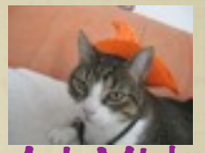
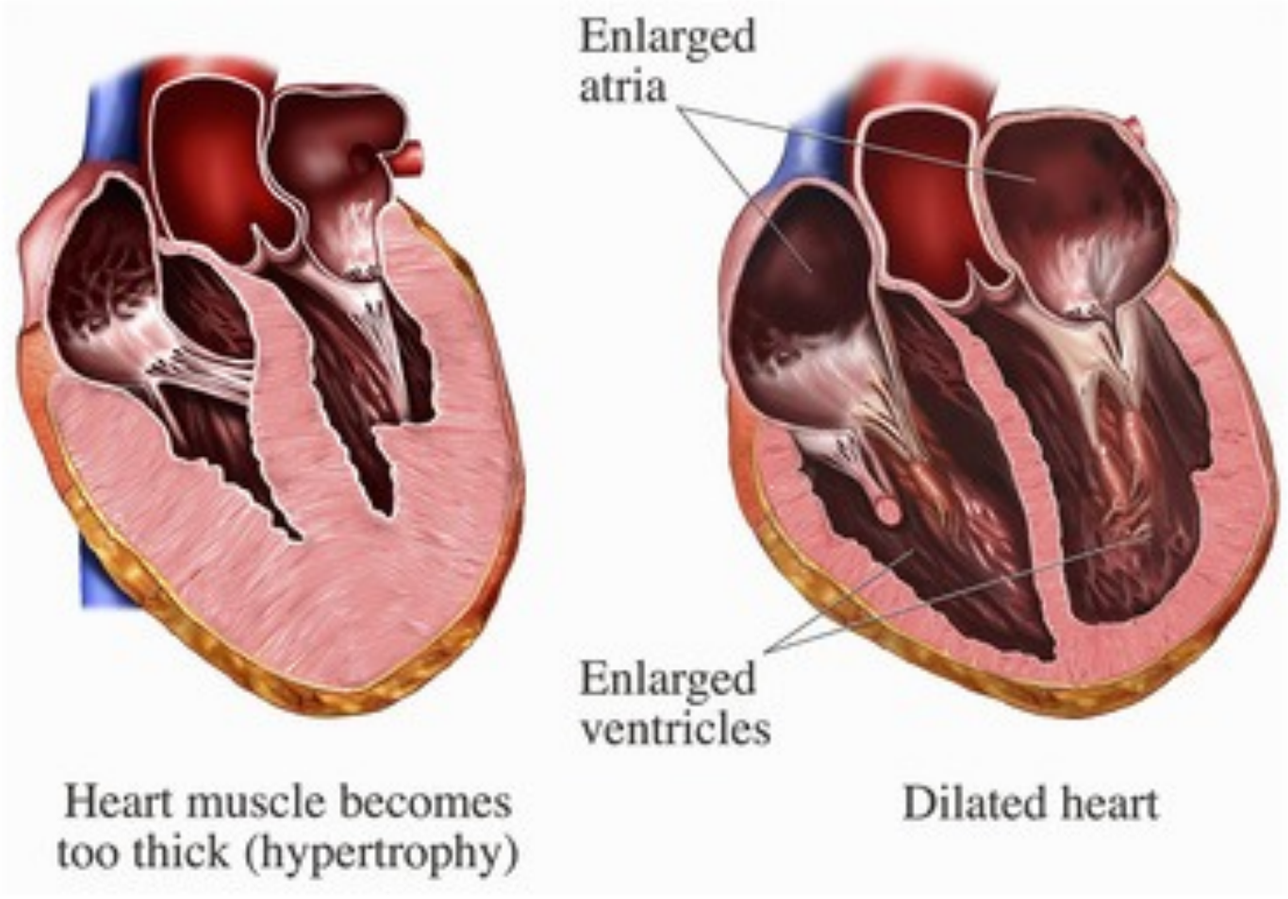
Hypertrophy and Enlargement

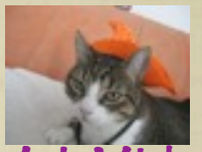
Hypertrophy & Enlargement





- HYPERTROPHY means increase in chamber wall thickness.
- ENLARGEMENT refers to increase in chamber size.
- On EKG, H&E show low sensitivity and a higher specificity for both atria and ventricles
- We use always the term ENLARGED or ABNORMAL for ATRIA while for VENTRICLES we use HYPERTROPHY or ENLARGED depending on the findings on echocardiography.

Hypertrophy & Enlargement



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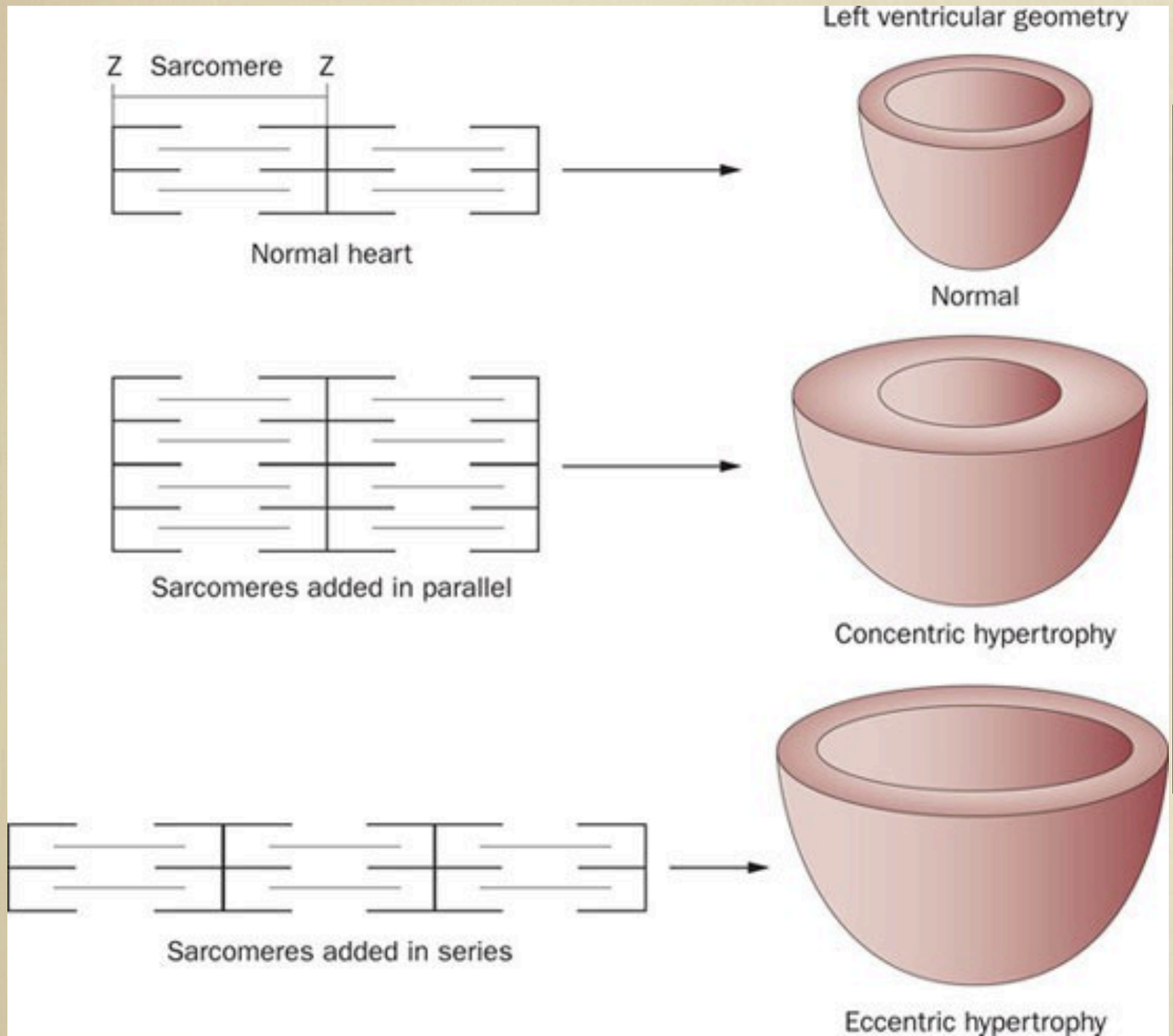
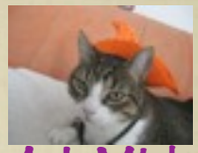


	Hypertrophy	Enlargement
↑ muscle mass	concentric	eccentric
due to overload*	pressure*	volume*
myocyte	thickening	lengthening
molecular level	gene expression	gene expression

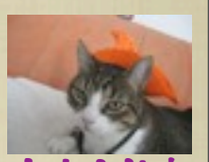
*in case of the overload pressure or volume pathophysiology is much more complicated

