



Chamber Enlargement and Premature Complex



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COI Disclosure

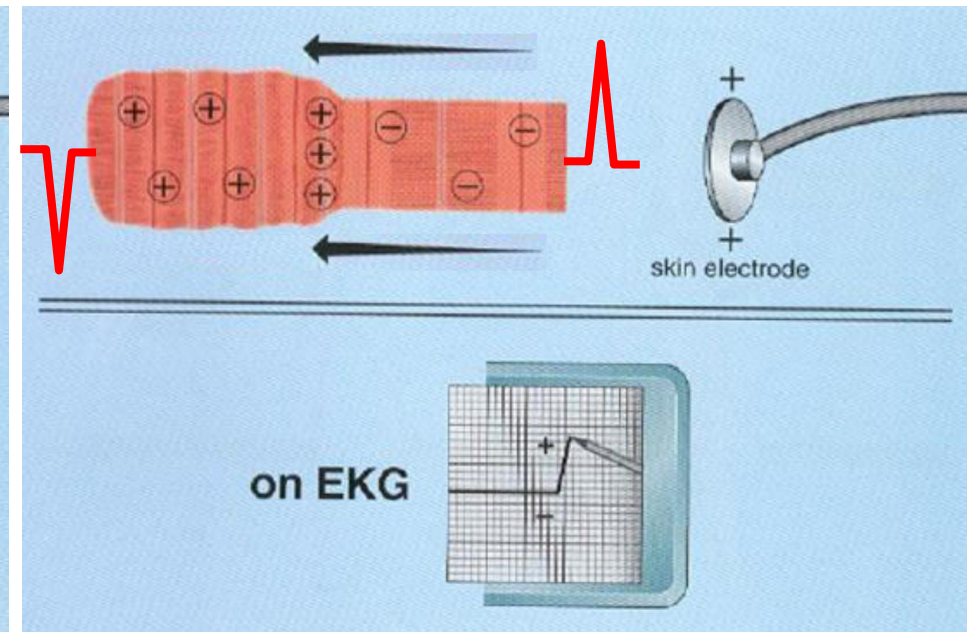
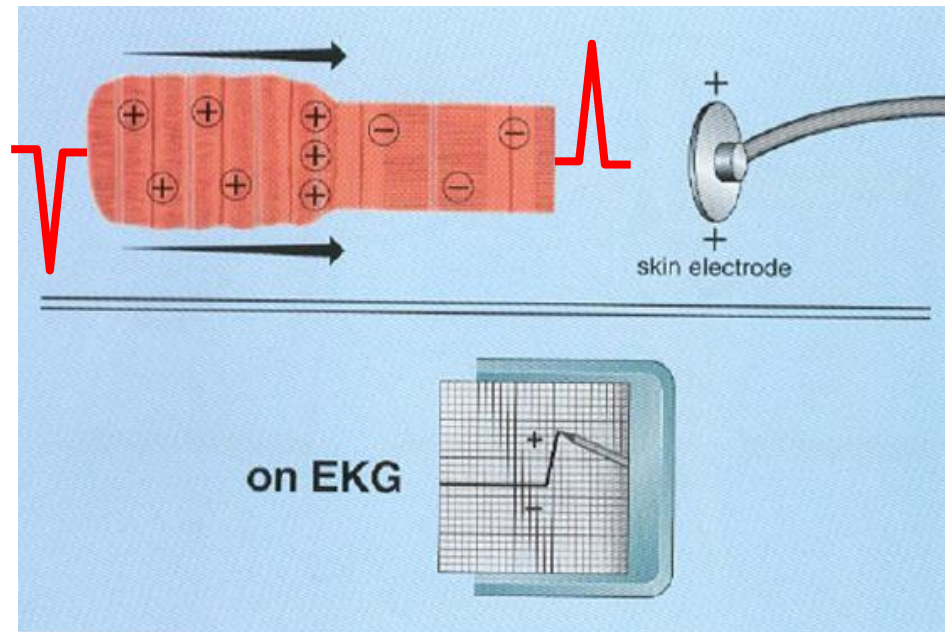
The authors have no financial conflicts of interest to disclose concerning the presentation



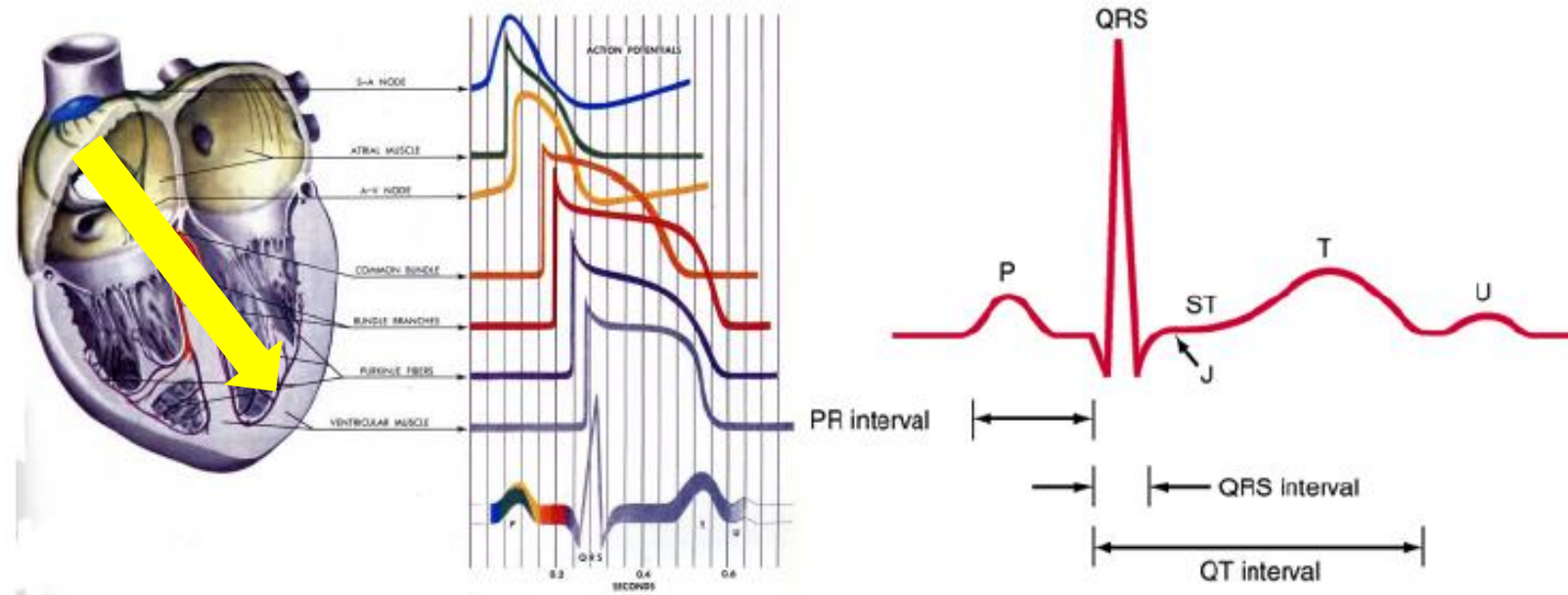
Chamber Enlargement

- Chamber :
 - Left Atrium, Right Atrium : P wave
 - Left Ventricle, Right Ventricle : QRS-T wave
- Enlargement : 확장, 확대..
 - LAE
 - RAE
 - RVE
 - LVE, LVH

심근세포다발



Summary of ECG Waves



P wave : Atrial Depolarization

PR : AV conduction (<200 ms)

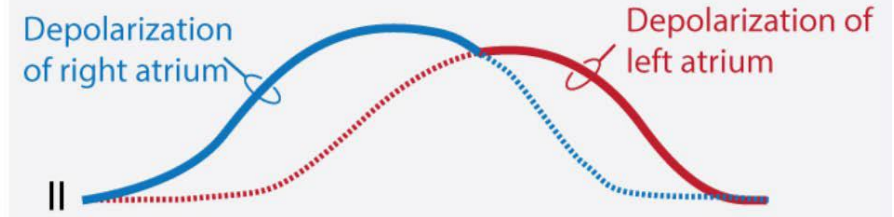
QRS : Ventricular Depolarization (<120 ms)

ST-T : Ventricular Repolarization (QTc <440 ms)

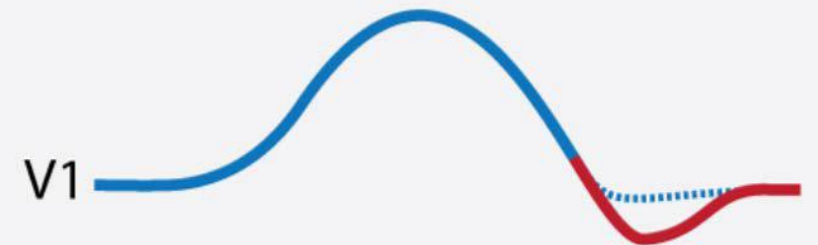
표면 심전도는 벡터의 총합 → 크기와 방향이 있다.

