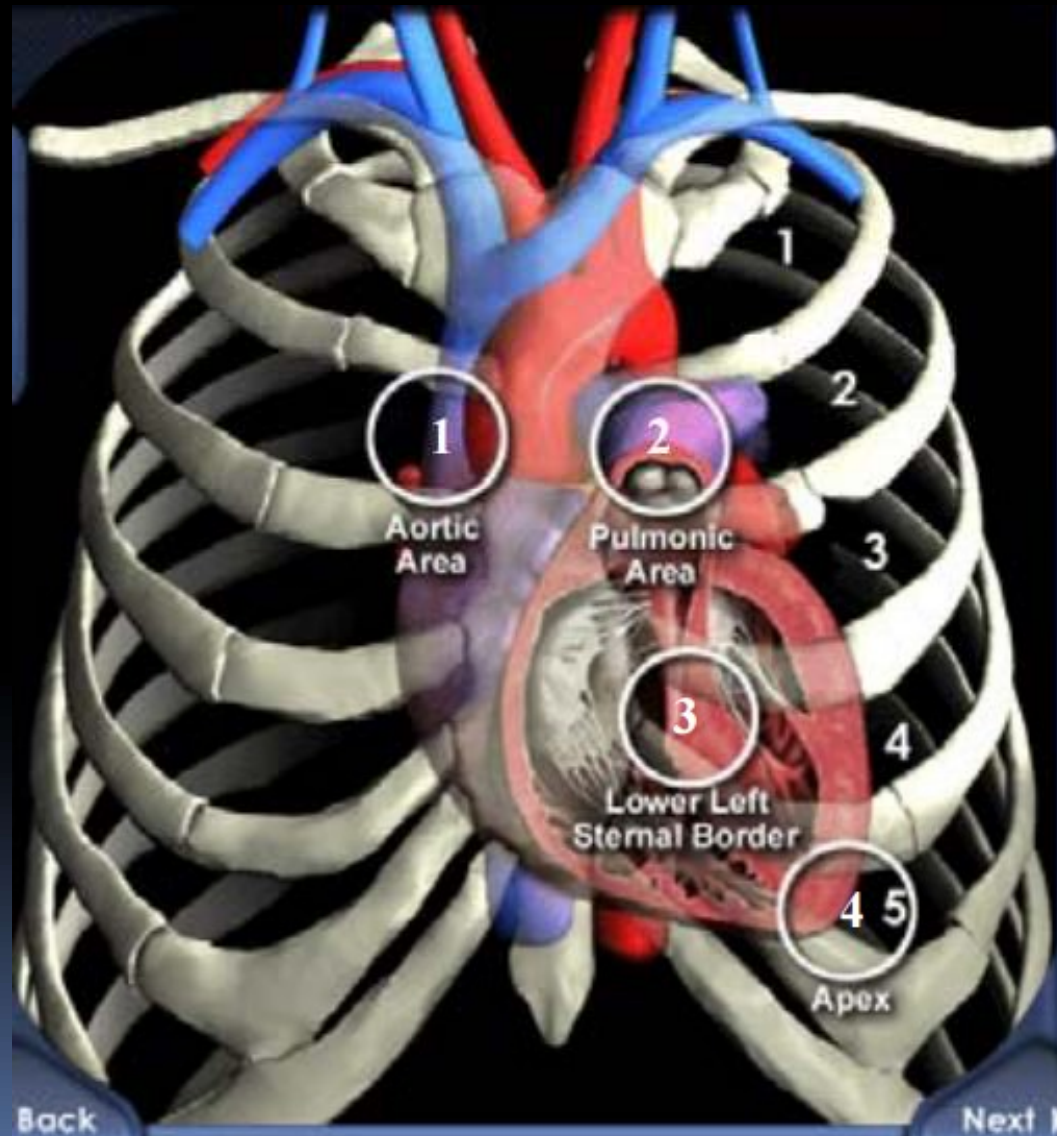
The square-wave response is present when there is no fall in blood pressure during and no rise in blood pressure after a Valsalva strain. This usually indicates an ejection fraction of $20 \pm 10\%$.