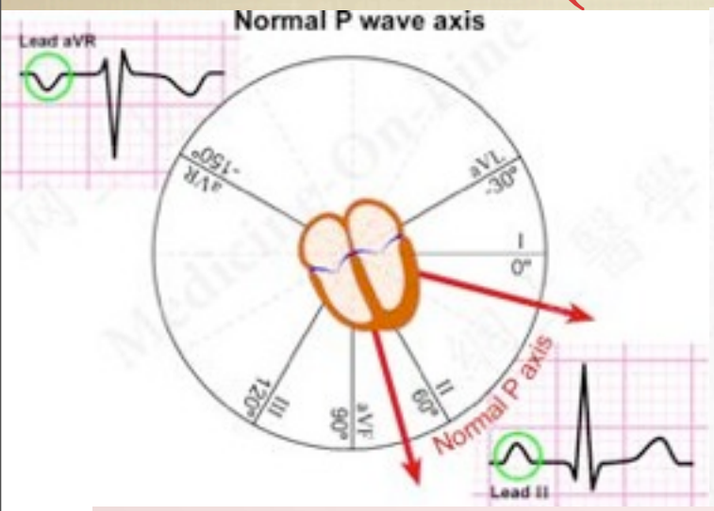
Hypertrophy & Enlargement

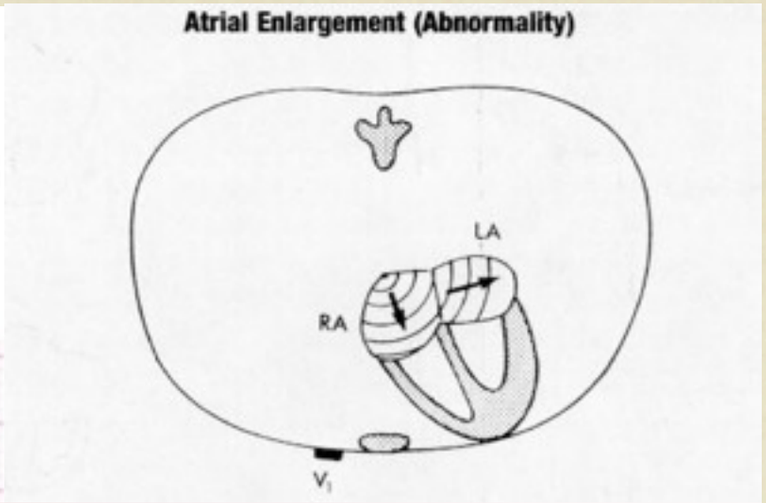


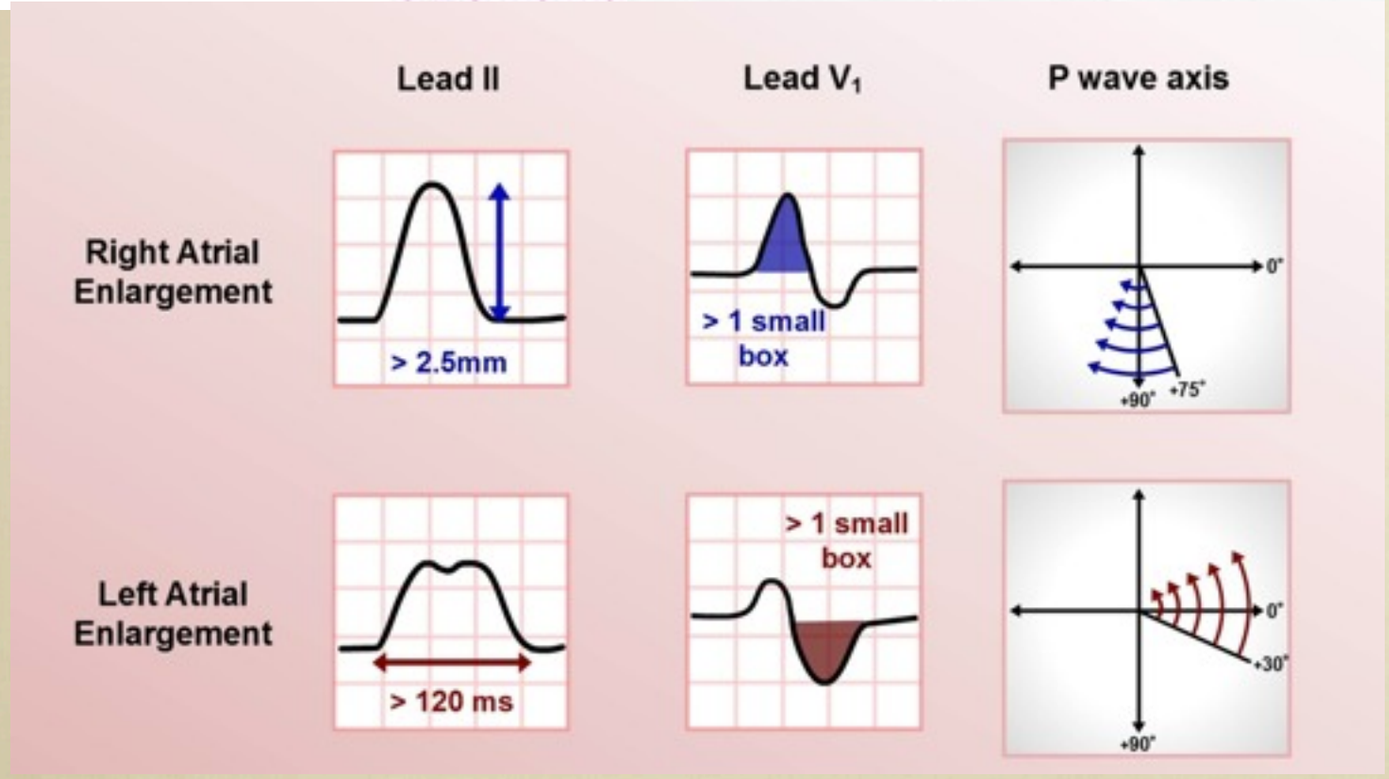
	ENLARGEMENT	HYPERTROPHY
DEFINITION	↑ chamber size	↑ chamber wall thickness
DUE TO:	volume overload	pressure overload
EKG distinguishes btw E&H	NO	NO
ECHO, MRI distinguishes btw E&H	YES	YES
↑ muscle mass	atria enlargement or enlarged ventricles	ventricles hypertrophy

Atrial Enlargement (Abnormality) 1







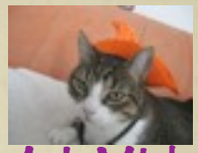


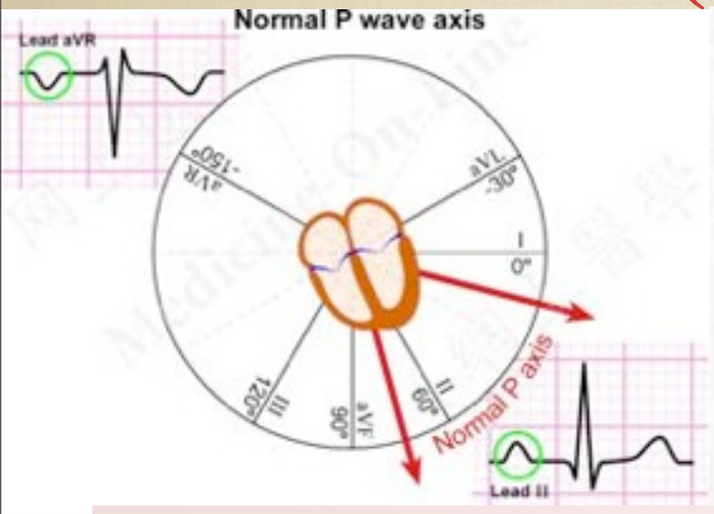
- P wave vector:
  -normal range 30-75 degrees
  -best seen on EKG in lead II(60 degrees) since it's approx. parallel and same direction with lead II as a positive wave < 2.5 mV
  -obtained by summation of depolarization vectors RA and LA.

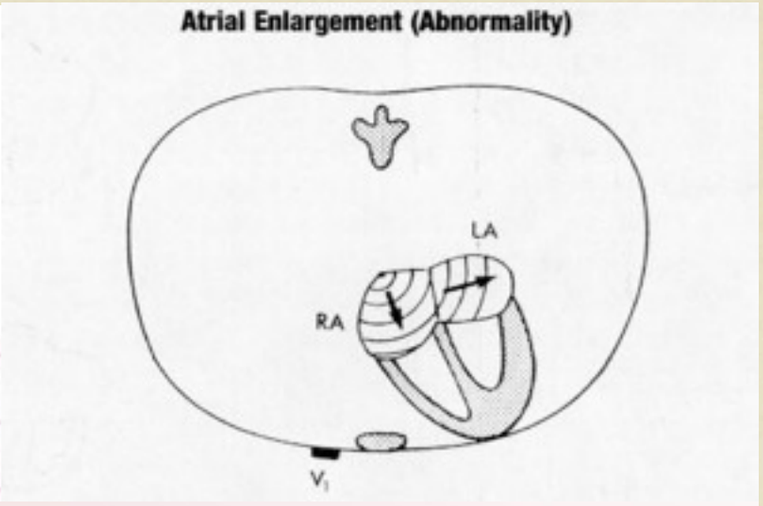
- RA depolarization vector:
  -normal orientation around 90 degrees pointing to inferior leads
  -on EKG normally makes the first half of the P wave