Normal P wave

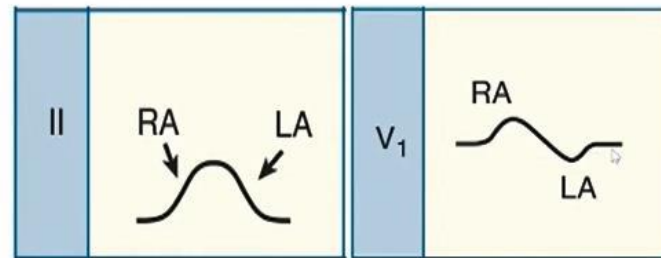
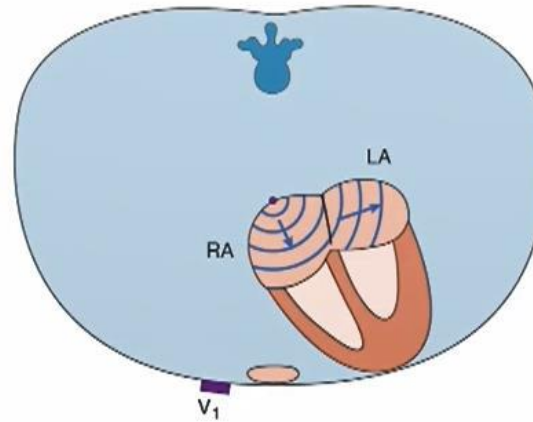
Contour of the normal P wave



The P-wave is always positive in lead II if the rhythm is sinus rhythm. The P-wave may, however, display two humps, as shown here. This is due to the fact that the atria are not depolarized (activated) simultaneously.



The P-wave in lead V1 may be biphasic, due to the negative deflection caused by depolarization of the left atrium (the electrical vector is directed away from V1).



Normal P wave

- Width $\leq 110\text{ms}$
- Height $< 2.5\text{mm}^*$
- Axis $+ 30\text{-}60^\circ$
- P Terminal force $< .04\text{mm/sec}$

.2mv

.1mv

RA

LA

LA lag

40ms

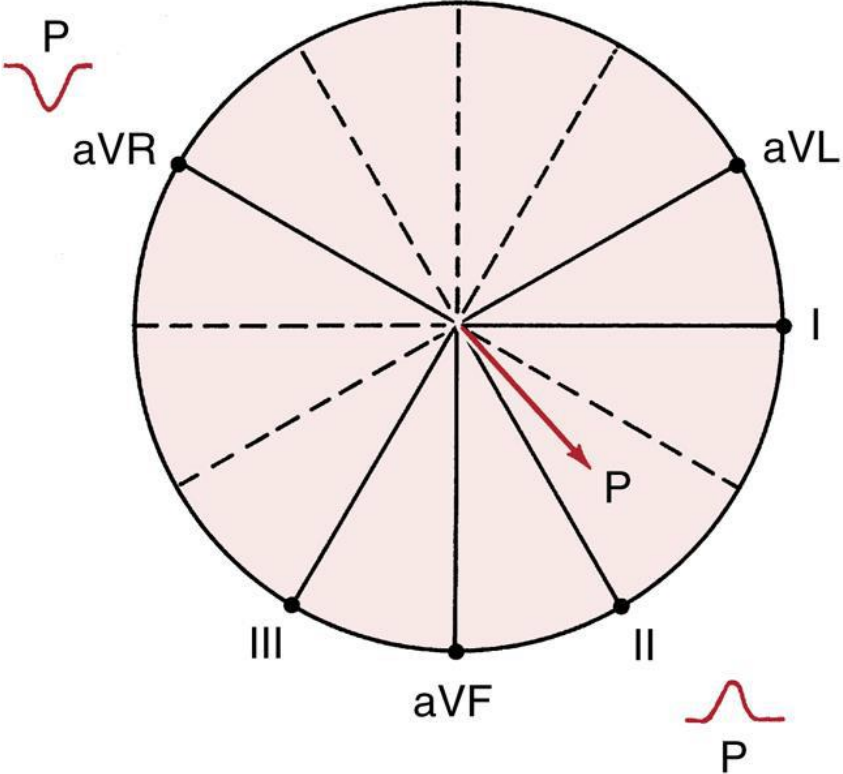
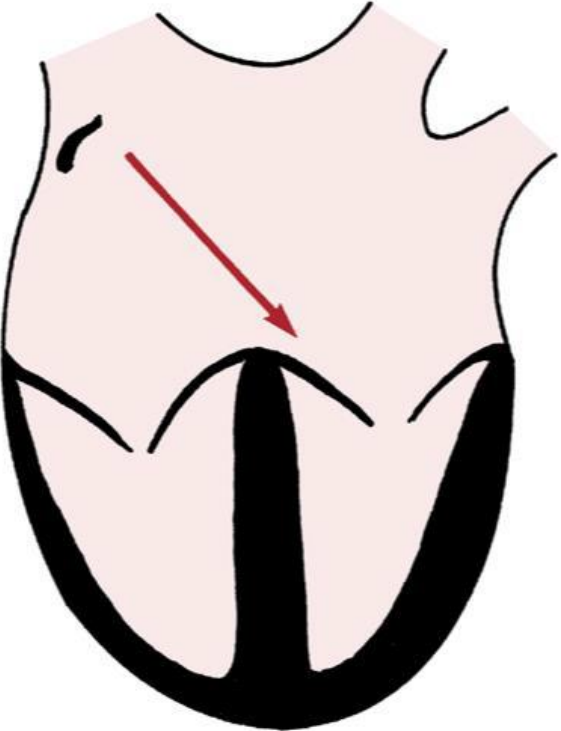
80ms

120ms

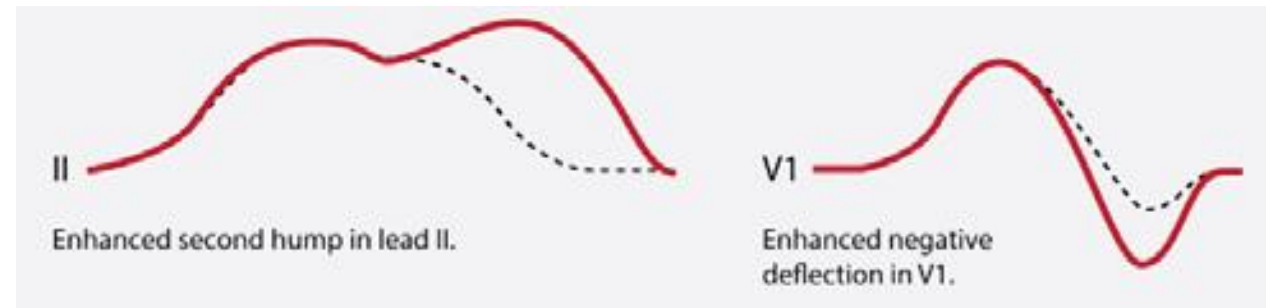
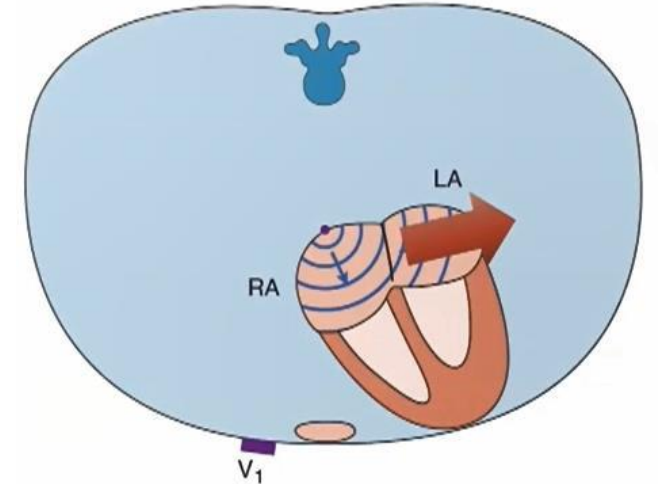
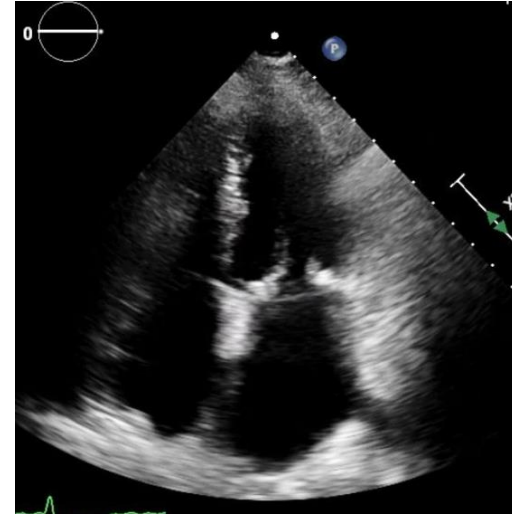
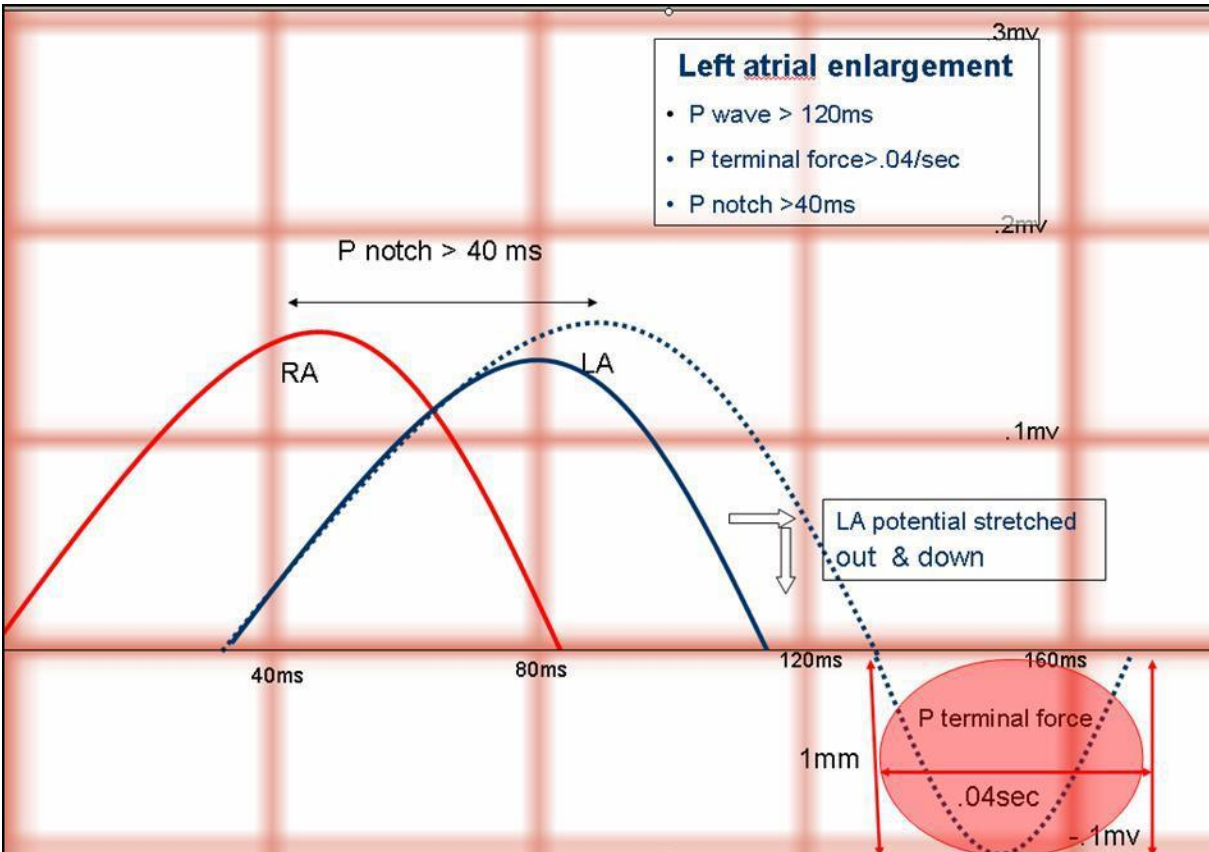
- Normal P waves are rounded contour,
- It can be up to 2.5mm in lead II and in V1 it is $< 1.5\text{mm}$.
- Usually unimodal with a single peak, can be bimodal with a small notch.
- Normally the inter peak distance (Notch) will be less than 40ms.
- Biphasic P waves are seen mainly in lead V1.
- Normal P terminal force is $.1\text{mv}/.04\text{sec}$