Επισκόπηση Προκαρδίου

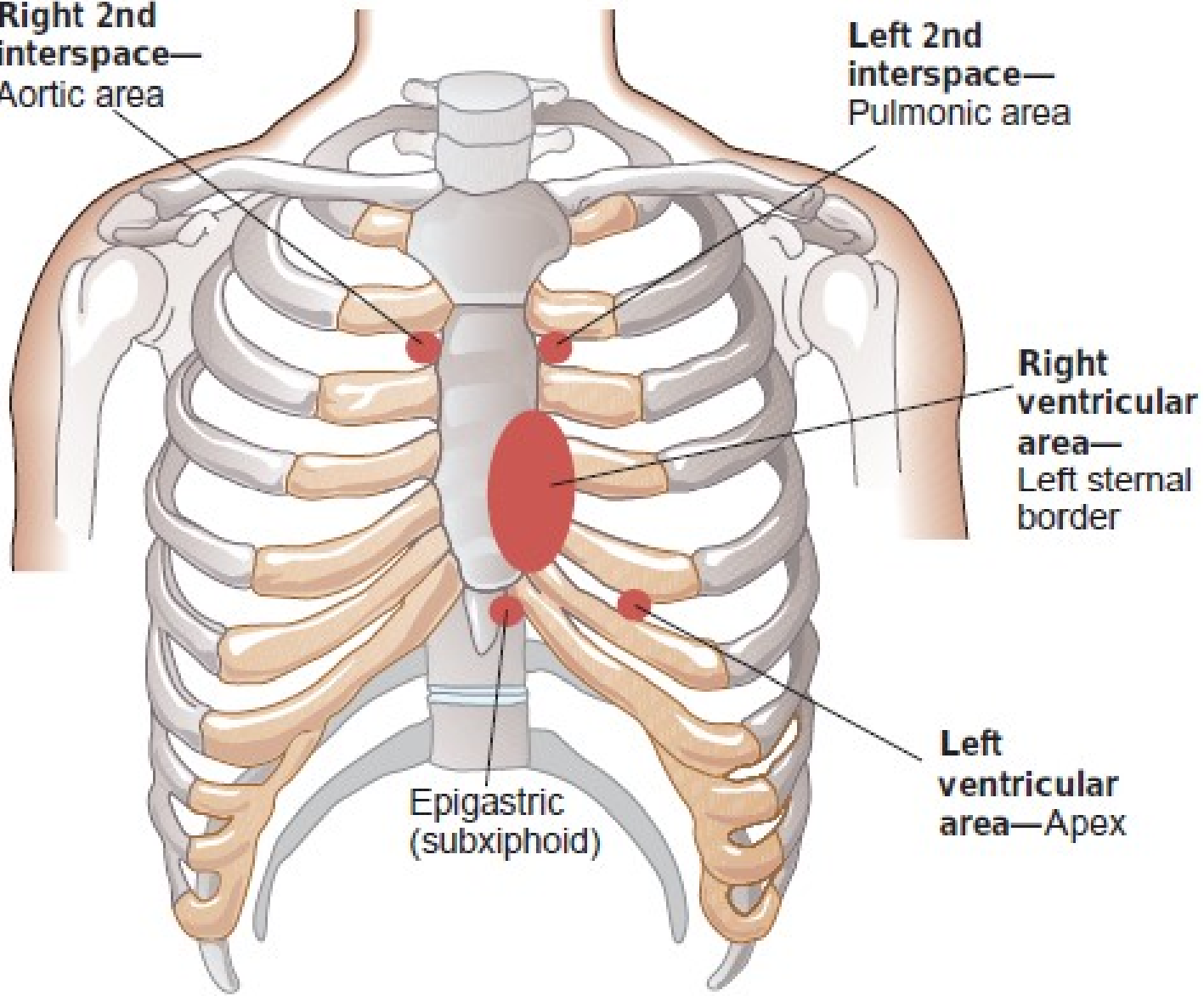


Ψηλάφηση Προκαρδίου



**Right 2nd interspace—
Aortic area**

**Left 2nd interspace—
Pulmonic area**



**Right
ventricular
area—
Left sternal
border**

**Left
ventricular
area—Apex**

**Epigastric
(subxiphoid)**

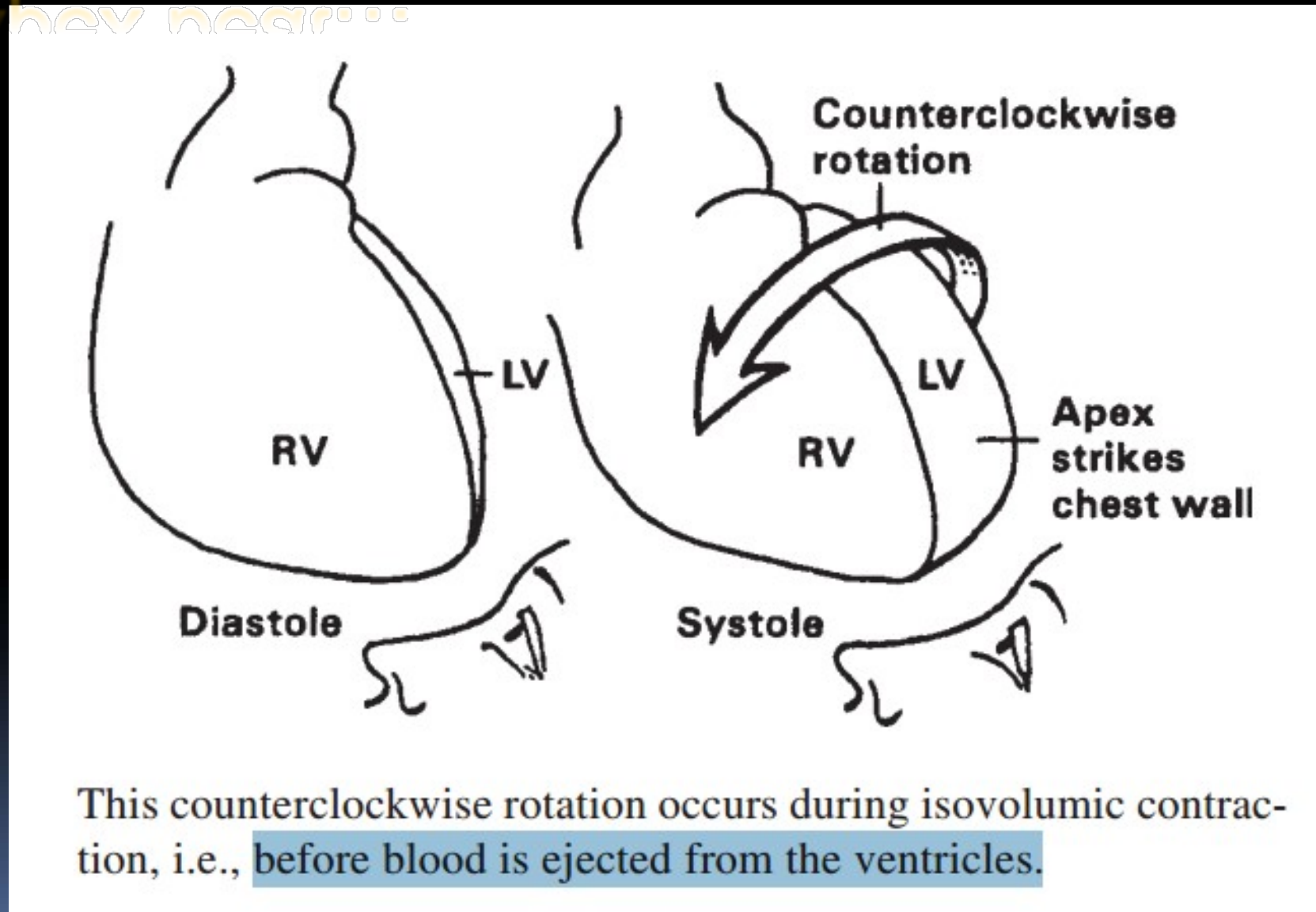


Κορυφαία ώση (Apex Beat...)

- Traditionally, the term *apical impulse* refers to the left ventricular (LV) impulse
- DDX: *point of maximal impulse (PMI)*
- *It occurs at the onset* of LV ejection and is normally located within the left midclavicular line in the fifth intercostal space



Apex beat...



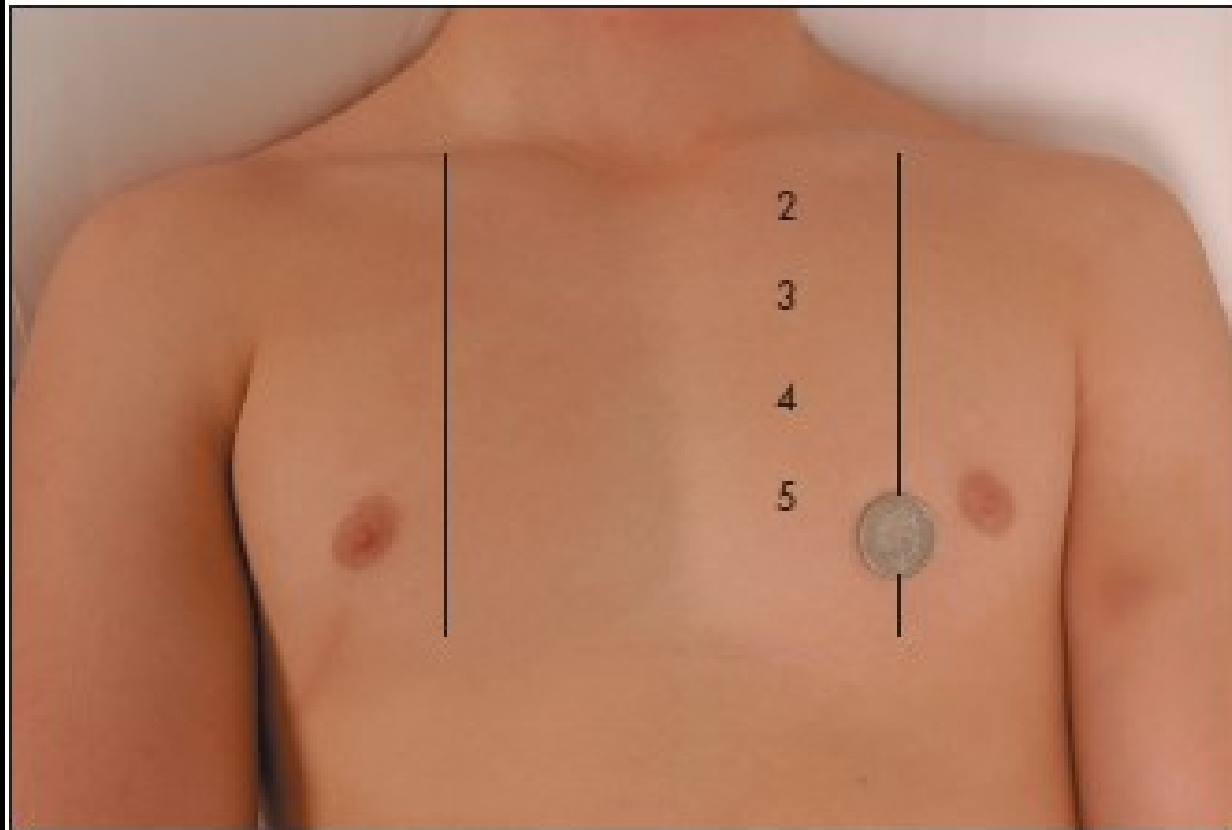
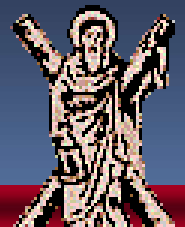
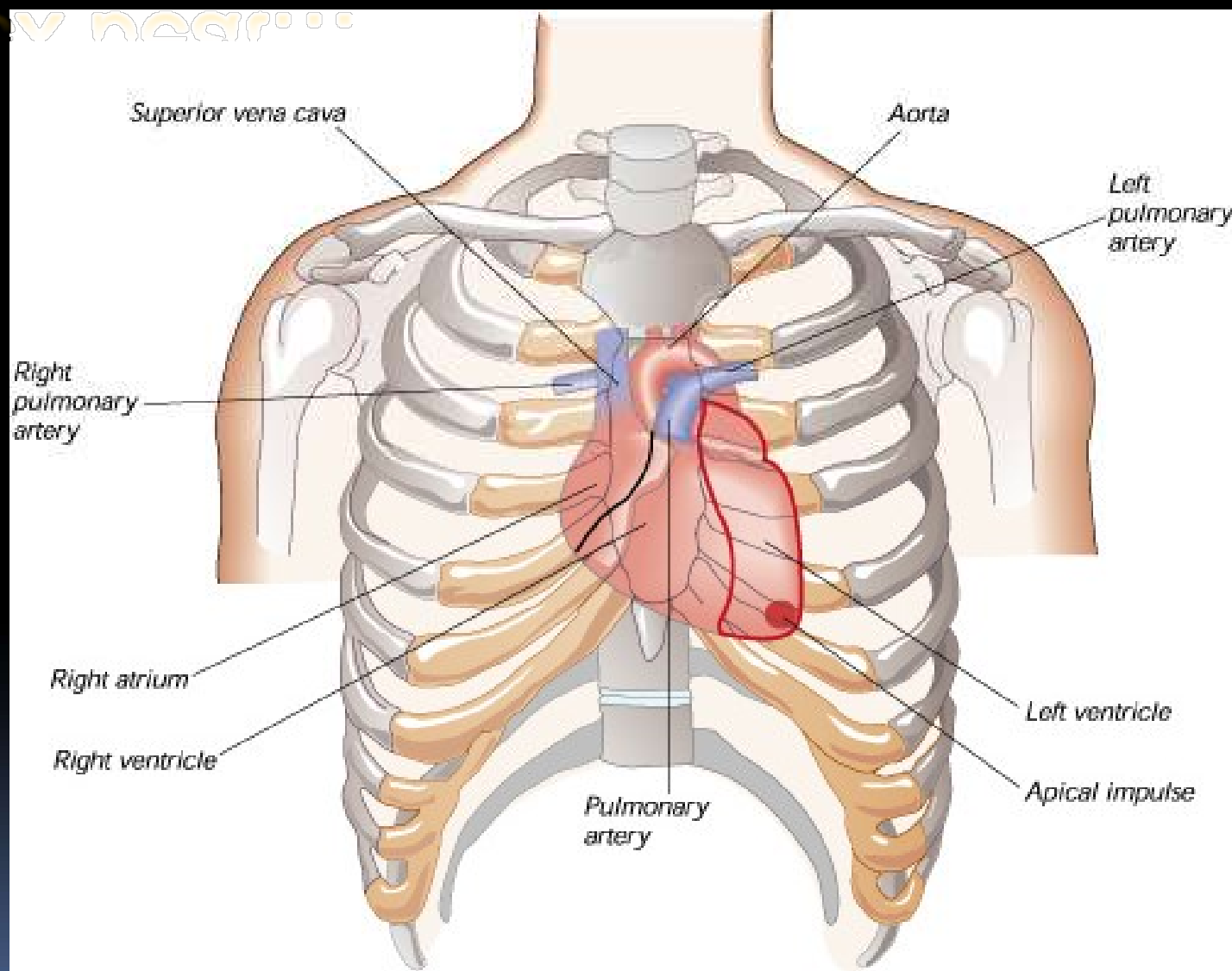


Figure 5.26 The apex beat
The coin is over the apex. The intercostal spaces are numbered. Vertical lines show right and left midclavicular and left anterior axillary lines. Care must be taken in identifying the midclavicular line; the inter-observer variability can be as much as 10 centimetres!