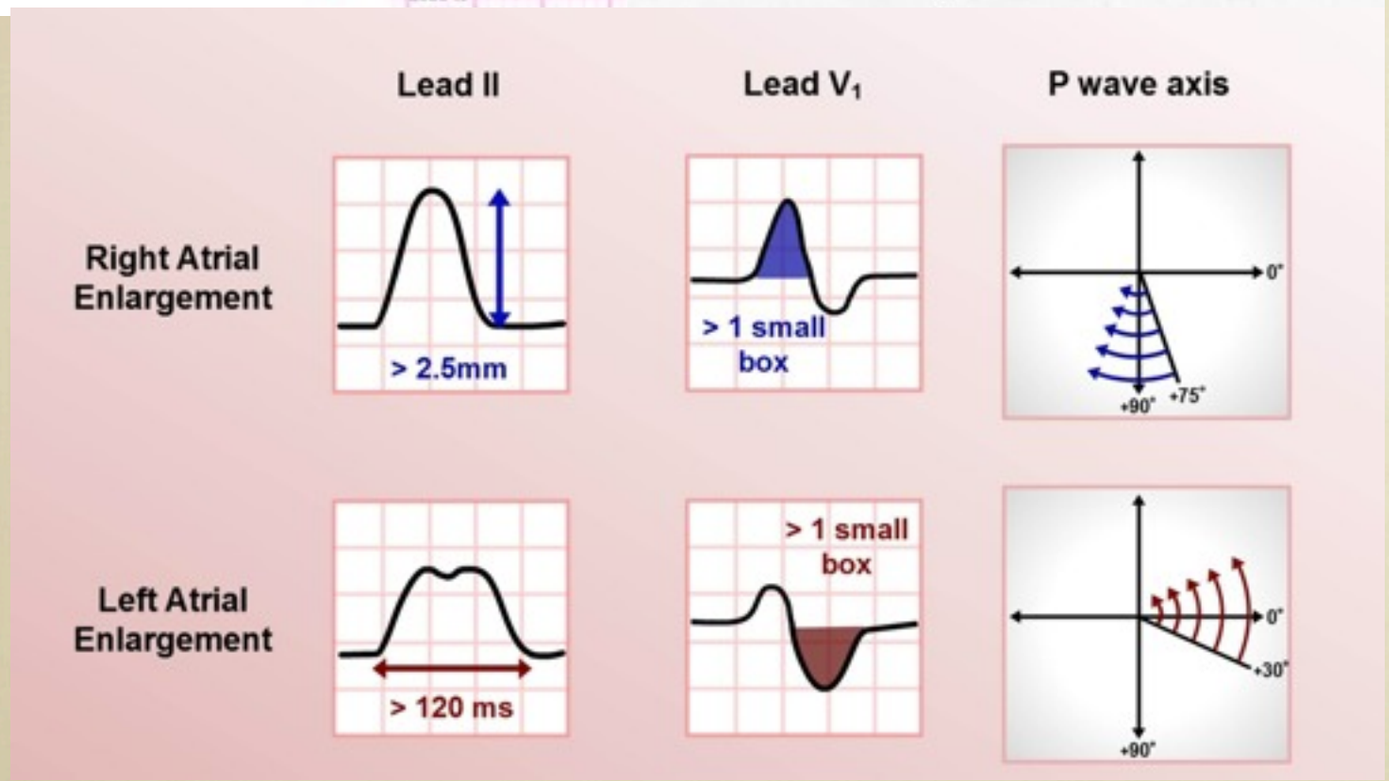
- LA depolarization vector:
  -normal orientation around 0-20 degrees pointing to lateral leads
  -on EKG normally makes the second half of the P wave

Atrial Enlargement (Abnormality)2



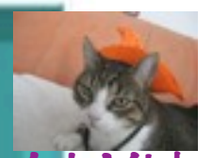






Enlargement	RA	LA
Vector depolarization	↑ RA	↑ LA
P wave	1st half ↑ & covers 2nd half	2nd half ↑ &delayed
Lead II	tall p > 2.5 mV	ᵐp > 0.12 s
LeadV_1	tall p > 1 small box	deep p > 1 small box
P wave axis	> 75 degrees toward RA	< 30 degrees toward LA

Atrial Abnormality



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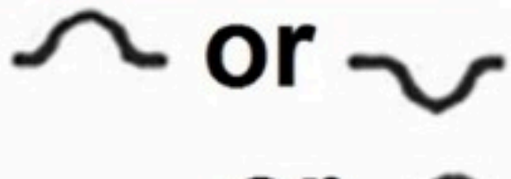
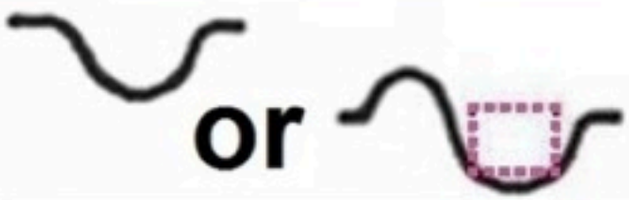
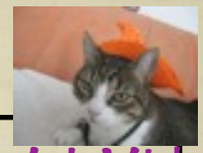
	Lead II	Lead V_1
NSR		 or or 
RAA	 2.5	
LAA	 0.12 sec	m  or 1 box deep & wide