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Normal Sinus P Wave axis



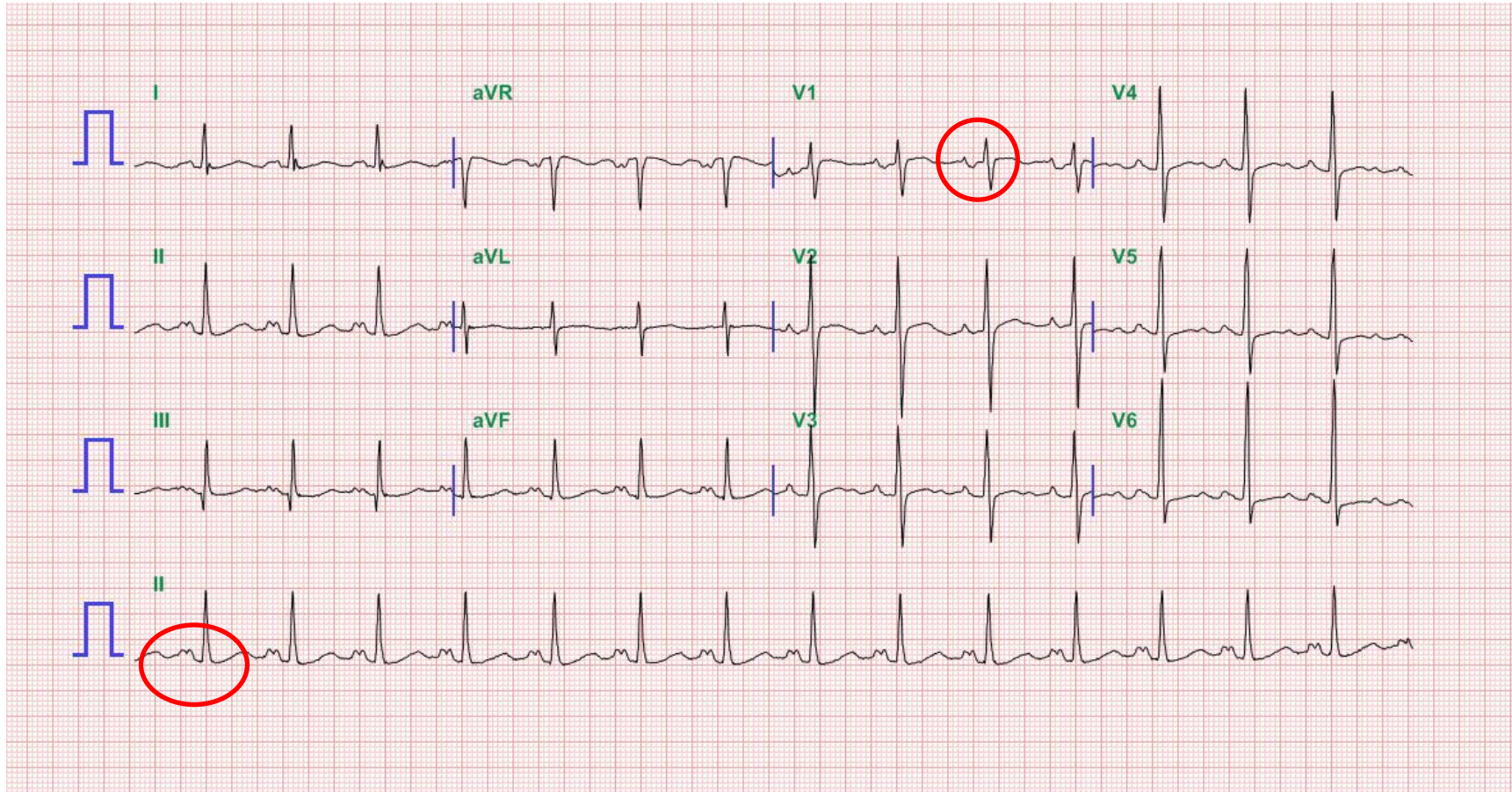
Left Atrial Enlargement



- (1) P wave duration $\geq 0.12s$ in frontal plane (usually lead II) Notched P wave with inter-peak duration $\geq 0.04s$
- (2) Terminal P negativity in lead V₁ (P-terminale) $\geq 0.04s$, depth $\geq 1mm$
- (3) P wave axis: $-30 \sim -45$

LAE

(2) Terminal P negativity in lead V1 (i.e. "P-terminal force") $\geq 0.04s$, depth $\geq 1mm$



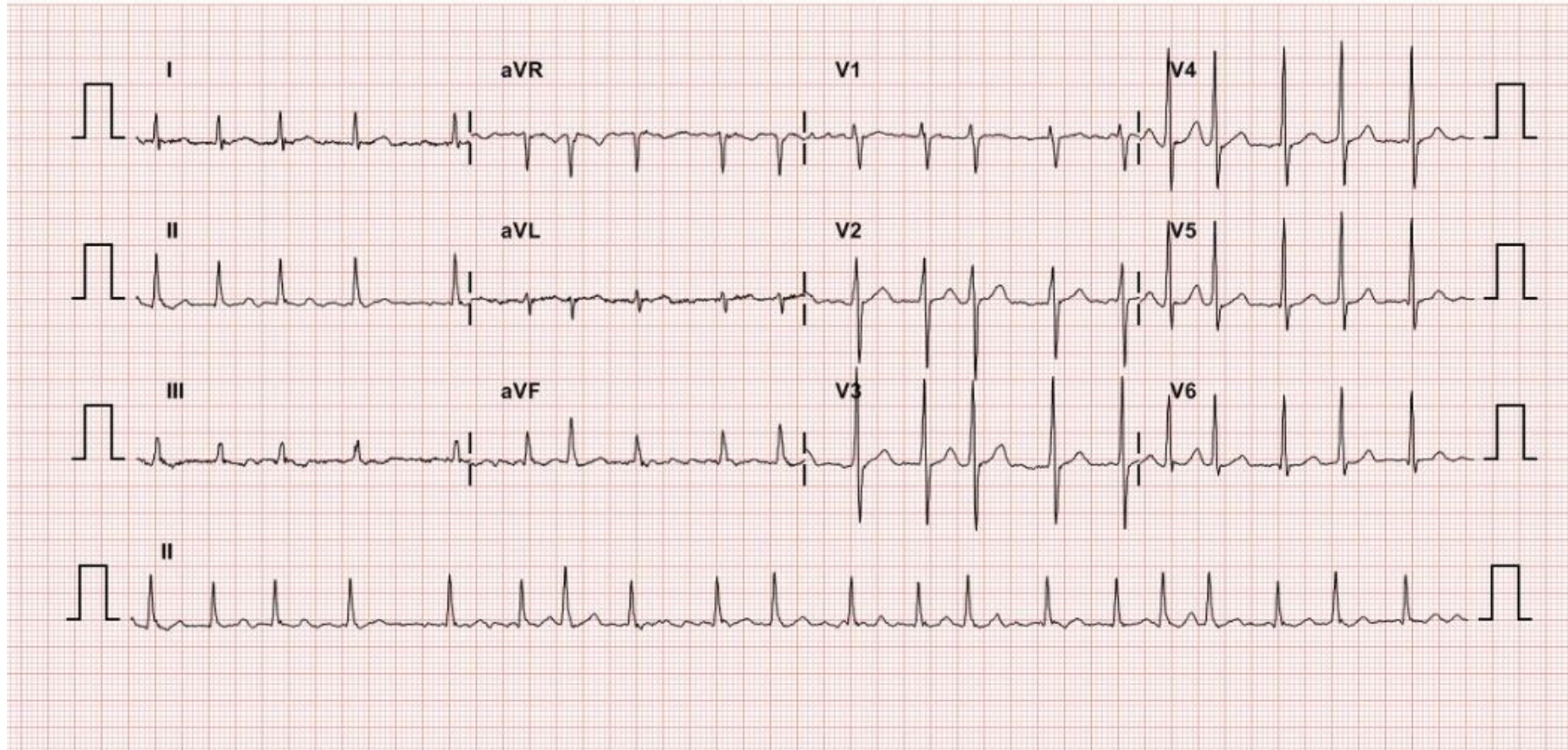
(1) P wave duration $\geq 0.12s$ in frontal plane (usually lead II)
Notched P wave with inter-peak duration $\geq 0.04s$