Apex beat...



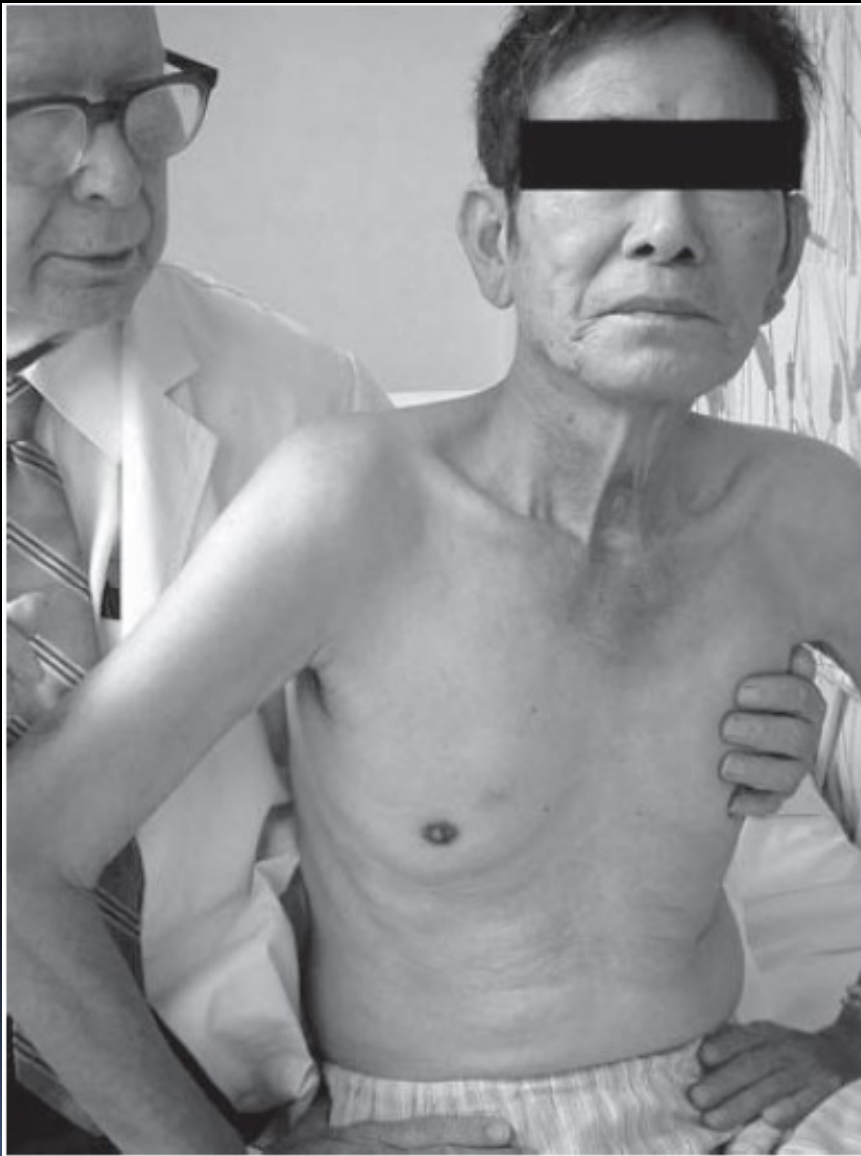
Οδηγά σημεία...





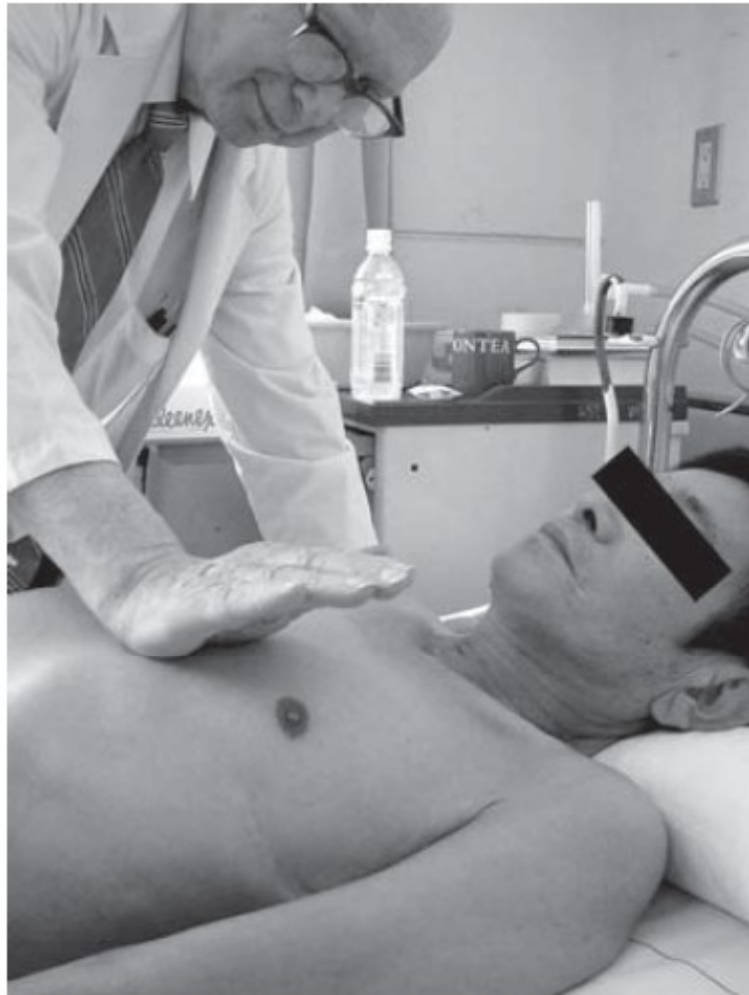
Note that the apex beat is palpable in only about 50% of adults





A posterior in addition to an anterior approach may allow you to feel more subtle movements, especially if your left hand is more sensitive than your right.





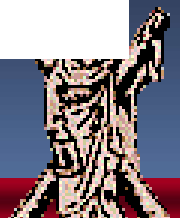
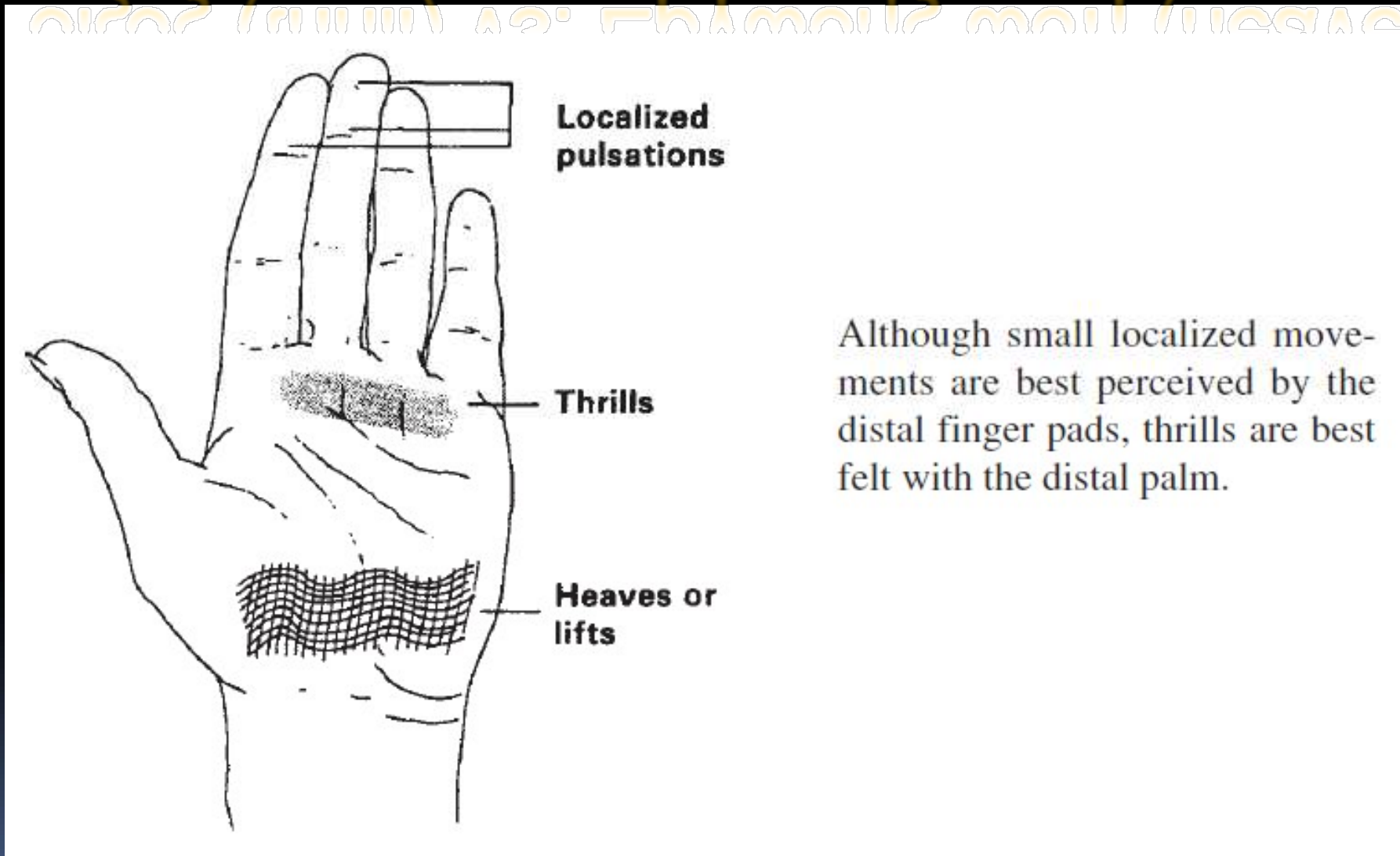
In this patient with mitral stenosis, the physician is palpating the movement of a large RV, which was producing a right ventricular rock, i.e., a sustained left parasternal impulse and lateral retraction.