Hypertrophy & Enlargement



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P axis

>75

<30

RAE

LAE

+30 +75

>2.5 mV

II

>0.12 ms

V1 **0.1 mV**

0.1 mV

QRS axis

RAD

LAD

RVH

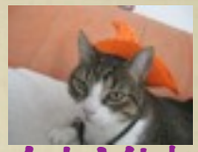
LVH

-30 +90

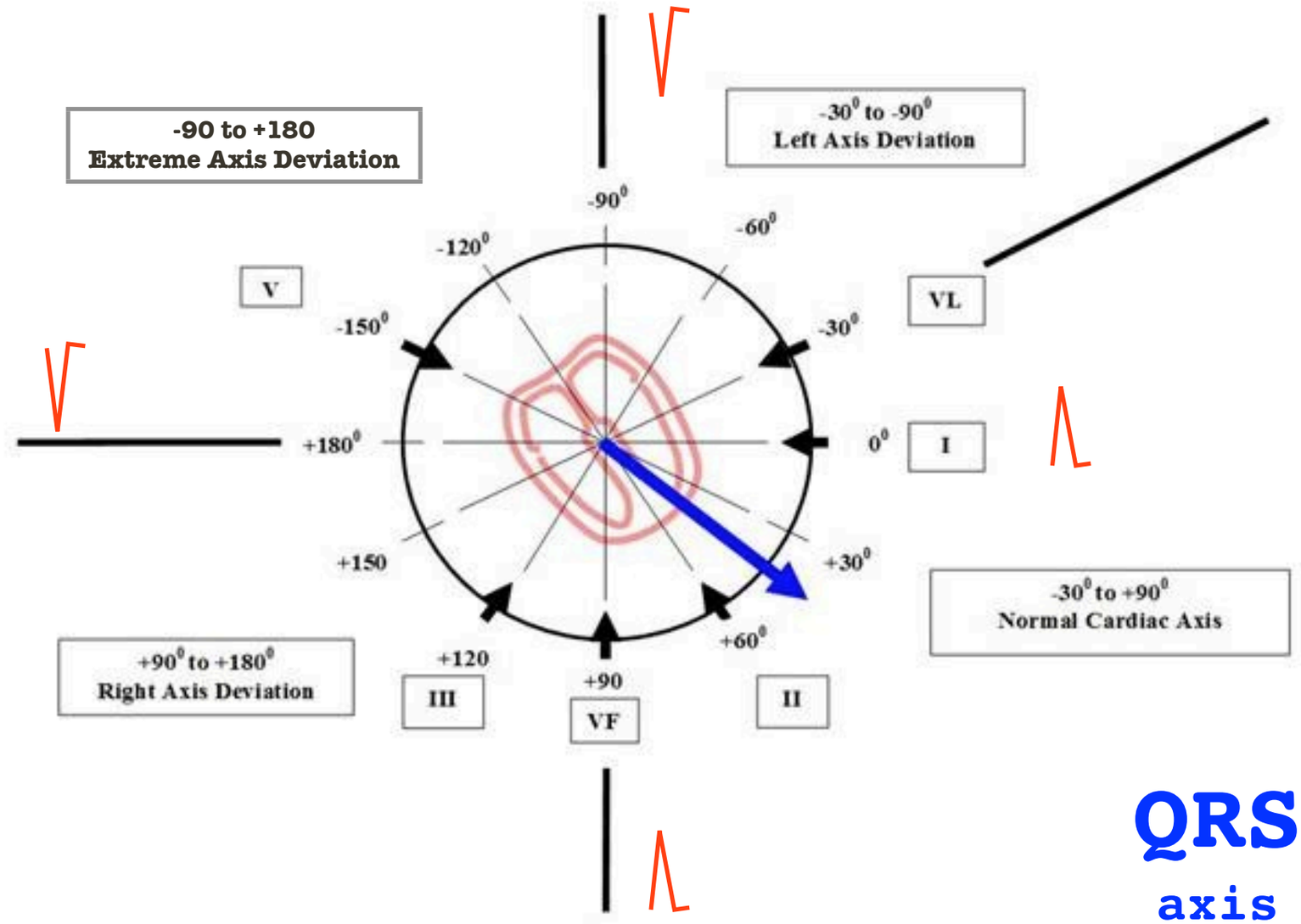
V1
V2

V5
V6

How to find axis on EKG



Ask Mish



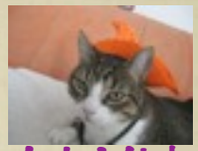
QRS axis

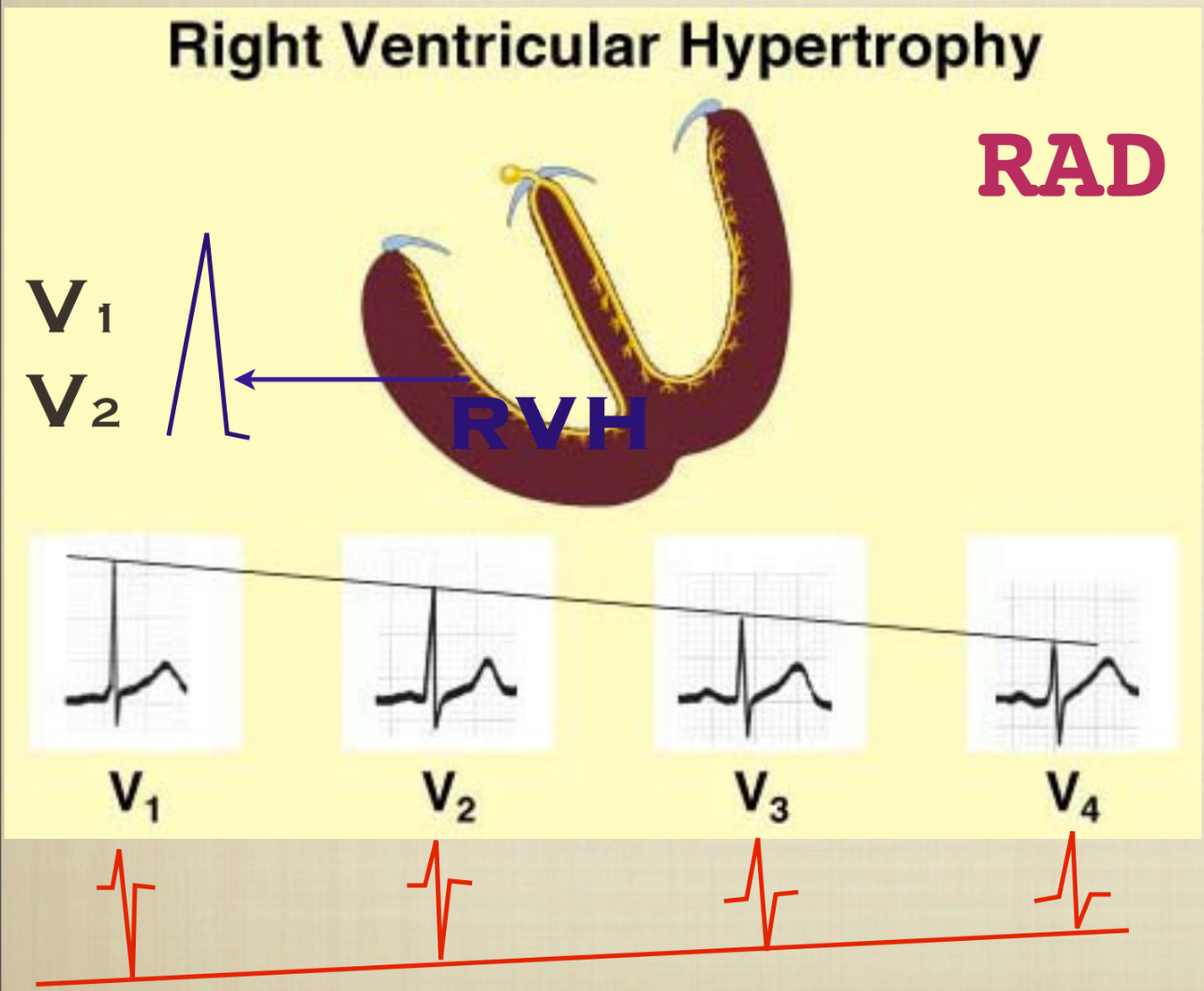
Normal cardiac axis (QRS) and P wave axis both being in a normal range approx. btw 0-90 degrees, check QRS or P on lead I and aVF

QRS/P	Normal	RAD	LAD	EAD
Lead I	+	-	+	-
aVF	+	+	-	-

For a more accurate determination of the axis look for the limb lead in which QRS or P is biphasic. This means that lead is perpendicular to the axis so e.g. if you find a QRS biphasic in lead III which is +120 you will subtract 90 and the answer is QRS axis or cardiac axis is at 30 degrees.If it's biphasic in lead II (+60) than you add 90 and the answer is +150 degrees.

Right Ventricular Hypertrophy





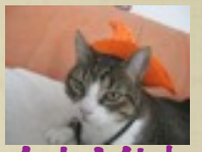
- In RVH, a big RV depolarization vector due to increased RV muscle mass is pointing toward V1 and V2 leads that covers the RV.

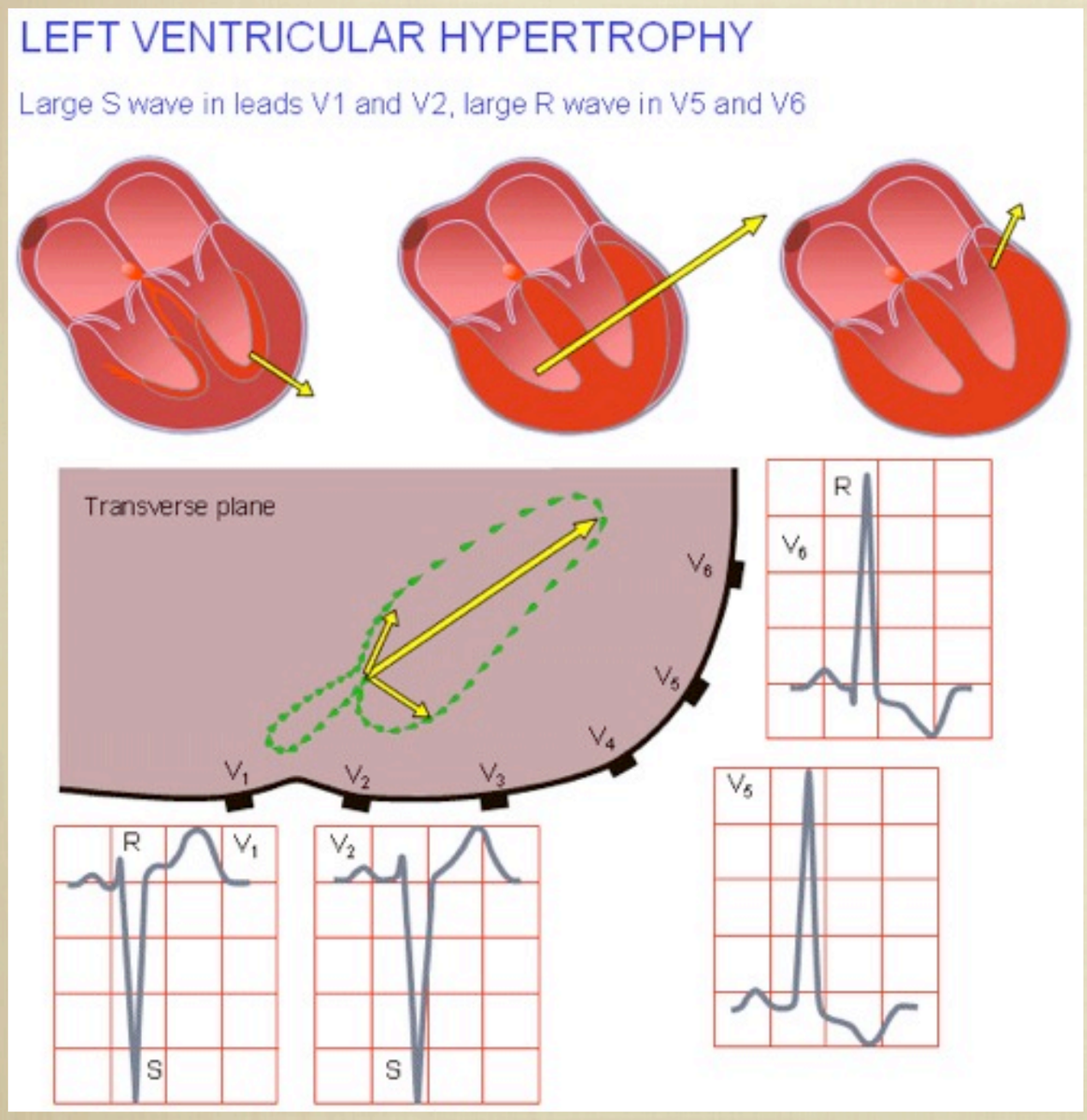
- The result of this vector on EKG is a high positive R wave in V1 and V2 and deep negative S waves in V5 and V6 and lateral leads. This disrupts the normal R wave progression(red on graph) on the EKG, sometimes looking like quite a reversed R wave progression.

- Many times, axis is deviated to the right RAD in RVH. Other possible findings:RAE and conduction problems RBBB.