AF

Rate	122	Age not entered, assumed to be 50 years old for purpose of ECG interpretation
RR	492	Atrial fibrillation V-rate 81-174, irreg A-activity
PR interval		
QRSD	87	
QT	327	
QTcB	466	
QTcF	414	
..... AXIS.....		
P		
QRS	61	
T	18	

- ABNORMAL ECG -

Unconfirmed Diagnosis



RE1002

Speed: 25 mm/sec

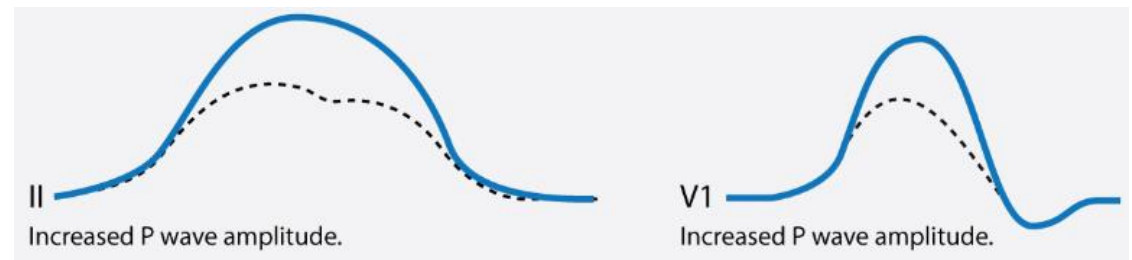
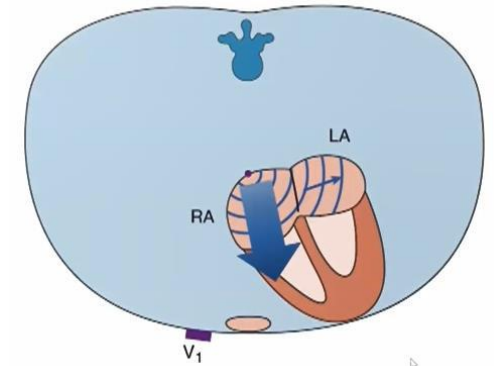
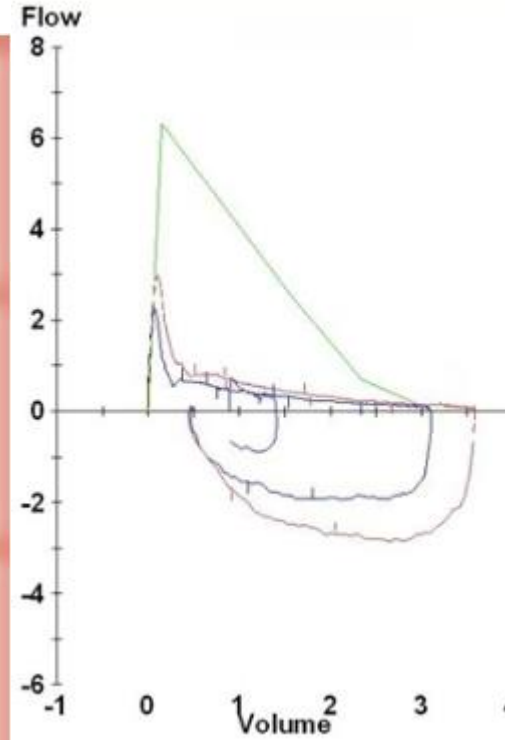
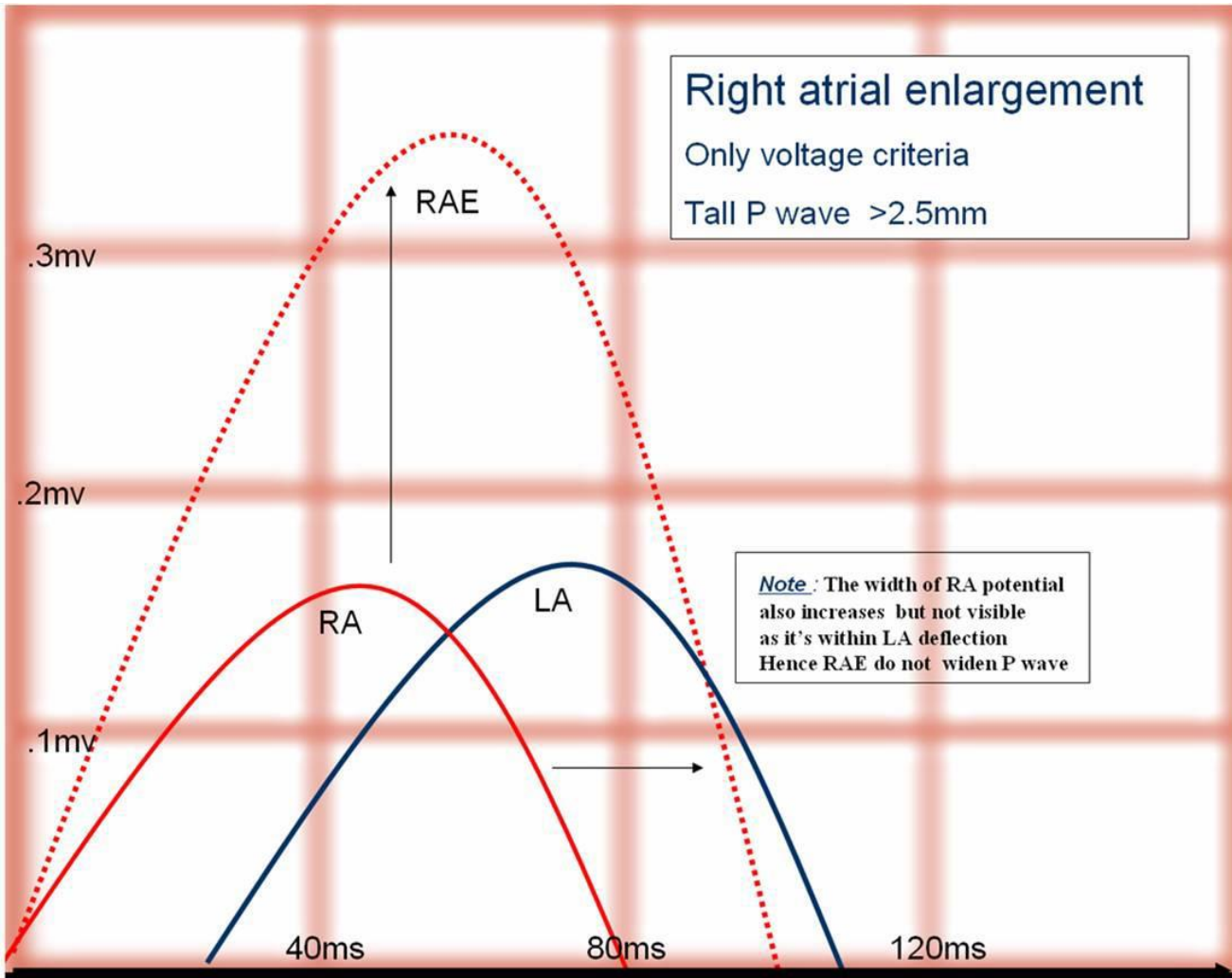
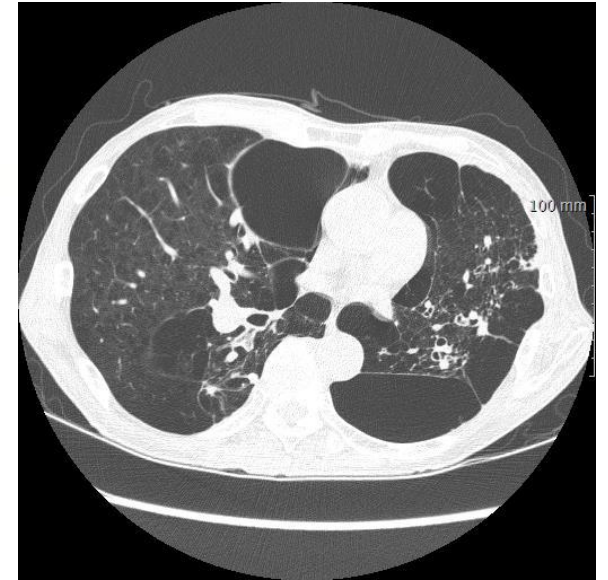
Limb: 10 mm/mV