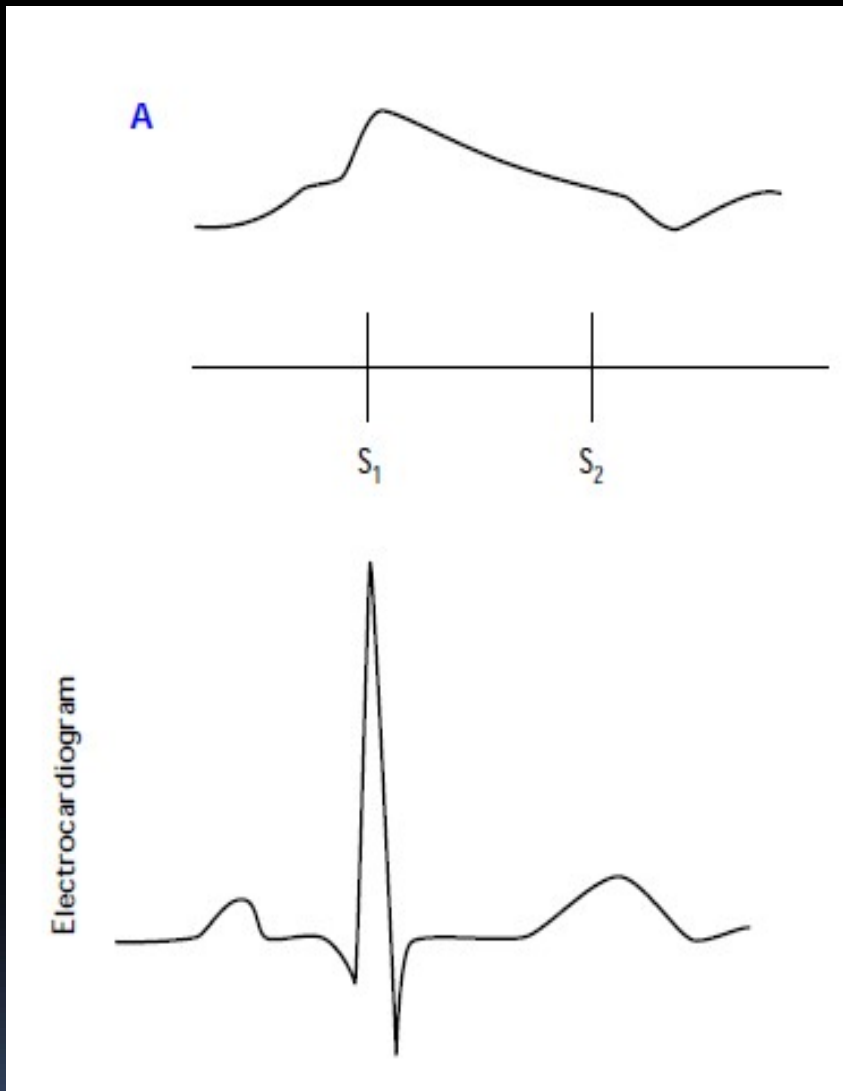


If your fingernails are long enough to cause discomfort when you push up into the epigastrium with your fingers, you may use the pad of your thumb to test for RV pulsations during a deeply held inspiration.

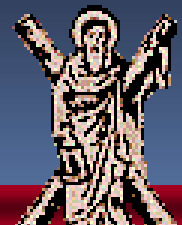


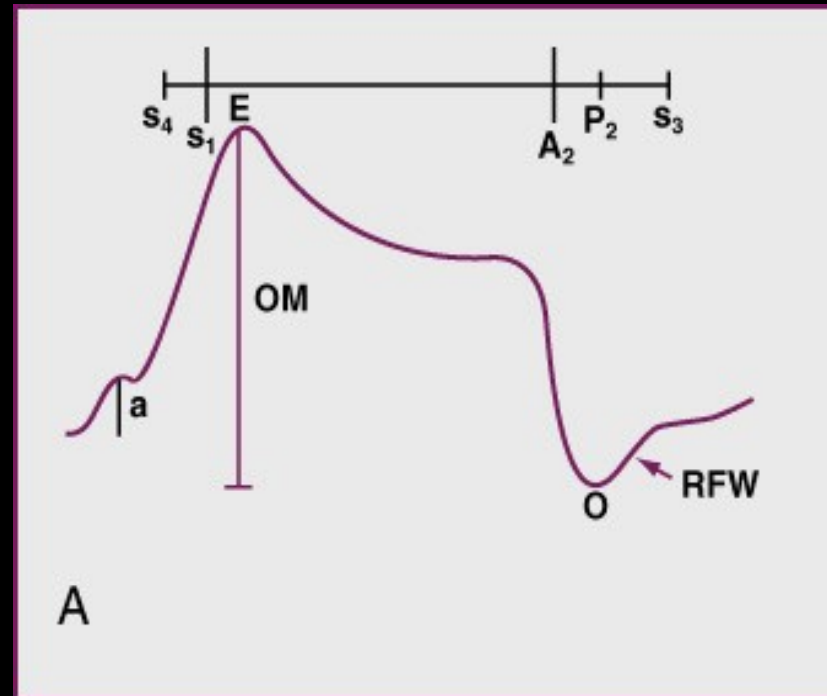
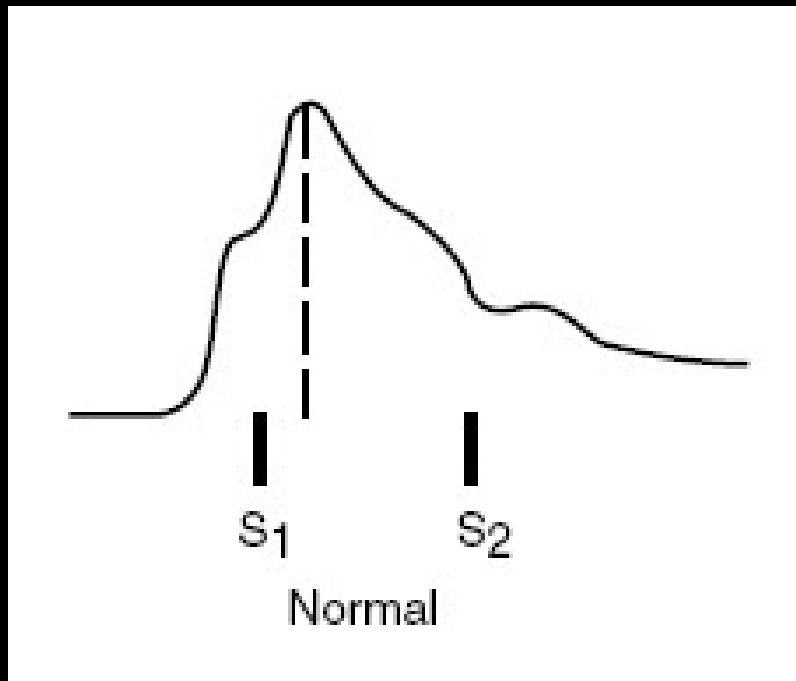
Ροίζος (thrill) vs. Εργώδης ώση (heave)





- It is worth noting that the palpable apex beat is not the anatomical apex of the heart but a point above it.
- At the time the apex beat is palpable, the heart is assuming a more spherical shape and the apex is twisting away from the chest wall.
- The area above the apex, however, is moving closer to the chest and is palpable



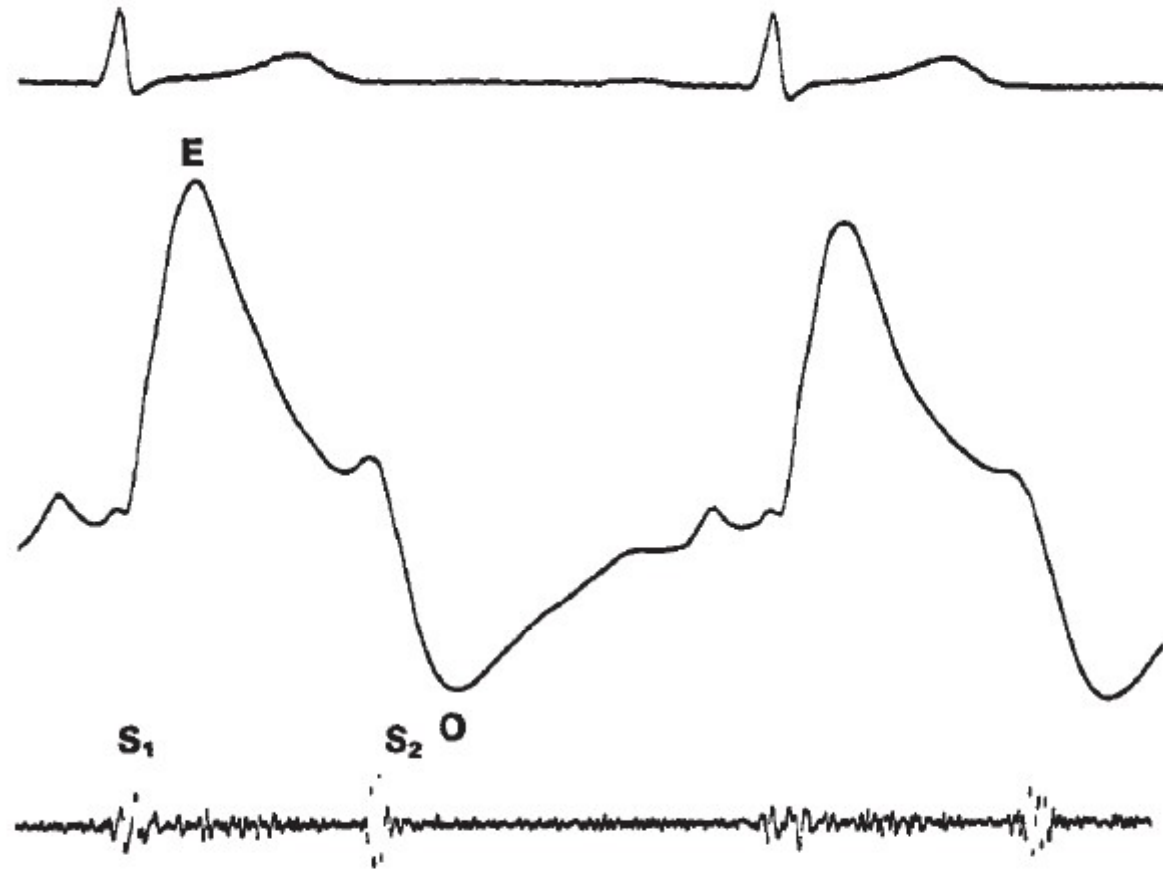


Φυσιολογικό κορυφογράφημα: Κύμα a < 15 % συνολικού ύψους.