- In COPD with RVH, due to overinflated lungs and positive intrathoracic pressure producing a downward displacement of the heart and diaphragm, the characteristic RVH tall R waves in right precordial leads never appear. Instead small R waves appear in right-to-midprecordial leads. Low voltage complexes appear in all leads.

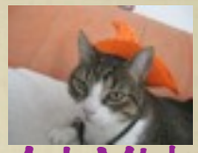
Left Ventricular Hypertrophy

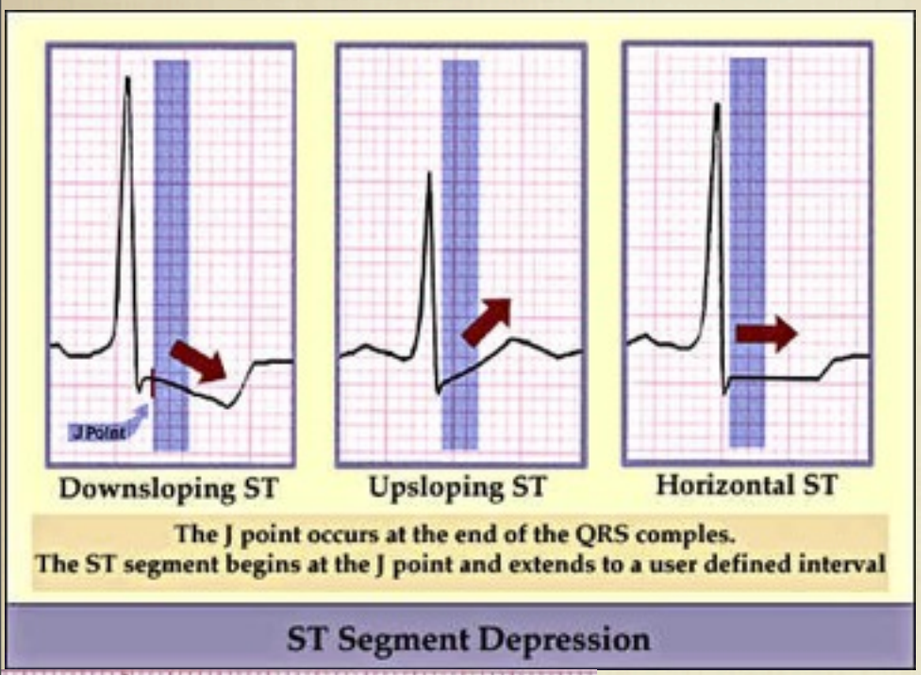


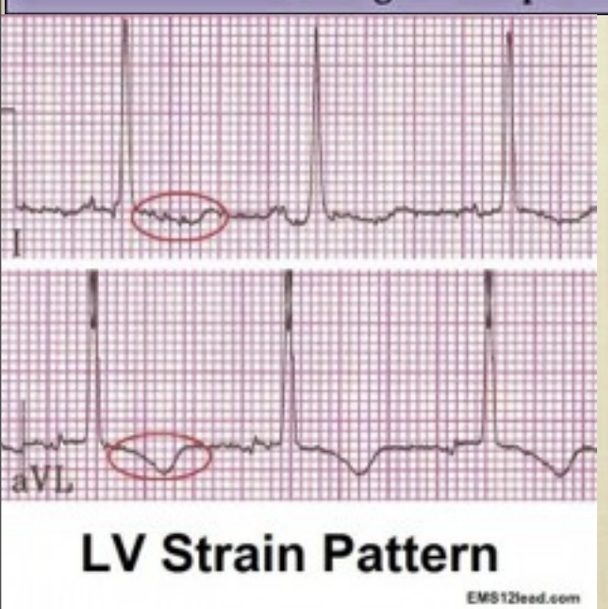


- In LVH, there is a big LV depolarization vector due to increased LV muscle mass, pointing toward V5 and V6 that covers LV and away from V1 and V2 that covers the RV.
- The result of this vector on EKG is a high positive R wave in V5, V6 and lateral leads: I and aVL and a deep negative S in V1 and V2.
- Most of the time, cardiac axis is deviated to the left: LAD
- Other possible findings: LAE and LBBB
- Secondary repolarization abnormalities and prolonged intrinsicoid deflection is present in LVH.

Secondary Repolarization Abnormalities

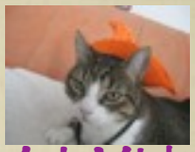






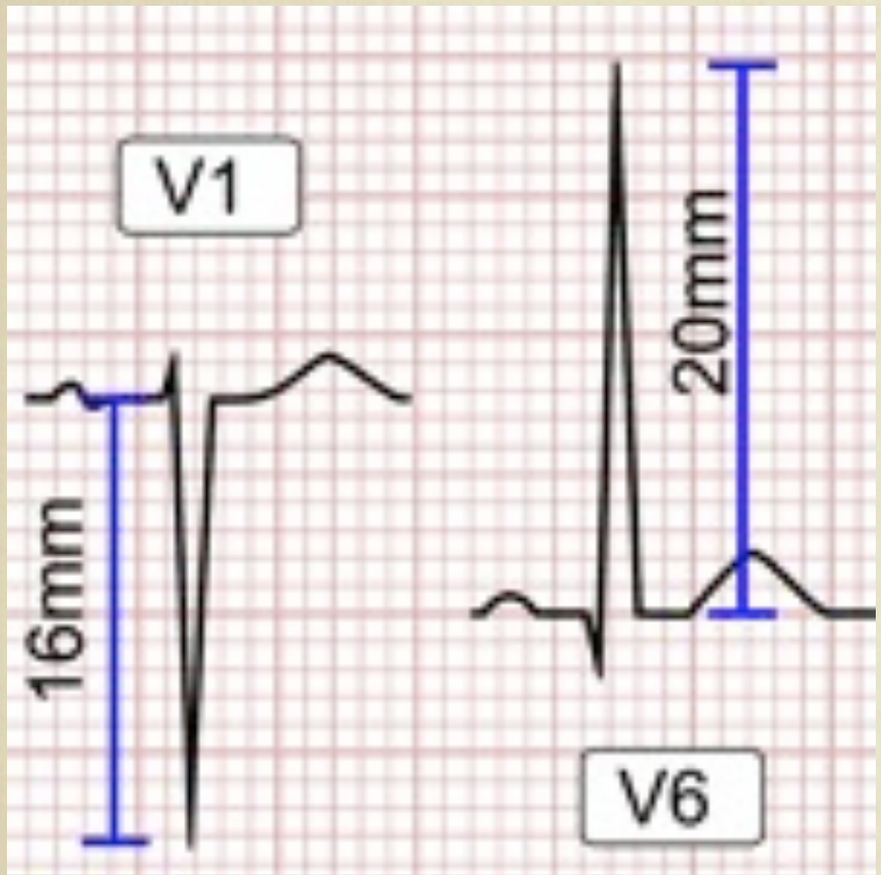
- They are:
- Downsloping ST segment
- T wave inversion
- appear in the leads with the highest R wave in both LVH and RVH
- usually accompany severe hypertrophy
- formerly called "strain pattern" since it was thought to reflect the strain of an overworked and hypoxic muscle; this theory is too simplistic, no one knows for sure why they appear so the term is no longer used

Intrinsicoid Deflection



- VENTRICULAR ACTIVATION TIME (VAT) also known as INTRINSICOID DEFLECTION is the time it takes the ventricle to fully depolarize.
- On the EKG it measures the time from the onset of QRS to the peak of QRS.
- Normal values:
- RIGHT LEADS (V1) < 0.35s or 35ms
- LEFT LEADS (V6) < 0.45s or 45ms
- Prolonged VAT is associated with ventricular hypertrophy, usually LVH

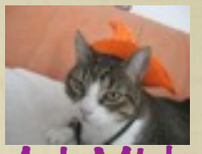
Left Ventricular Hypertrophy - EKG criteria



Sokolow-Lyon criterion

- There are many EKG criteria for LVH.
- Many criteria are based on QRS amplitude (voltage).
- **1. Sokolow-Lyon criterion:**
- **S in V1 + R in V5 or V6 > 3.5 mV (35 mm)**
  or R wave in aVL > or = 1.1 mV (11 mm)
- **2. Cornell criterion** is sex specific:
- **R in aVL + S in V3 > 2.8 mV (28mm) for males**
  R in aVL + S in V3 > 2.0 mV (20 mm) for females

Romhilt-Estes point system



Romhilt-Estes criteria:

Limb lead R or S amplitude > 2.0mV or S in V_1 or V_2 > 3.0mV or R in V_5 or V_6 > 3.0mV	3 points
ST segment abnormality: Without digitalis	2 points
With digitalis	1 point
Left atrial enlargement	3 points
Left axis deviation > -30°	2 points
QRS duration > 0.09s	1 point
Intrinsicoid deflection V_5 and V_6 > 0.05s	1 point

Total Points:
4 : LVH likely
5 : LVH present

Sensitivity 40-50%
Specificity 80-90%

Romhilt and Estes built a point system where voltage and other criteria are used . They give 1, 2 or 3 points to each criterion and sum up the points. If the total points > 5 LVH is definite if total points < 4 LVH is probable.
Even it is more accurate than other criteria, Romhilt-Estes point system brought a modest diagnostic benefit.