Chest: 10 mm/mV

F 60~ 0.05 - 150 Hz W

INFINITT CIS

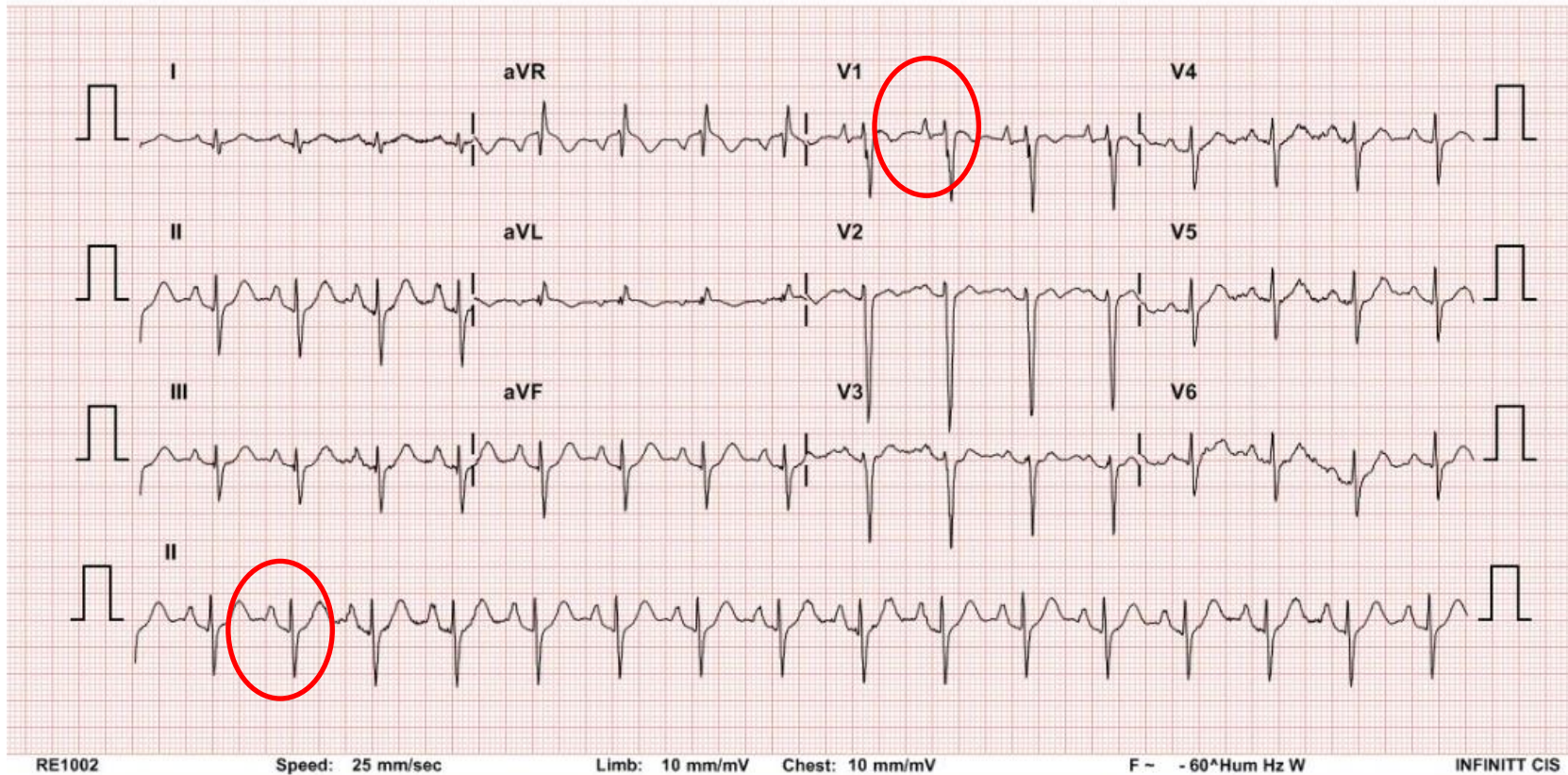
Right Atrial Enlargement



P in II > 0.25 mV, P in V1 or V2 > 0.15 mV, RAD of P

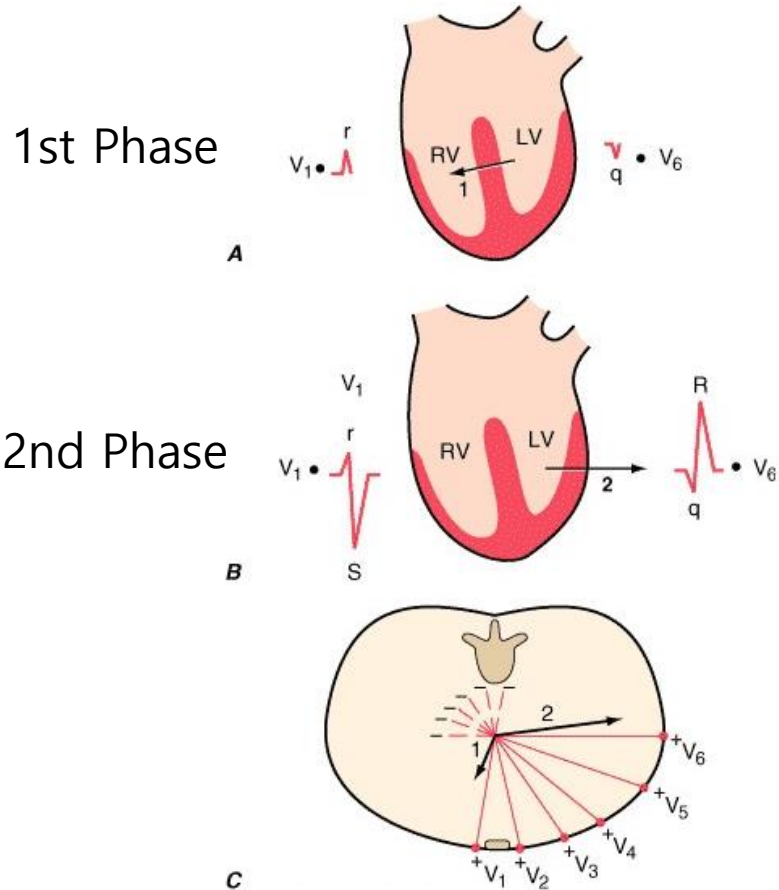
Right Atrial Enlargement

Rate	98	** abnormal ECG **
RR		Sinus rhythm
PR interval	168	Left anterior fascicular block
QRSD	112	Possible right atrial enlargement
QT	374	
QTcB	429	
QTcF		
-----AXIS-----		
P	73	
QRS	-84	
T	71	



P in II > 0.25 mV, P in V1 or V2 > 0.15 mV, RAD of P

Genesis of QRS complex



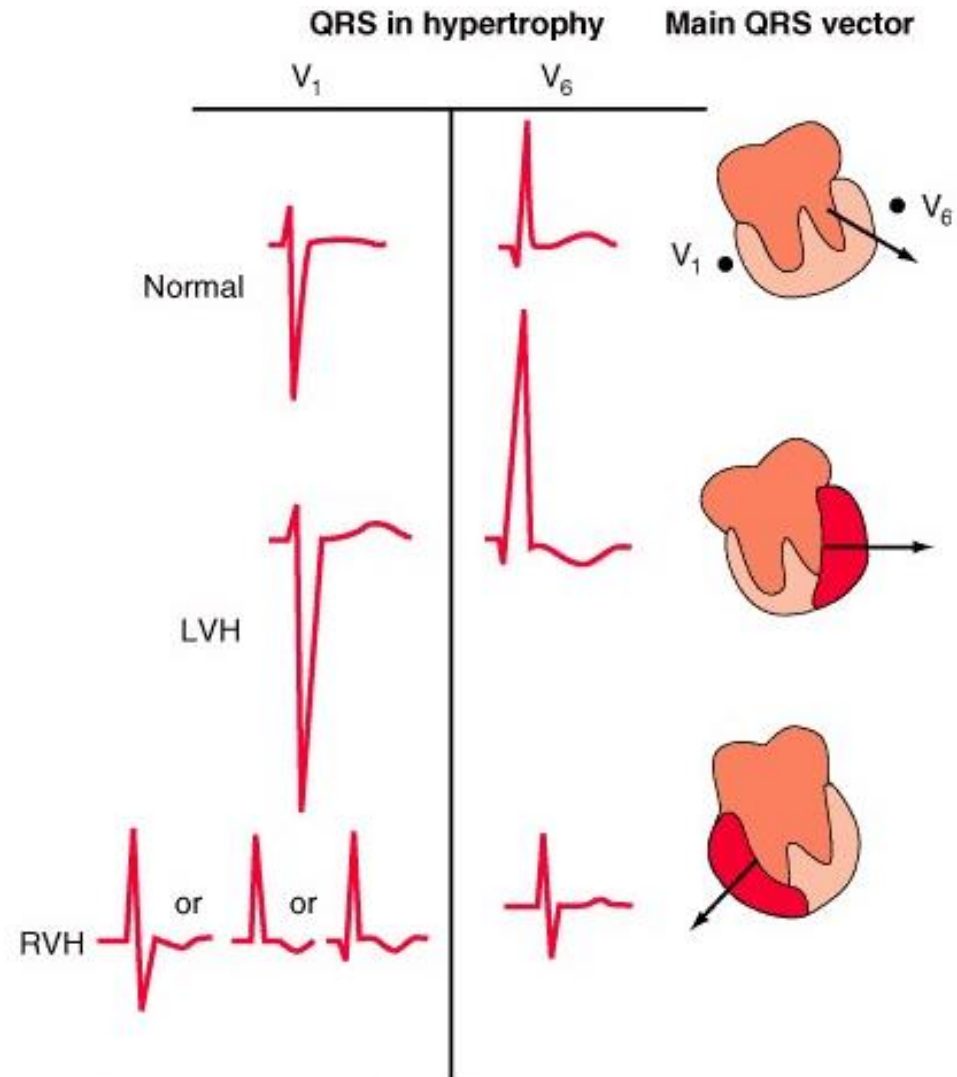
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Depolarization of the interventricular septum from the Left to Right and anteriorly