Σημείο E => αρχή συστολής LV. Ακολουθεί σταδιακή υποχώρηση ως το σημείο O (διάνοιξη MV).

Τα δάκτυλα «νοιώθουν» στιγμιαία ώση και κατόπιν την E-O απομάκρυνση ως τον S₂...





This depicts a normal apex impulse (apex cardiogram, or ACG) recorded over the apex beat with the subject in the left lateral decubitus position. The fingers feel the E–O slope as a purely systolic retraction. The S_2 –O portion of the slope is so short and rapid that the O nadir is perceived as ending at the S_2 . The end-systolic hump of the ACG is not perceived by palpation as interrupting the E–O slope.



Apex:

- Palpable in 1 of 5 adults < age 40
- Best felt with fingertips or finger pads

Normal Location:

- No more than 10 cm from mid-sternal line in the supine position
- Left decubitus position not reliable for apical location

Normal Size:

- No larger than 3 cm (about 2 finger breadths)



The normal apex beat is not felt in two interspaces during the same phase of respiration.



A normal apical impulse is no larger than about 1½ fingertip widths (3 cm).



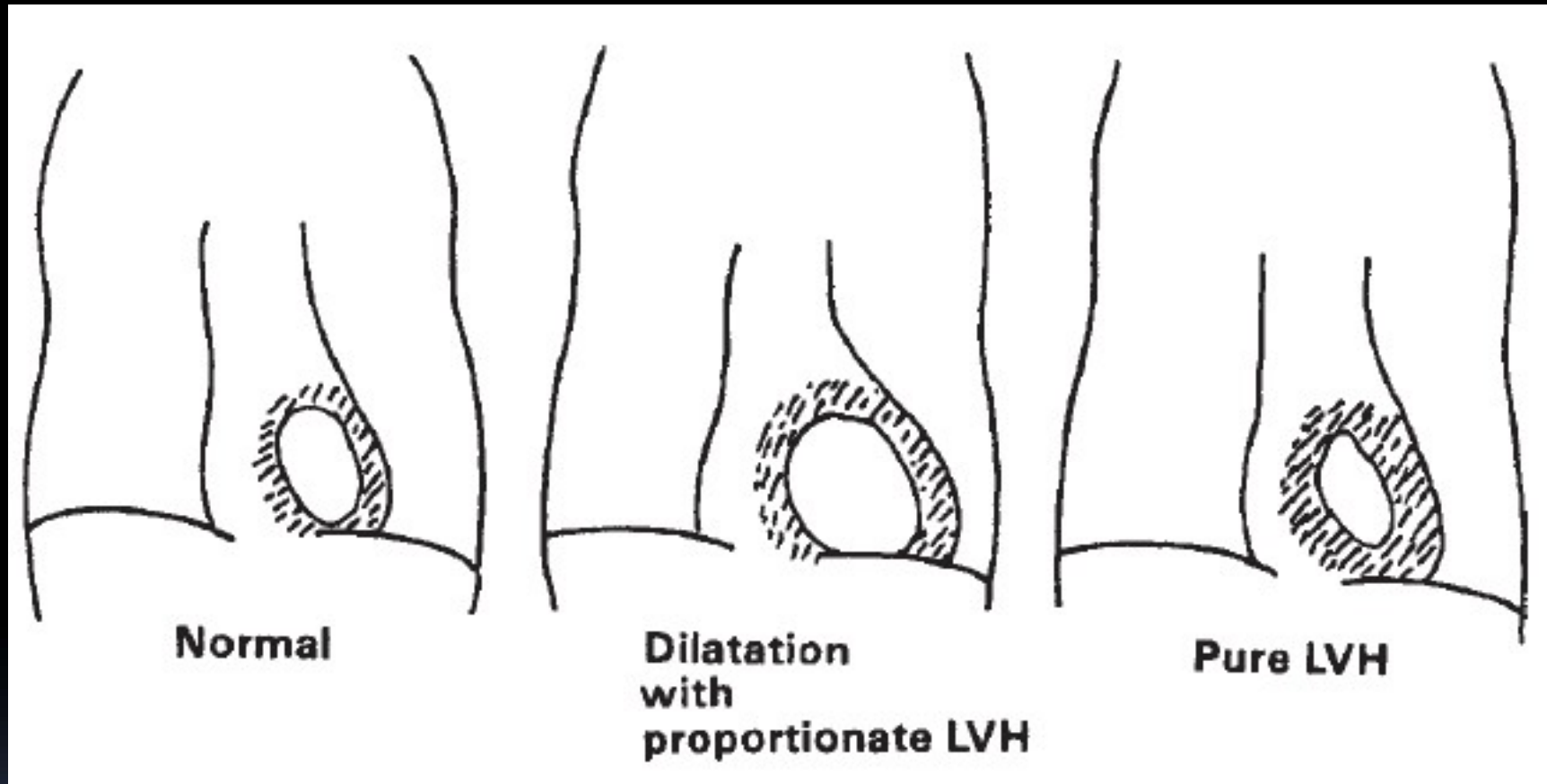
- Διάταση LV:
Μετατόπιση > 10 cm
πλαγίως, ευαίσθητο
αλλά μη ειδικό σημείο
- Στην left lateral
decubitus θέση,
διάμετρος > 3 cm πιο
αξιόπιστο σημείο.



Διαταραχές της κορυφαίας ώσης...

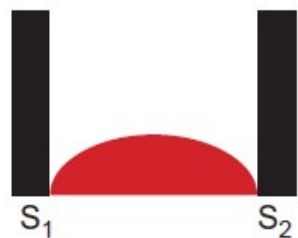
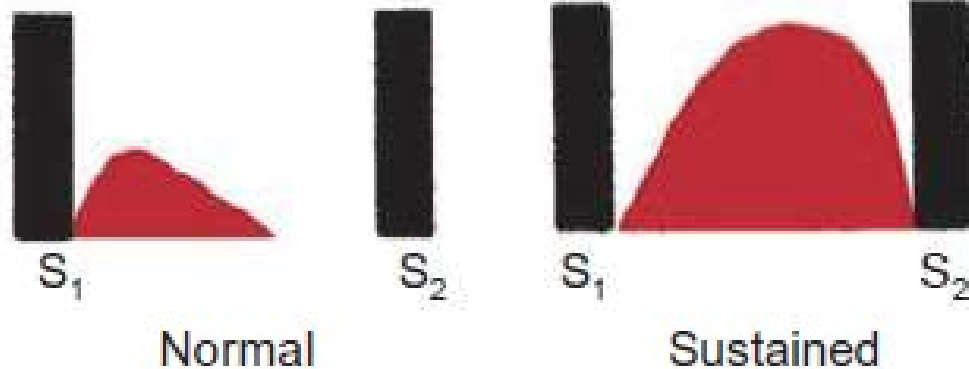
- **Εντόπιση:** Μετατόπιση → Διάταση και/ή LVH
- **Διάμετρος:** Ευρεία → Διάταση LV
- **Διάρκεια:** Παρατεταμένη → LVH, HFrEF
- **Ύψος:** Υπερκινητική → Φόρτιση όγκου



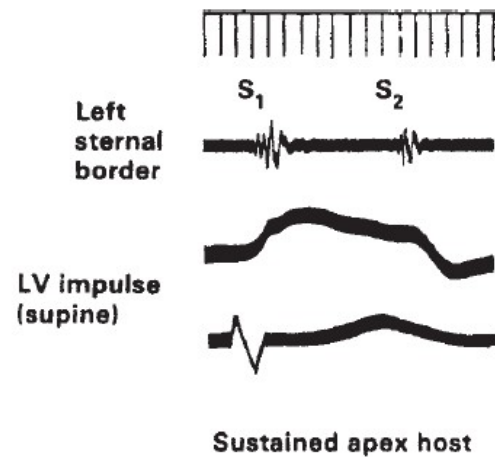


Διαταραχές της κορυφαίας ώσης...