Sensitivity & Specificity for LVH criteria

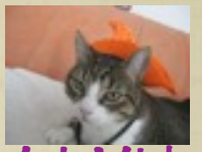


Table: The sensitivity and specificity of various electrocardiographic criteria for left ventricular hypertrophy predicting increased left ventricular mass index on echocardiogram

Criterion	Sensitivity	Specificity
Sokolow-Lyon	31%	86%
Cornell	23%	96%
Romhilts-Estes	27%	84%
12 Lead sum	25%	80%
12 Lead-QRS Product	30%	86%
QRS Duration	3%	94%
Left ventricular strain	21%	62%

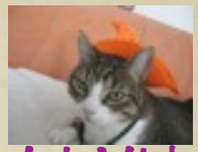
- There are many EKG criteria for LVH. Most of them have low sensitivity and high specificity, this being the case with all EKG criteria for hypertrophy and enlargement.

	Sensitivity ↑	Specificity ↑
QRS	QRS ↑	QRS ↓
age	< 40	> 40
gender	male	female
		obesity
		COPD
		effusions*

*cardiac & pleural effusions

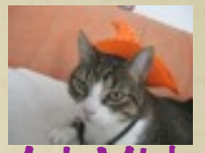
- All factors that produce an increase in QRS will increase sensitivity and decrease specificity of these criteria.
- All factors that produce a decrease in QRS will increase specificity and decrease sensitivity of these criteria.

RVH vs LVH



FINDINGS	RVH	LVH
TALL R WAVES +/- REPOLARIZATION ABNORM.	V_1 AND V_2	I, AVL,V_5 AND V_6
DEEP S WAVES	I, AVL, V_5 AND V_6	V_1 AND V_2
AXIS DEVIATION	RAD (>+90)	LAD (<-30)
ATRIAL ABNORMALITIES	RAE	LAE
ABNORMAL CONDUCTION	RBBB	LBBB
OTHER	POOR R WAVE PROGRESSION	INTRINSICOID DEFLECTION

Hypertrophy & Enlargement



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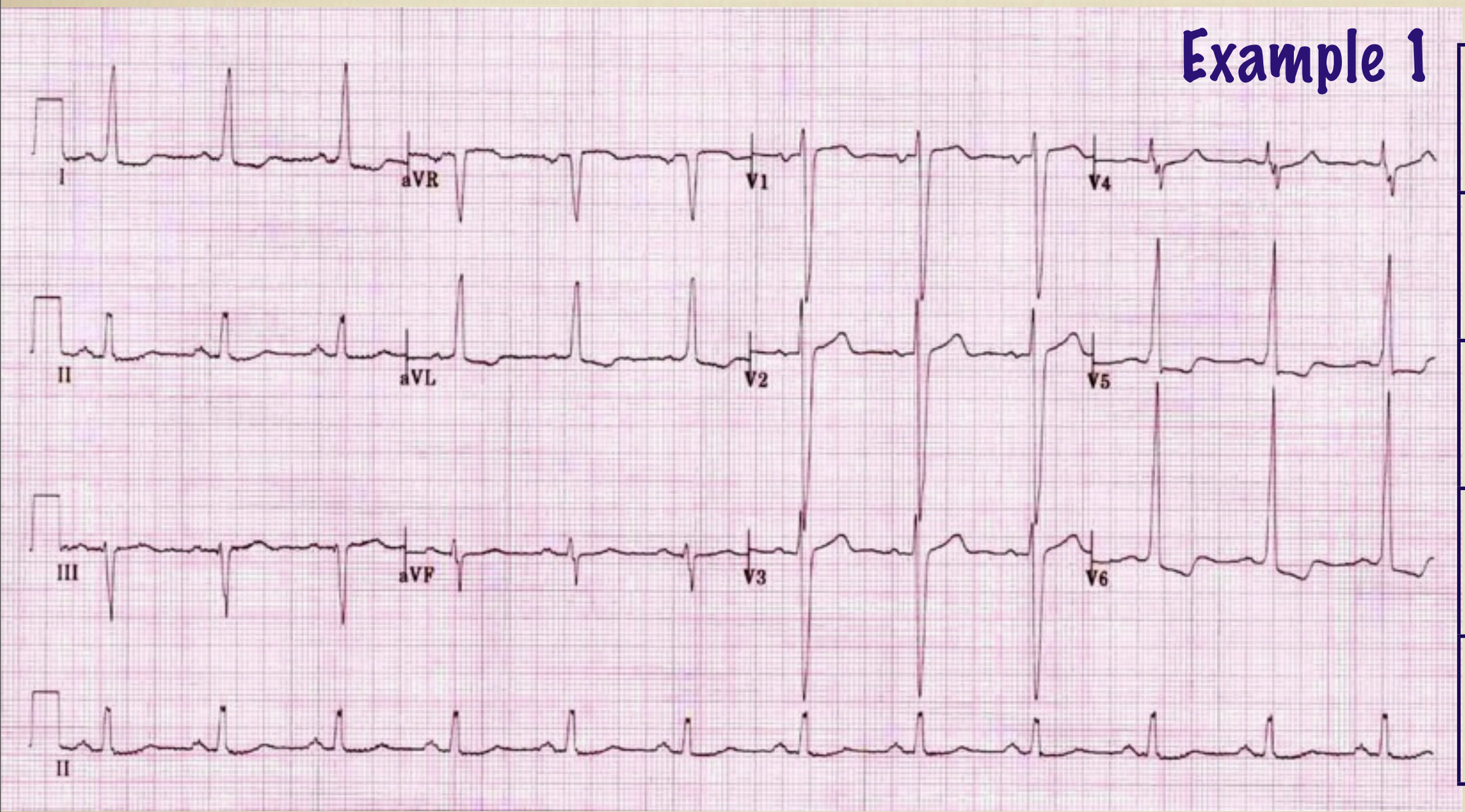
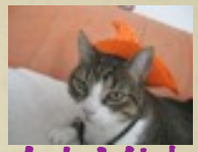
Example 1



LVH	Sokolow-Lyon + S1+R6>35
Rep. abn.	in V5 and V6
VAT	in V5 and V6
LAD	+ in lead I and - in aVF
LAE	P in lead II and V1

Examples 1-6 from LIFTL: LVH and RVH, Dr. Edward Burns

Hypertrophy & Enlargement



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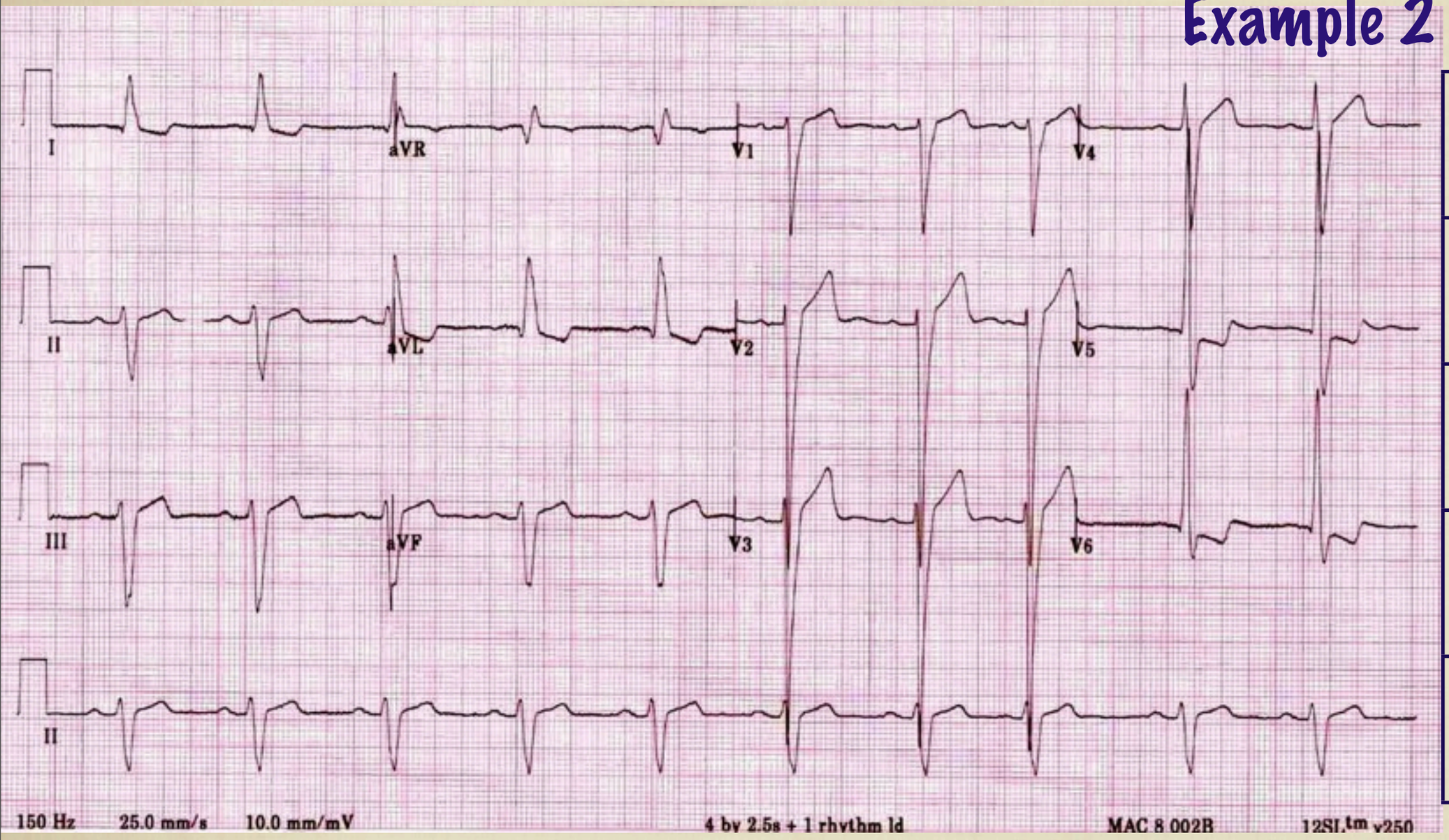
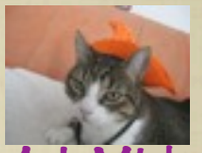
Example 2