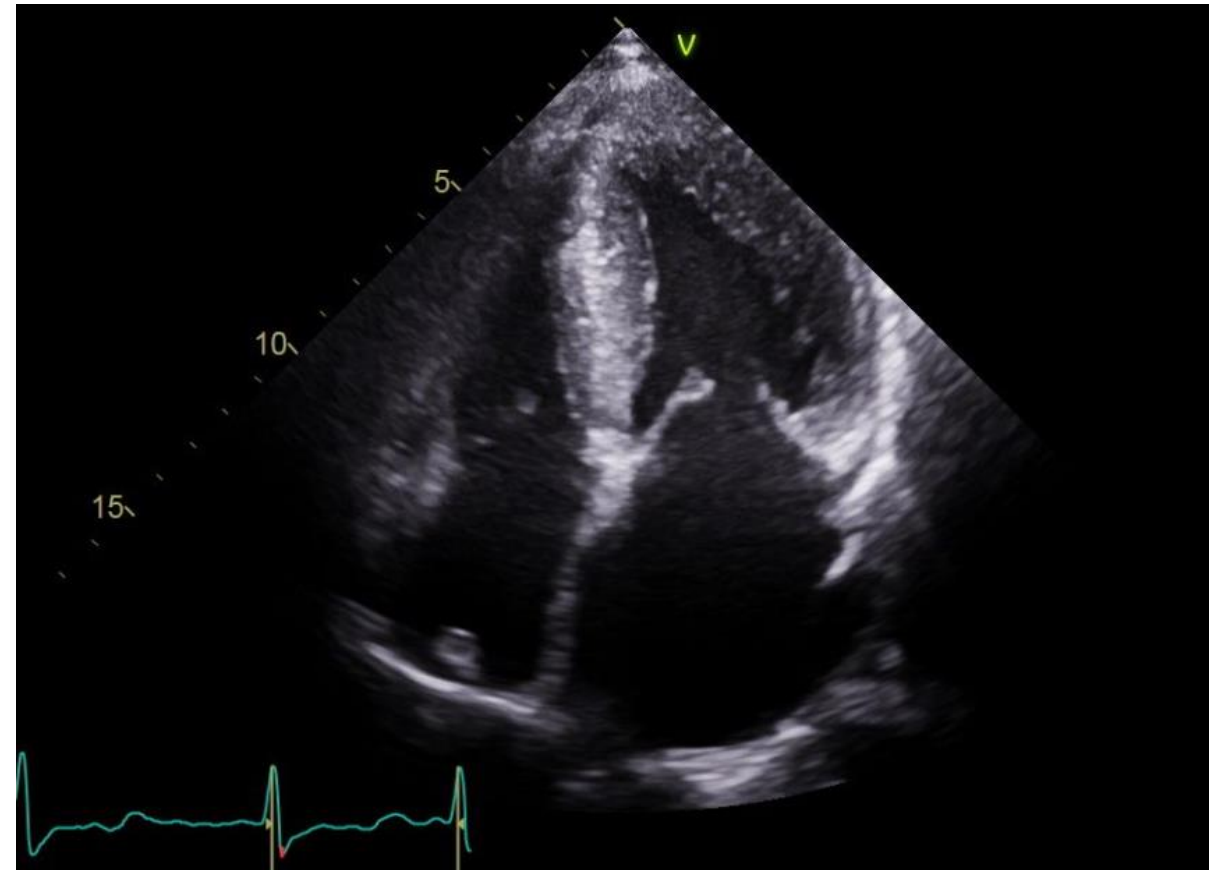
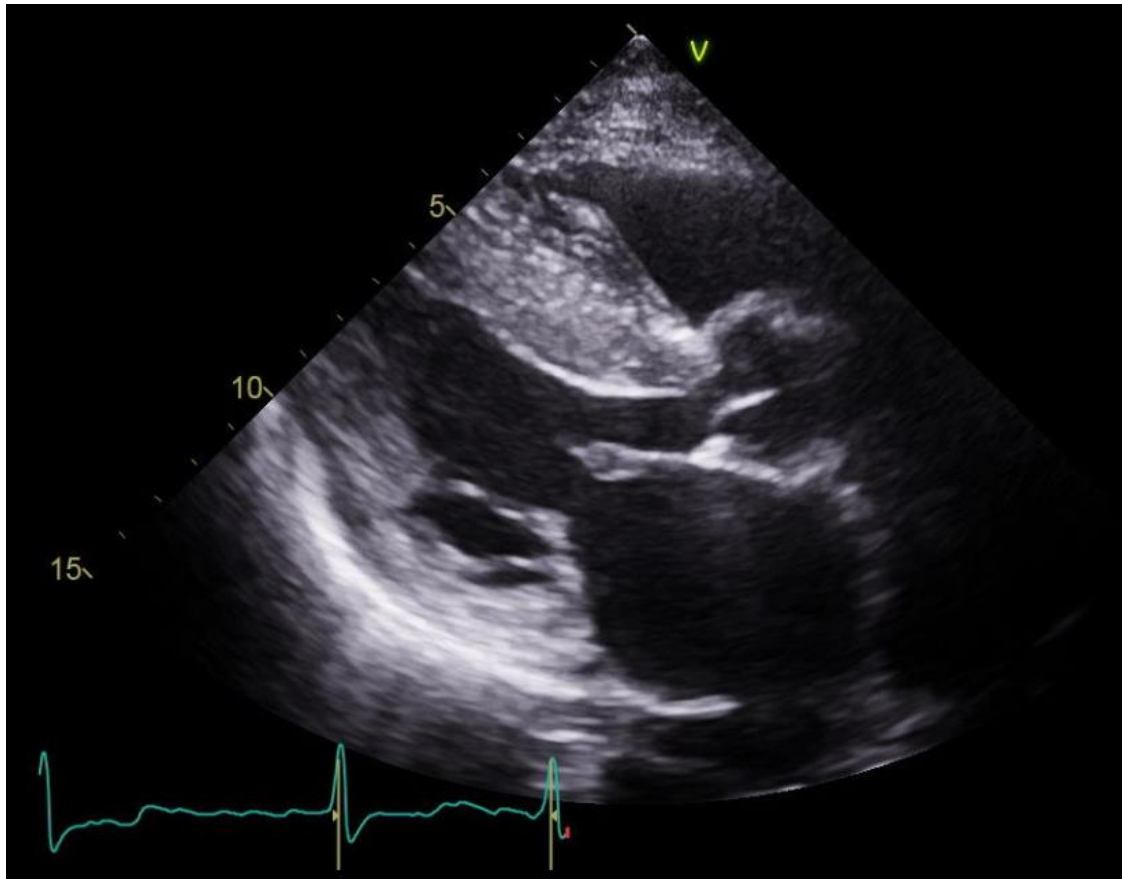
Simultaneous depolarization of the right and left ventricles

QRS wave: Ventricular Depolarization
QRS width: V Depol Time
QRS amplitude: Muscle Mass