- Παρατεταμένη => Φόρτιση πίεσης (Υπερτροφία)

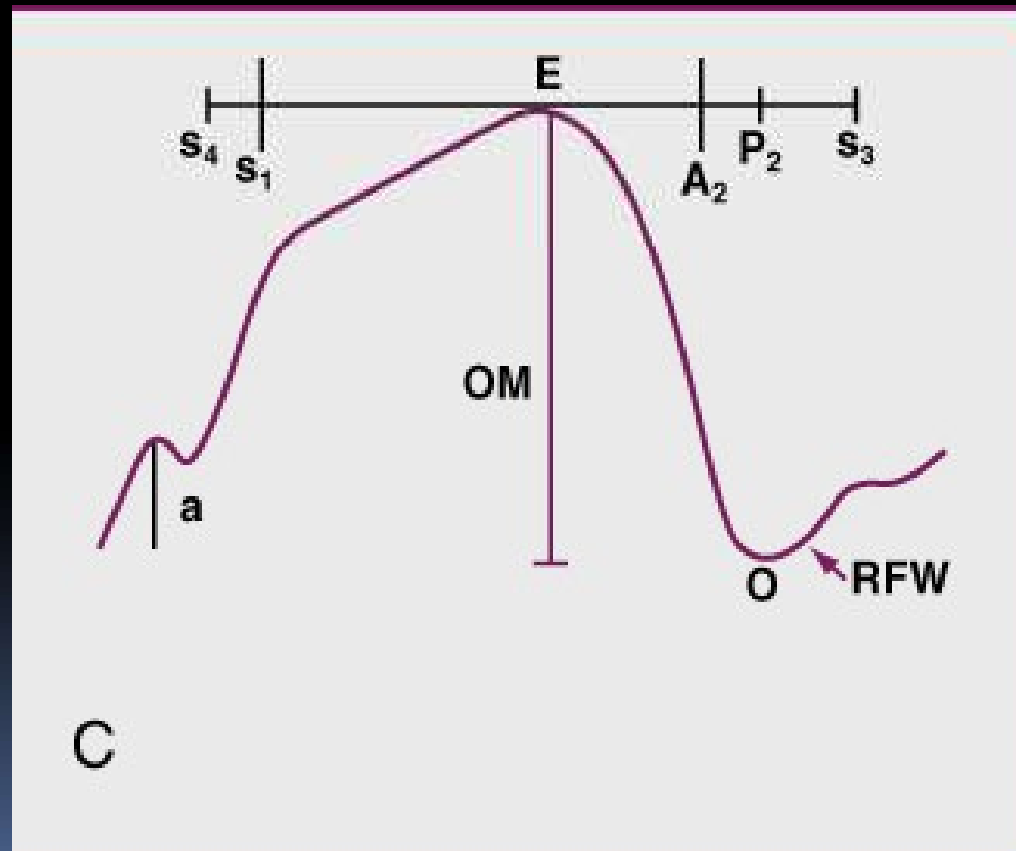


A sustained low-amplitude (hypokinetic) impulse is seen in *dilated cardiomyopathy*.



Διαταραχές της κορυφαίας ώσης...

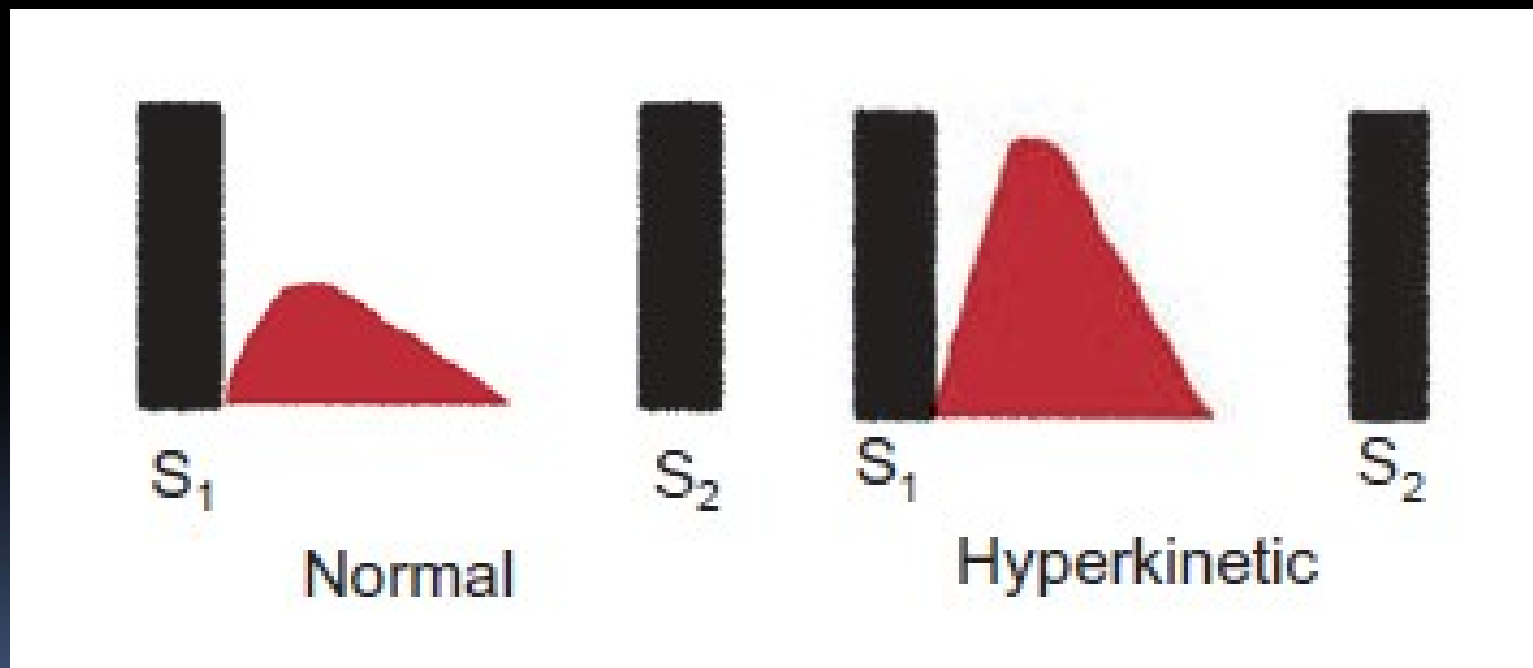
- **Severe AS, HTN, HCM:** Δυνατή, Μη μετατοπισμένη (ή λίγο...), Παρατεταμένη (>50% συστολής), ενίοτε διπλή ($\pm S_4$)

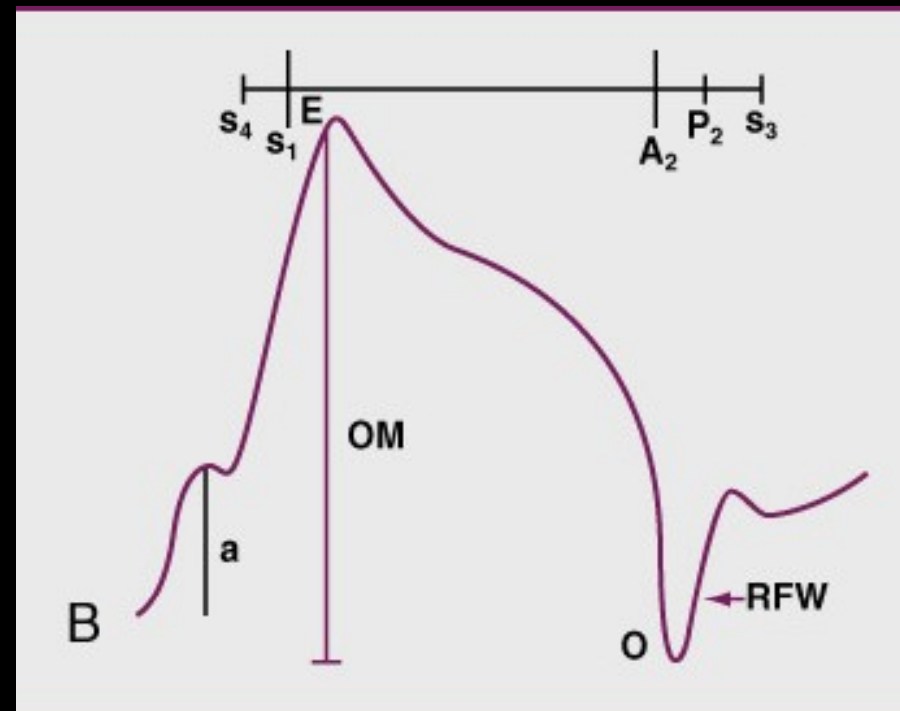
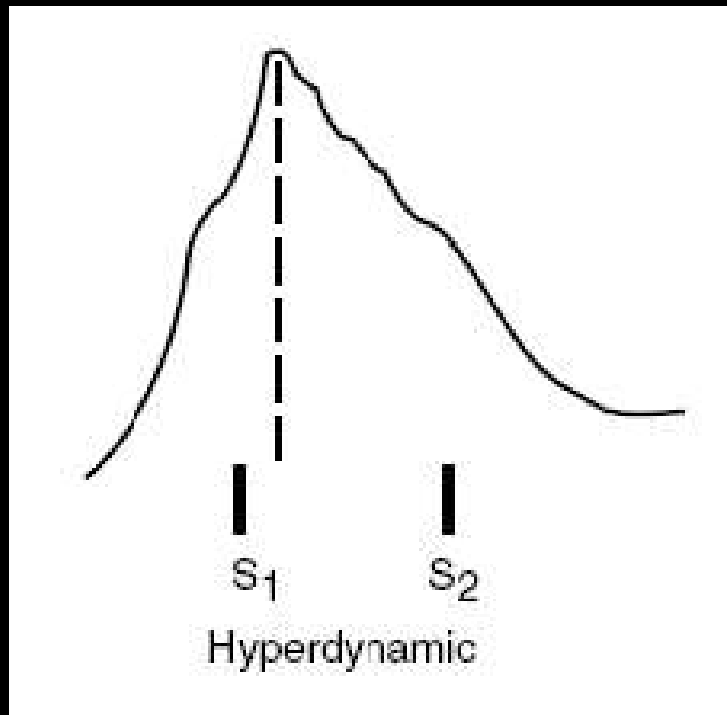


Διαταραχές της κορυφαίας ώσης...

παιδαγωγός μηδ κορυφαία? μου?...