LVH	Sokolow-Lyon + S1+R6 >35
Rep. ABN.	V5, V6 lead I and aVL
VAT	in V5 and V6 ?
LAD	+ in lead I and - in aVF
ST elevation and U wave	V1, V2, V3

ST elevation in V1-V3 is "discordant" to the deep S waves
prominent U waves are proportional to QRS amplitude

Hypertrophy & Enlargement



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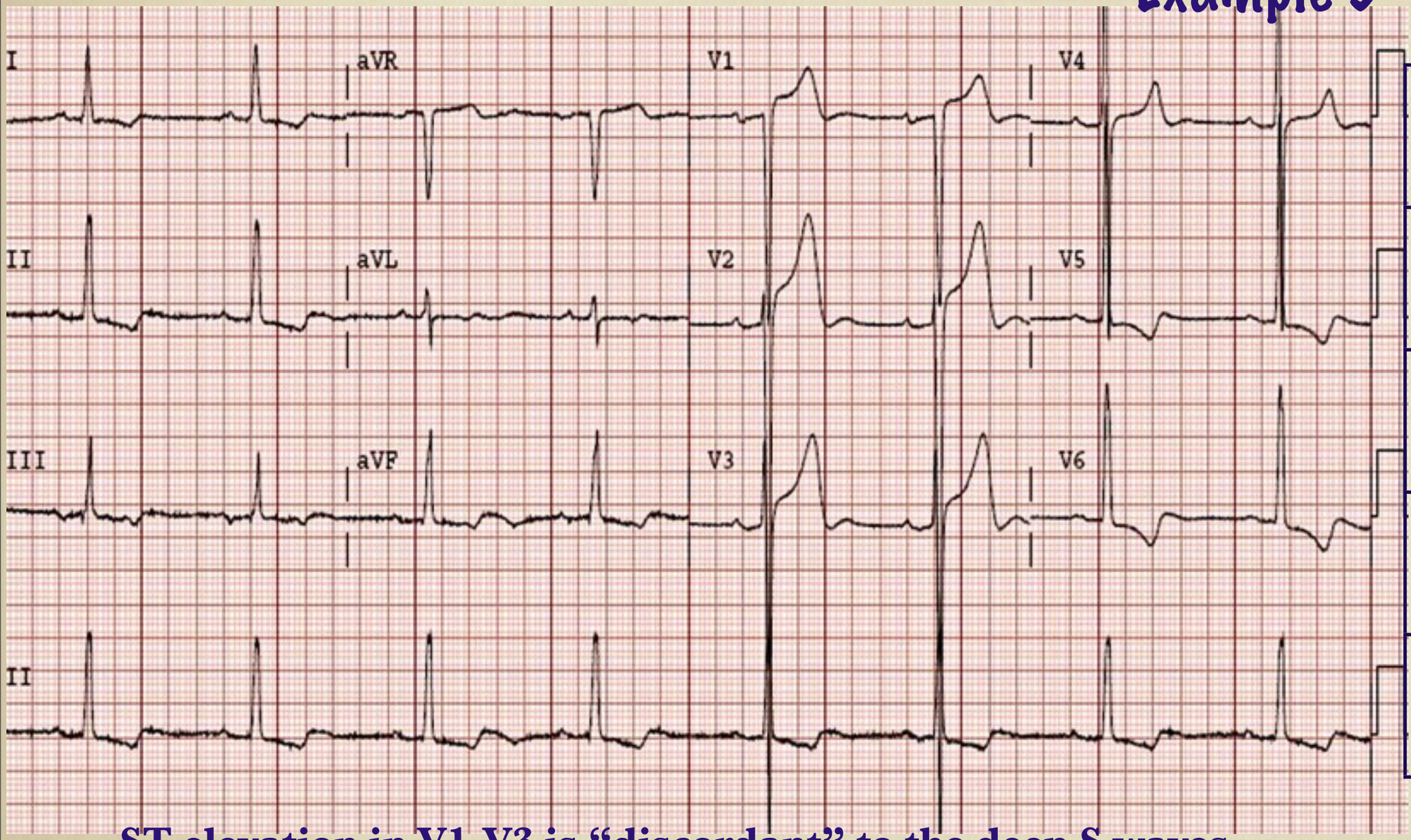
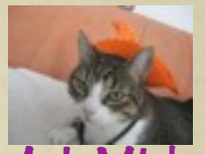
Example 3



LVH	Sokolow-Lyon + S1+R6 >35
REP. ABN.	V5, V6 lead I,II,III and aVL
VAT	in V5 and V6 ?
AXIS	normal + in lead I and + in aVF
ST elevation and U wave	V1, V2, V3

ST elevation in V1-V3 is "discordant" to the deep S waves
prominent U waves are proportional to QRS amplitude

Hypertrophy & Enlargement



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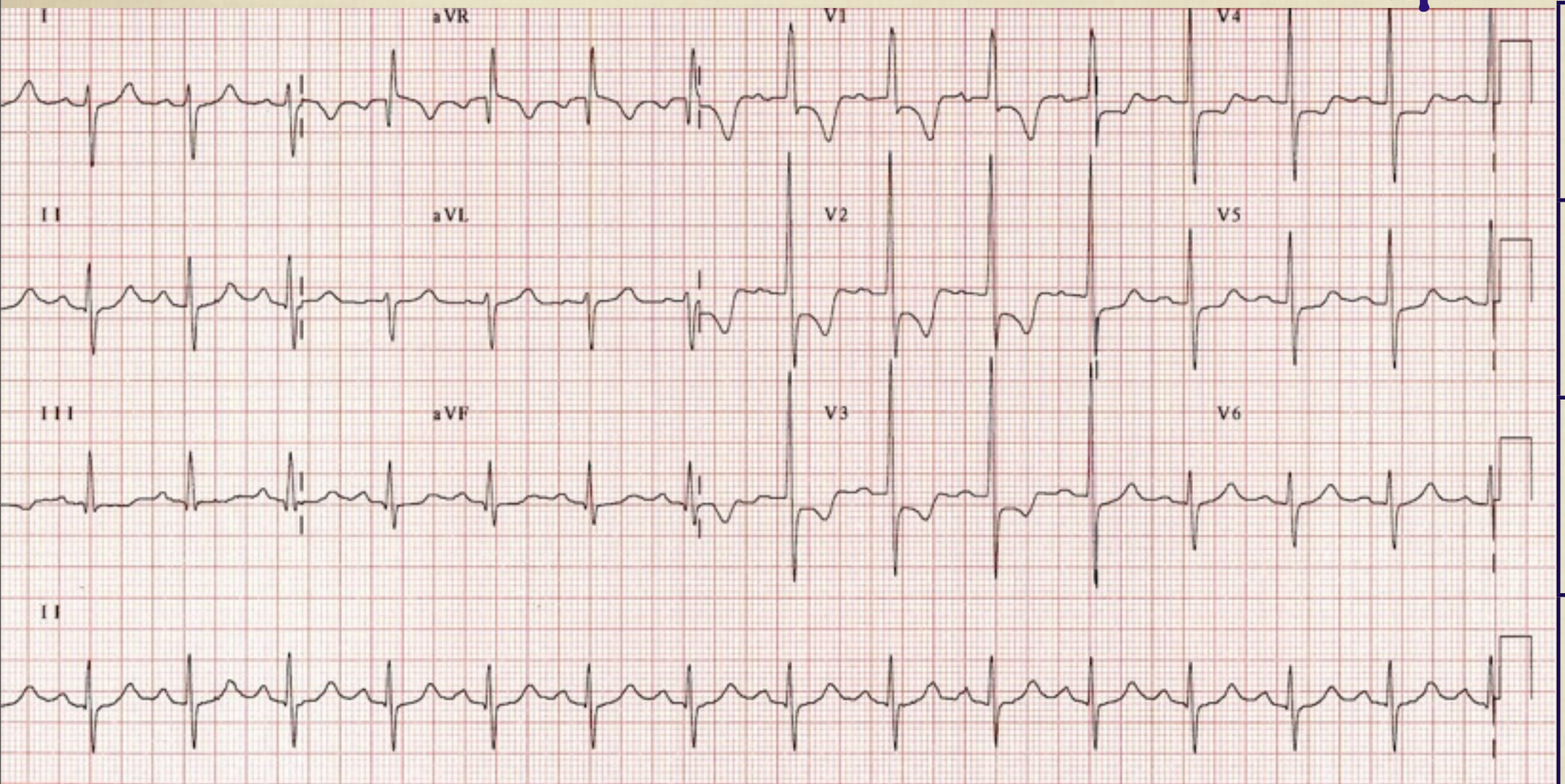
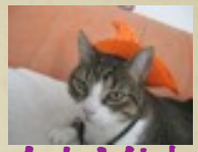
Example 4