Ventricular hypertrophy

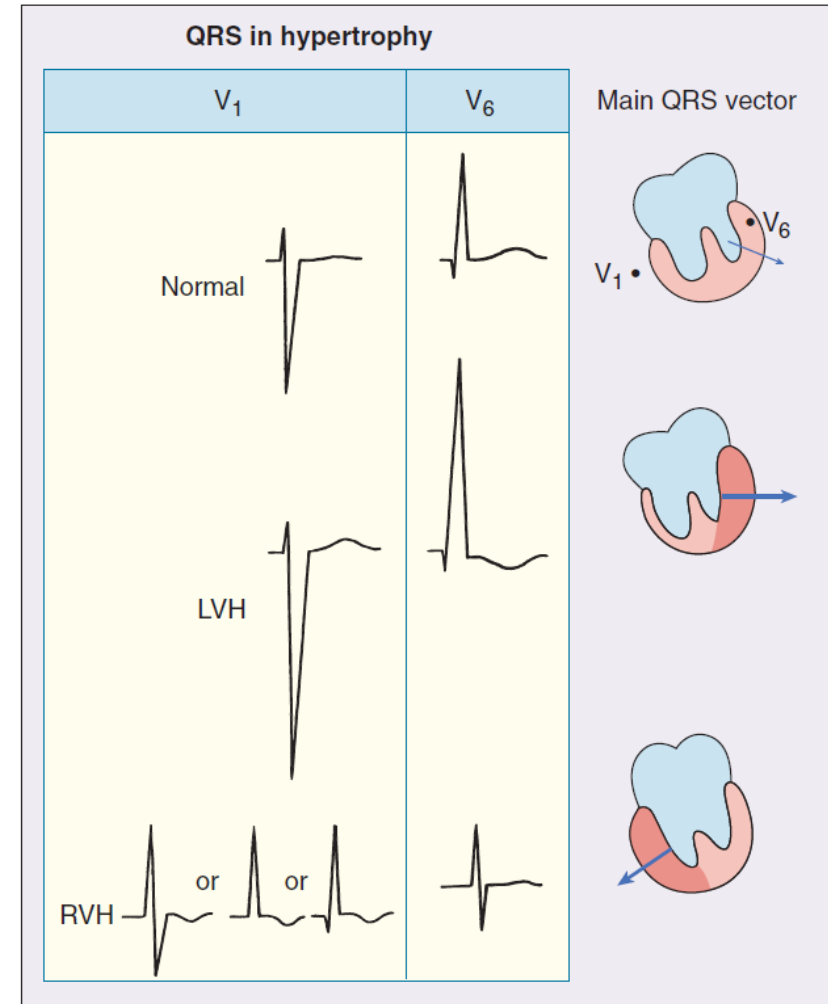


Left Ventricular Hypertrophy



Criteria for LVH

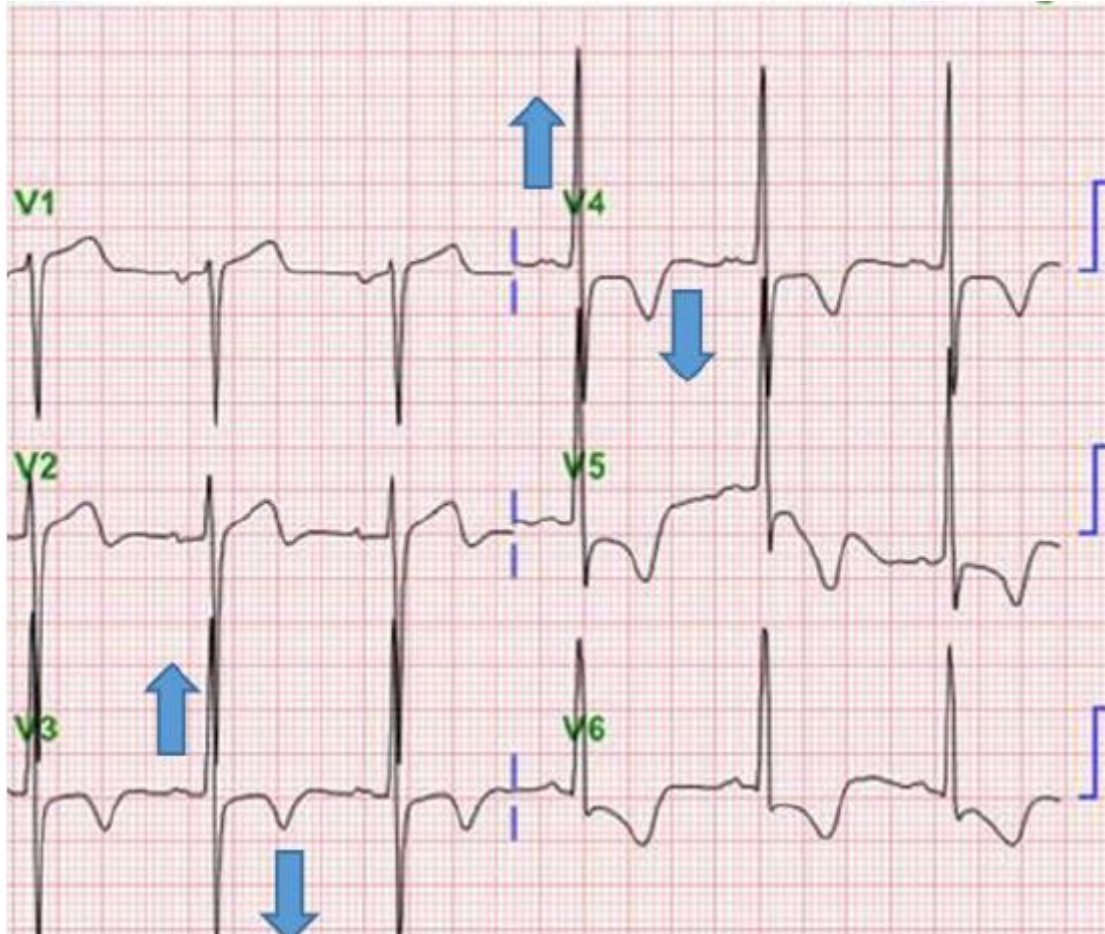
MEASUREMENT	CRITERIA
Sokolow-Lyon voltages	SV1 + RV5 >3.5 mV RaVL >1.1 mV
Romhilt-Estes point score system	Any limb lead R wave or S wave > 2.0 mV (3 points) or SV1 or SV2 ≥ 3.0 mV (3 points) or RV5 to RV6 ≥ 3.0 mV (3 points) ST-T wave abnormality, no digitalis therapy (3 points) ST-T wave abnormality, digitalis therapy (1 point) Left atrial abnormality (3 points) Left axis deviation ≥ -30 degrees (2 points) QRS duration ≥ 90 msec (1 point) Intrinsicoid deflection in V5 or V6 ≥ 50 msec (1 point)
Cornell voltage criteria	SV3 + RaVL ≥ 2.8 mV (for men) SV3 + RaVL > 2.0 mV (for women)
Cornell regression equation	Risk of LVH = $1/(1 + e^{-x})^{\dagger}$
Cornell voltage duration measurement	QRS duration × Cornell voltage > 2436 mm-sec [‡] QRS duration × sum of voltages in all leads > 1742 mm-sec [‡]



ECG criteria for LVH

- **Precordial voltage was the most sensitive criterion**
- **Limitation of ECG voltage criteria**
 - Low sensitivity
 - High false positive rate in young adults
- **High QRS voltage and the secondary repolarization changes are both present, a false positive diagnosis of LVH is seldom made**