- Υπερκινητική => Φόρτιση όγκου



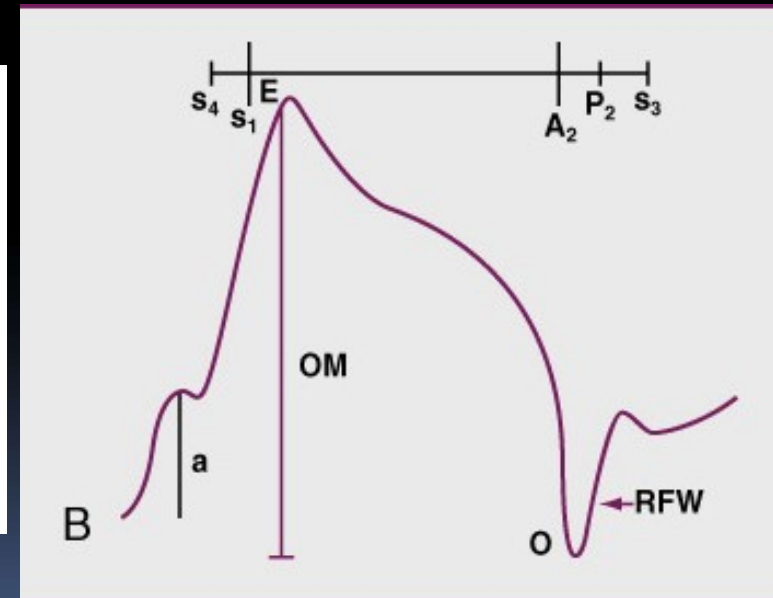
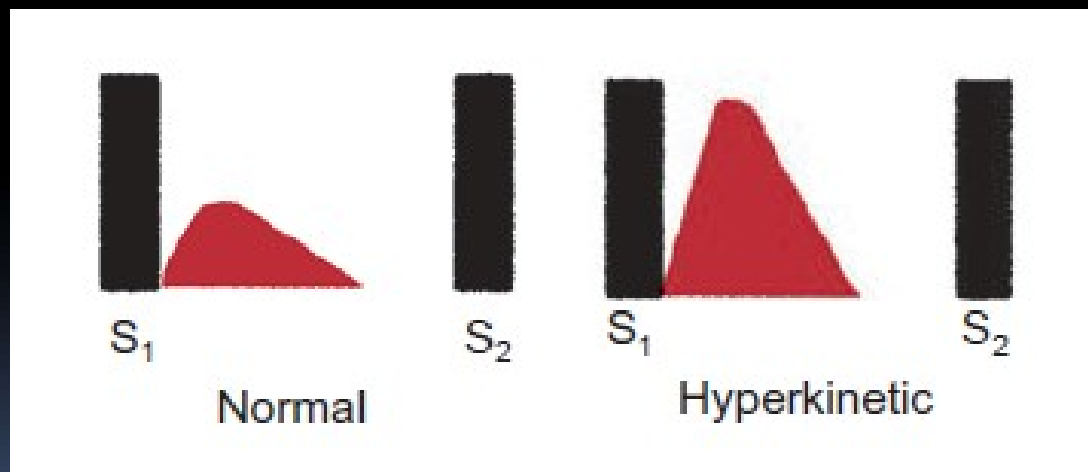


Υπερδυναμική ώση: LV volume overload (MR & AR...). Ενίσχυση a (ψηλαφητό) συνήθως σημαίνει \uparrow LVEDP. Συνυπάρχει S₃...



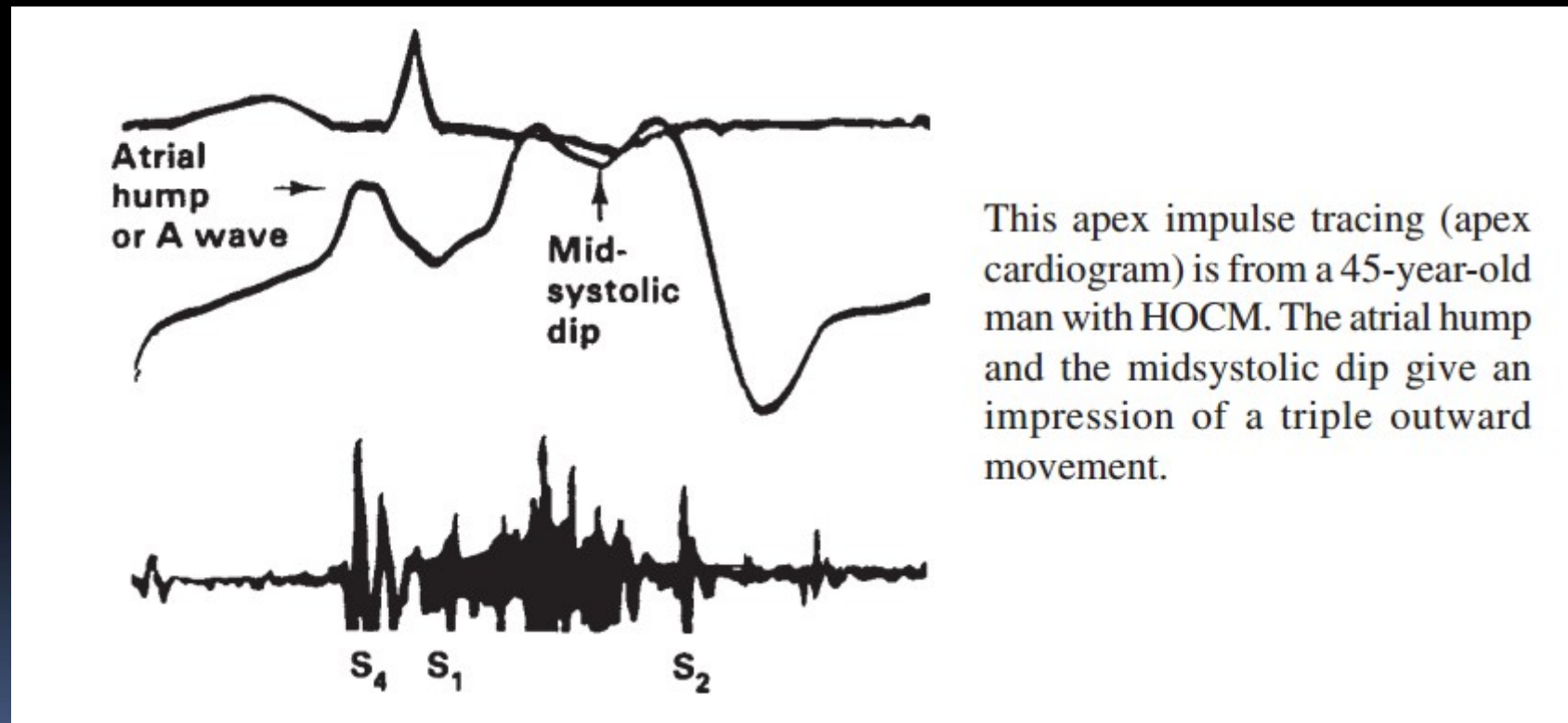
Διαταραχές της κορυφαίας ώσης...

- Severe AR/MR: Μετατοπισμένη, ευρεία, υπερκινητική, <50% συστολής, \pm S3

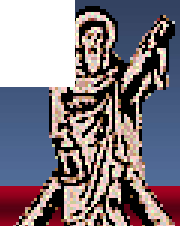


Διαταραχές της κορυφαίας ώσης...

- **Severe HOCM**: Μη μετατοπισμένη, Παρατεταμένη (>50% συστολής), ενίοτε διπλή (\pm S4), ή τριπλή!



This apex impulse tracing (apex cardiogram) is from a 45-year-old man with HOCM. The atrial hump and the midsystolic dip give an impression of a triple outward movement.



Analysis of the type of Apex beat

Is it forceful?

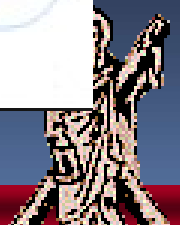
Yes

Is it sustained?

Yes

**Heaving
Apex**

Will be
displaced too.
Localized apex
generally.
Ventricular
hypertrophy
(pressure
overload)



Analysis of the type of Apex beat

Is it forceful?

Yes

Is it sustained?