RVH	tall R in V1,2,3
RVH	deep S in V6
Rep. Abn.	V1-V4
RAD	- in lead I and + in aVF +150

Hypertrophy & Enlargement



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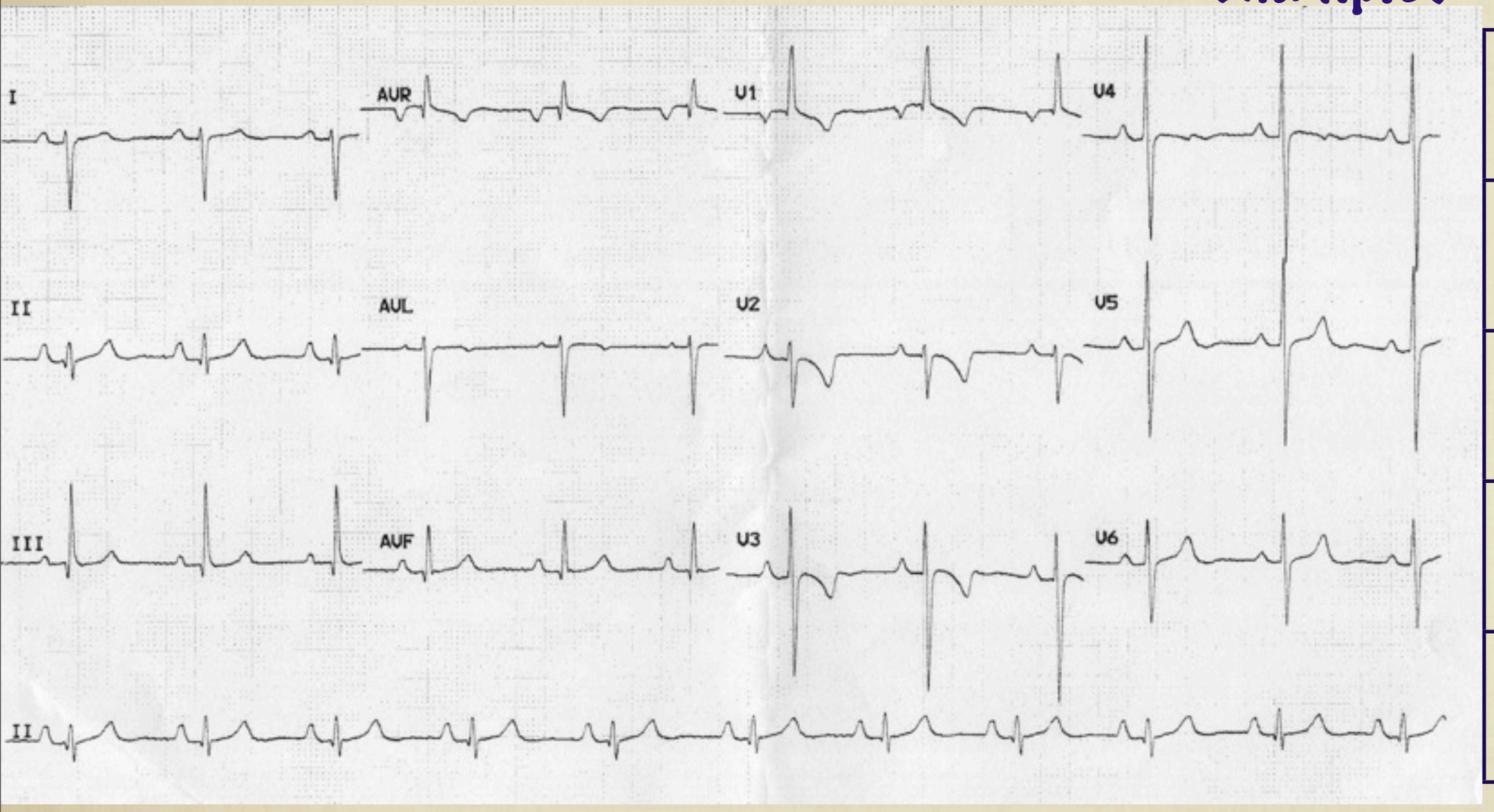
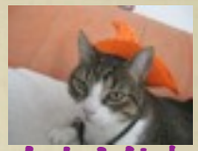
Example5



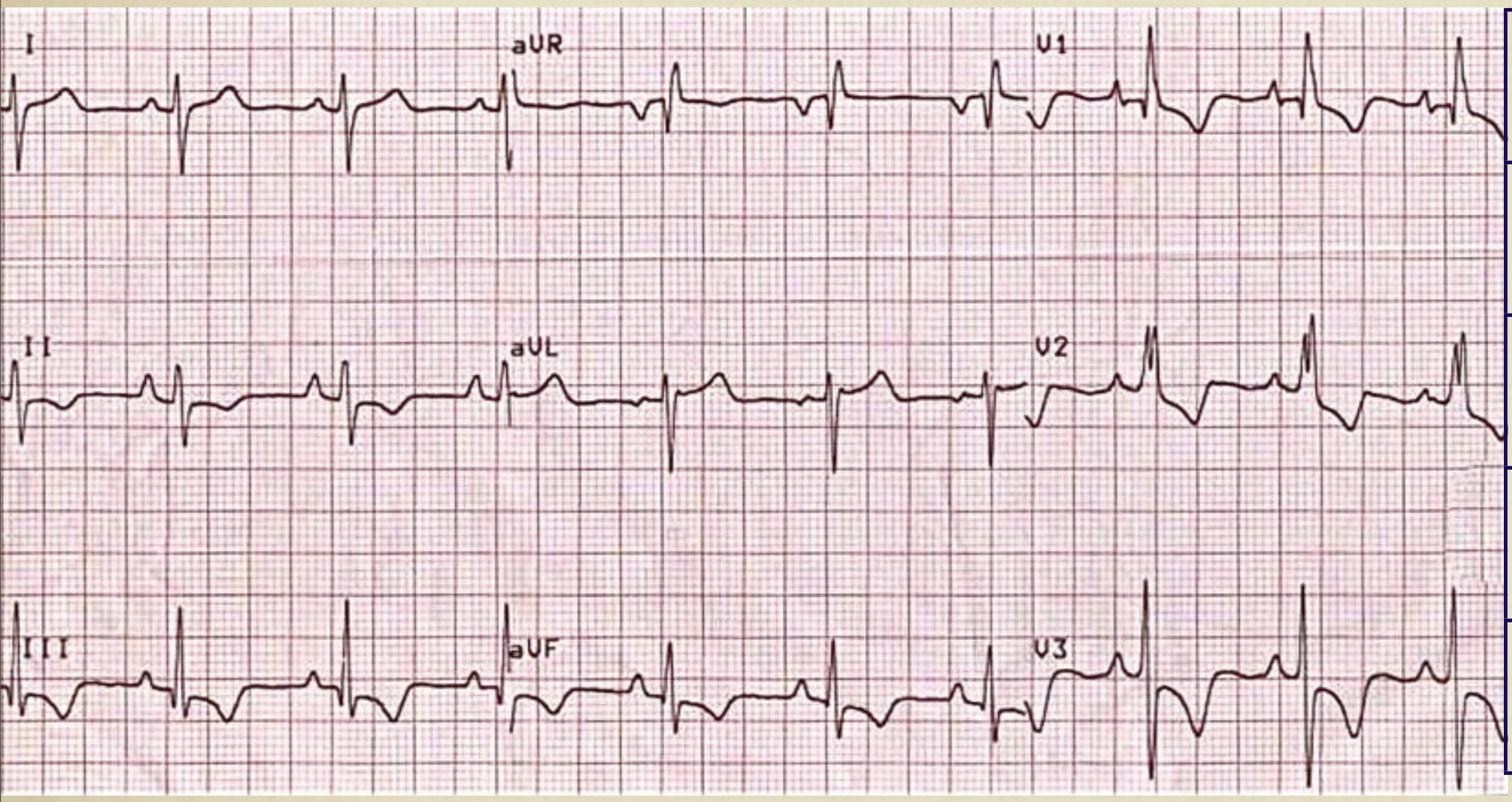
RVH	tall R in V1
RVH	deep S in V6
Rep. Abn.	V1-V3
RAD	- in lead I and + in aVF
RAE	tall p in lead II P"pulmonale"

Hypertrophy & Enlargement



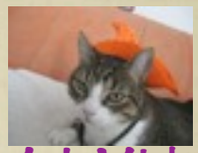
Ask Mish

Example6



RVH	tall R in V1
Rep. ABN.	V1-V3
RAE	tall p in lead Ii P"pulmonale"
RAD	- in lead I and + in aVF +150
RBBB	in V2

Bibliography



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