No

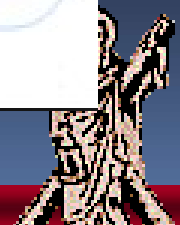
Yes

**Hyperdynamic
Apex**

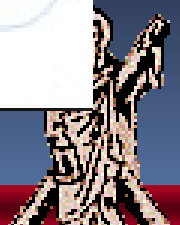
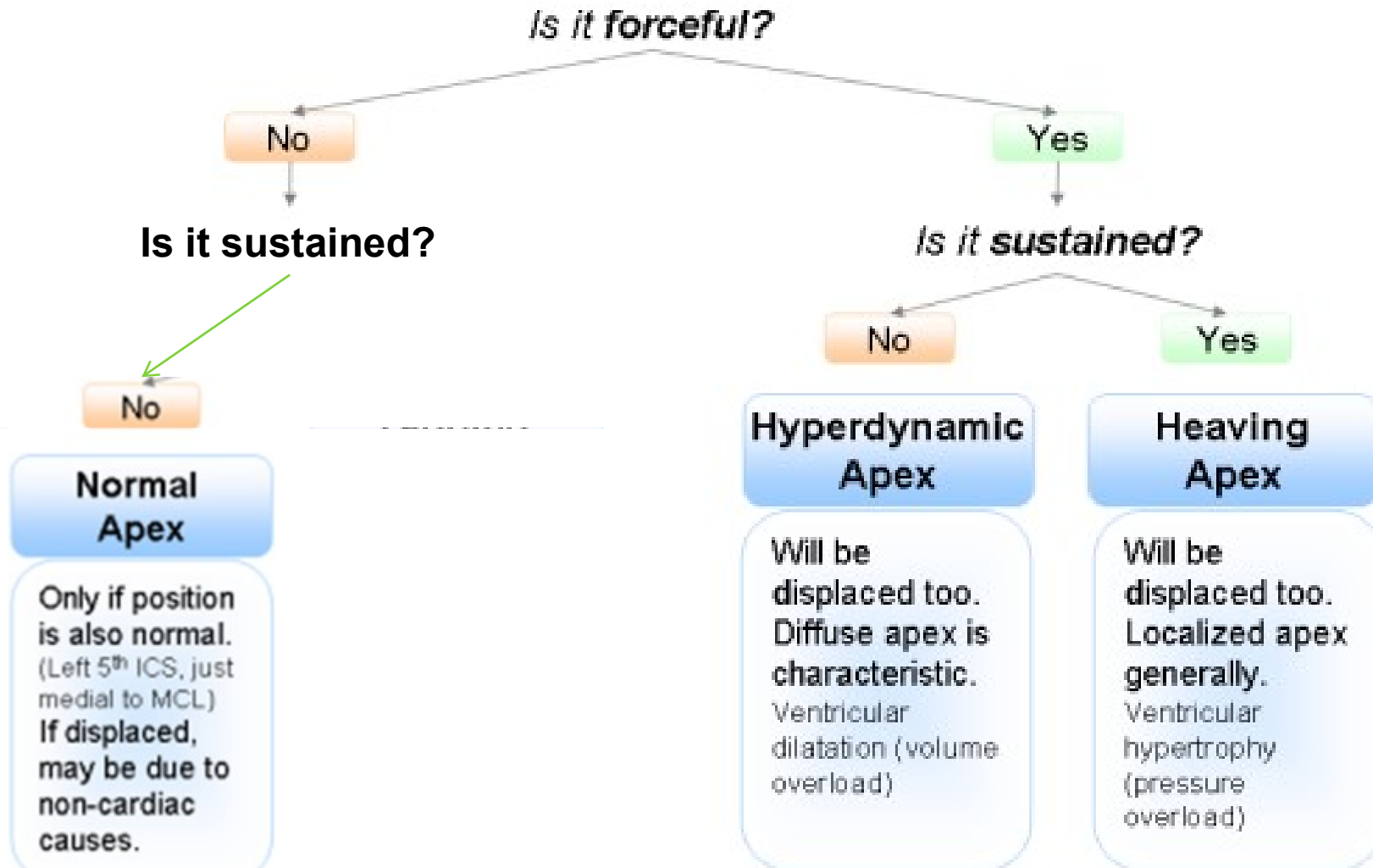
Will be displaced too.
Diffuse apex is characteristic.
Ventricular dilatation (volume overload)

**Heaving
Apex**

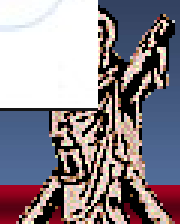
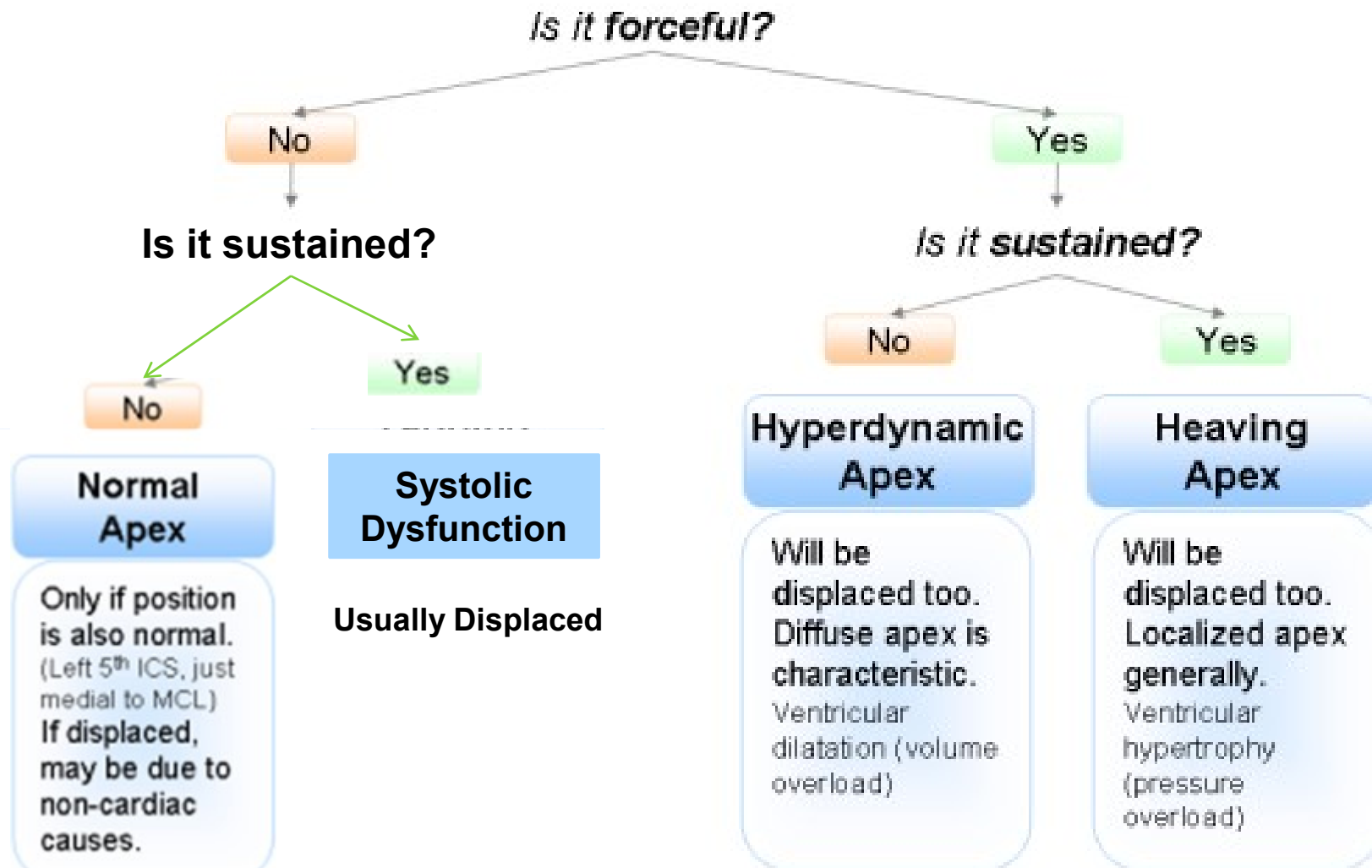
Will be displaced too.
Localized apex generally.
Ventricular hypertrophy (pressure overload)

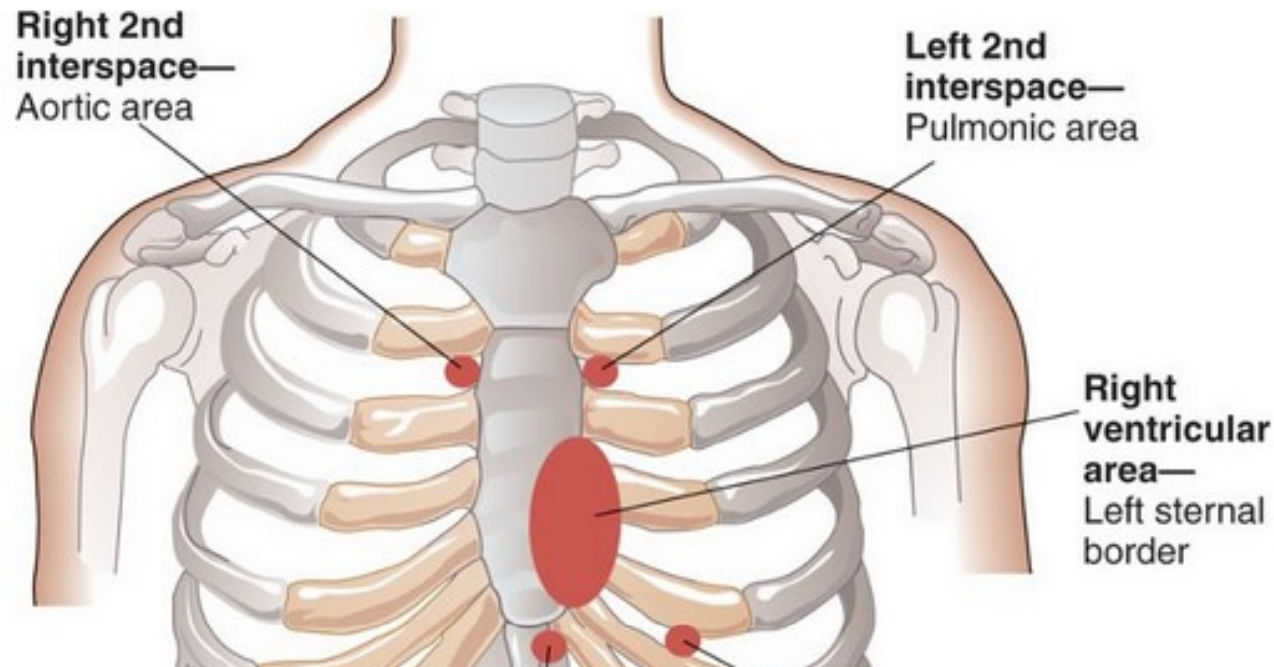


Analysis of the type of Apex beat



Analysis of the type of Apex beat





Parasternal:

- Lift: RV enlargement or severe MR
- Thrill: VSD, HOCM (IHSS)
- Palpable P2 (ULSB): pulmonary hypertension





Figure 5.28 Feeling for the parasternal impulse

A *parasternal impulse* may be felt when the heel of the hand is rested just to the left of the sternum with the fingers lifted slightly off the chest. Normally no impulse or a slight inward impulse is felt.

In cases of RV enlargement or severe LA enlargement, where the right ventricle is pushed anteriorly, the heel of the hand is lifted off the chest wall with each systole.





In obstructive pulmonary disease, hyperinflated lung may prevent palpation of an enlarged right ventricle in the left parasternal area. The impulse is felt easily, however, high in the epigastrium where heart sounds are also more audible.





Figure 5.29 Palpating the base of the heart

Palpation with the fingers over the pulmonary area may reveal the palpable tap of pulmonary valve closure (*palpable P₂*) in cases of pulmonary hypertension