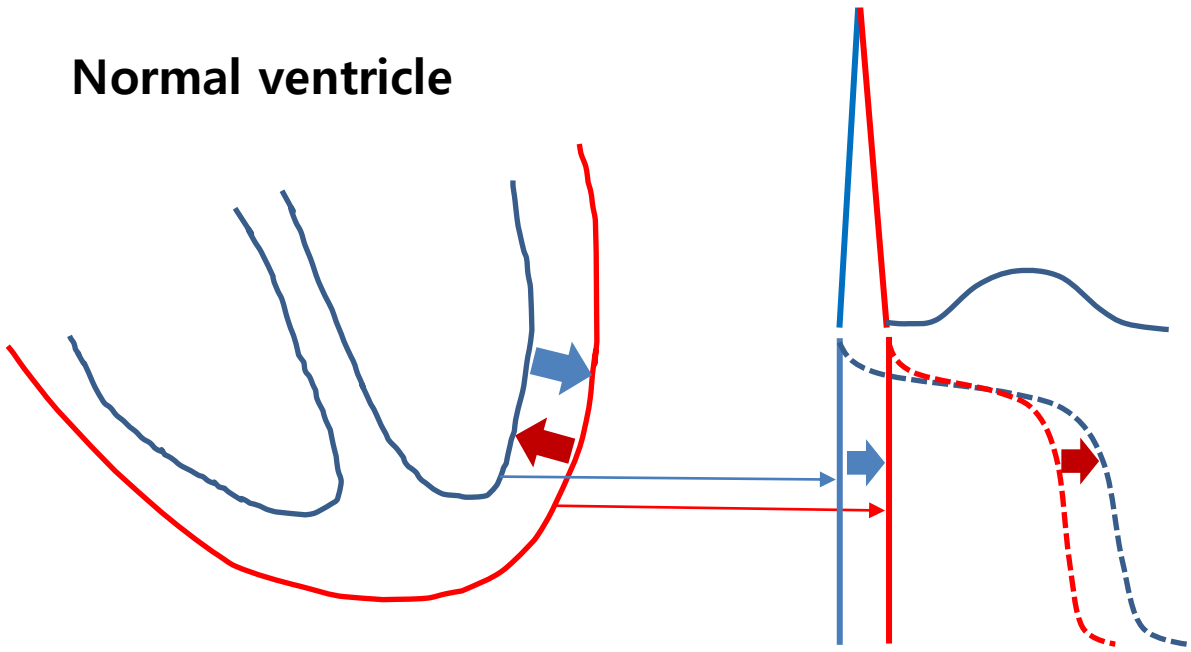
Secondary repolarization changes in LVH



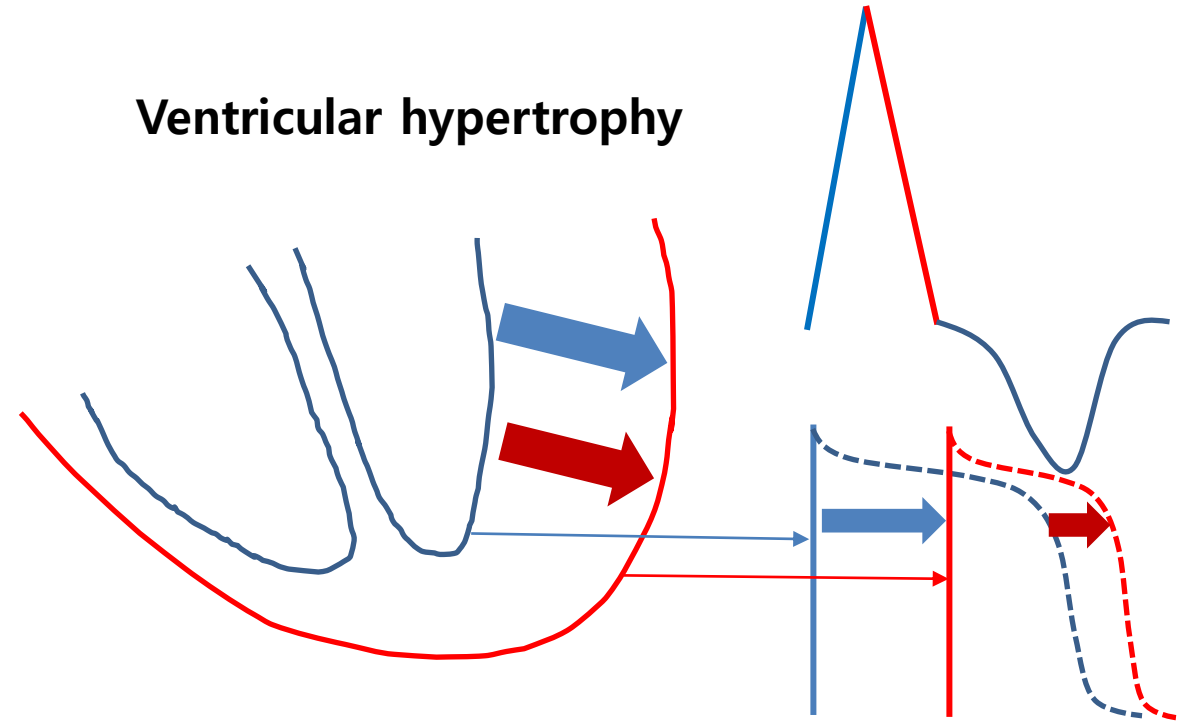
- The direction of the ST and T vectors is also directed opposite to the main QRS forces
- T wave morphology is asymmetric

Secondary repolarization changes in LVH

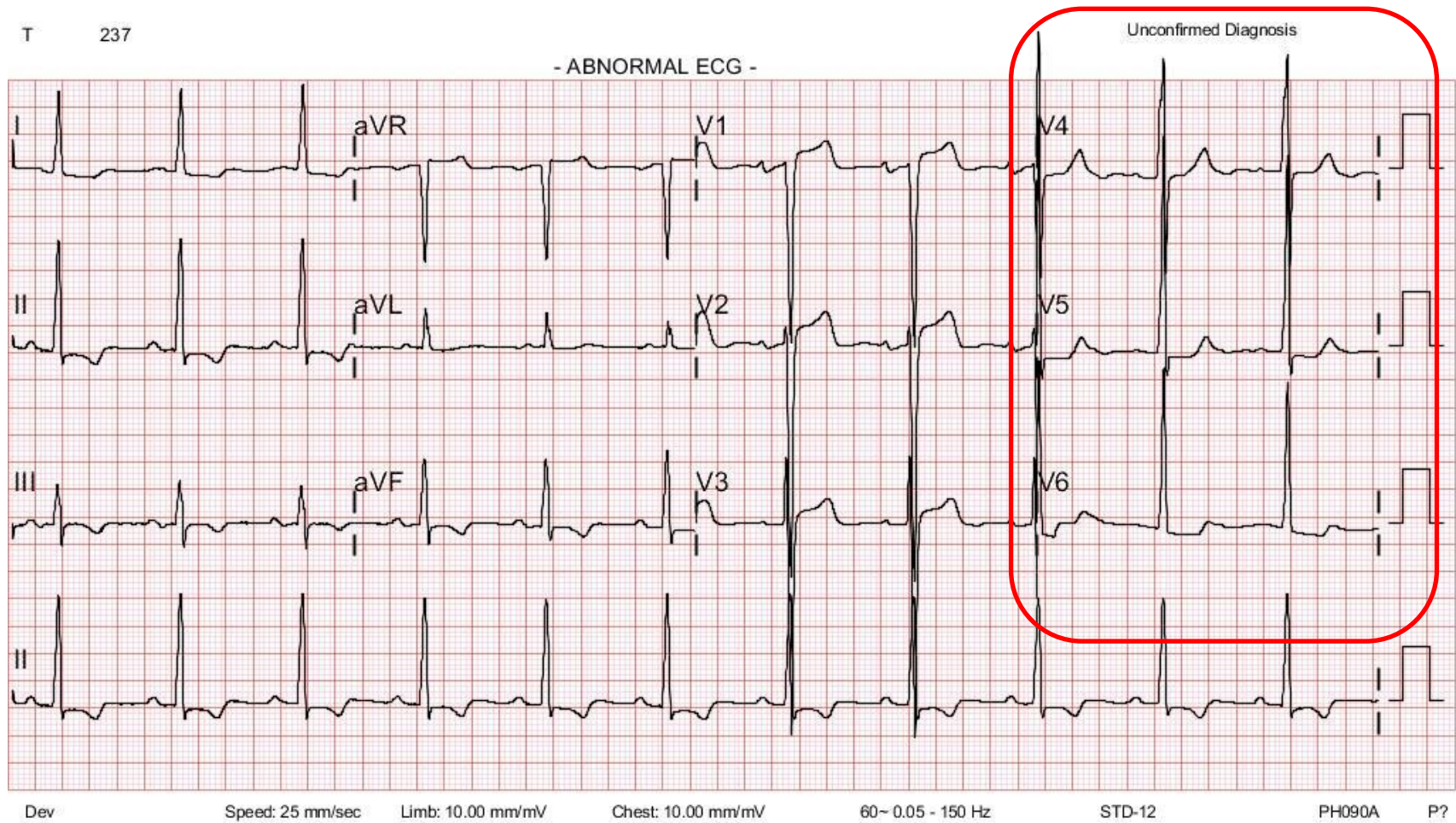
Normal ventricle



Ventricular hypertrophy



LVH

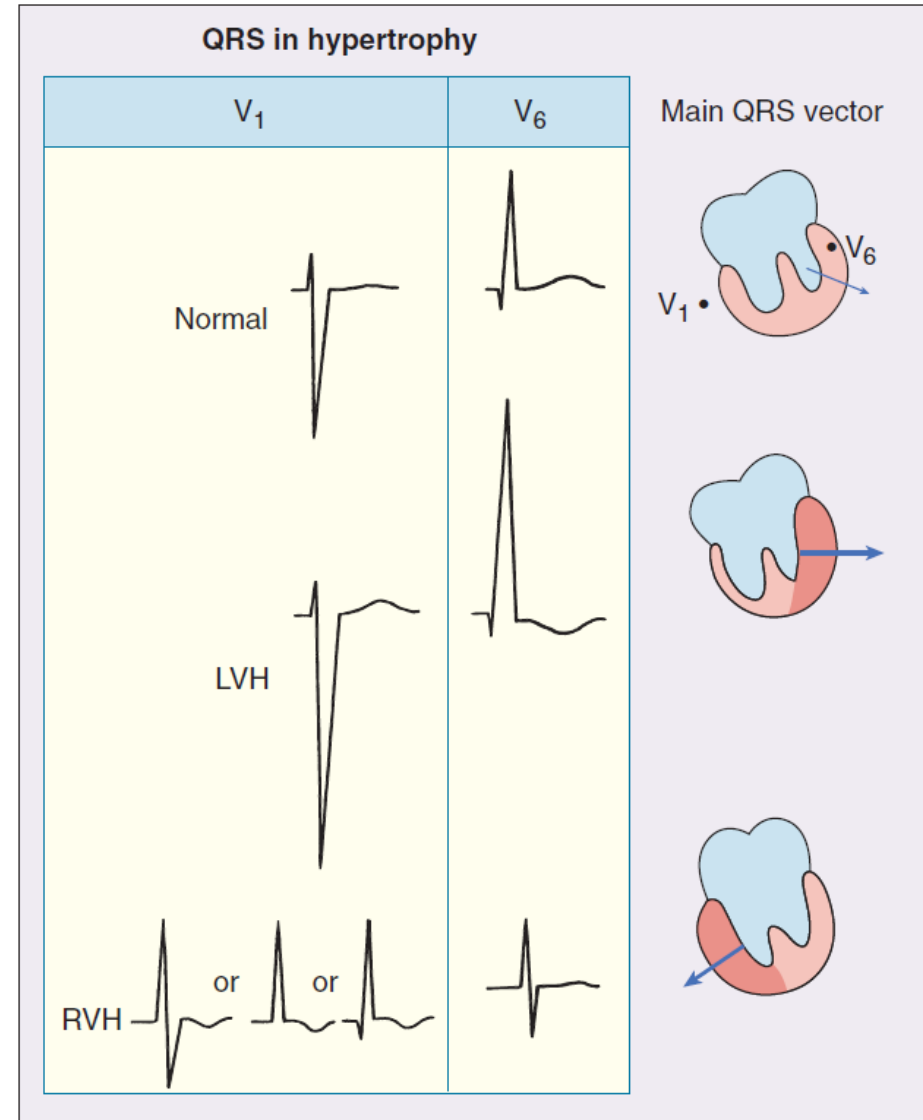


RVE, RAE

- **Pulmonary HTN**
- **Pumonary Thromboembolism**
- **COPD, cor-pulmonale**

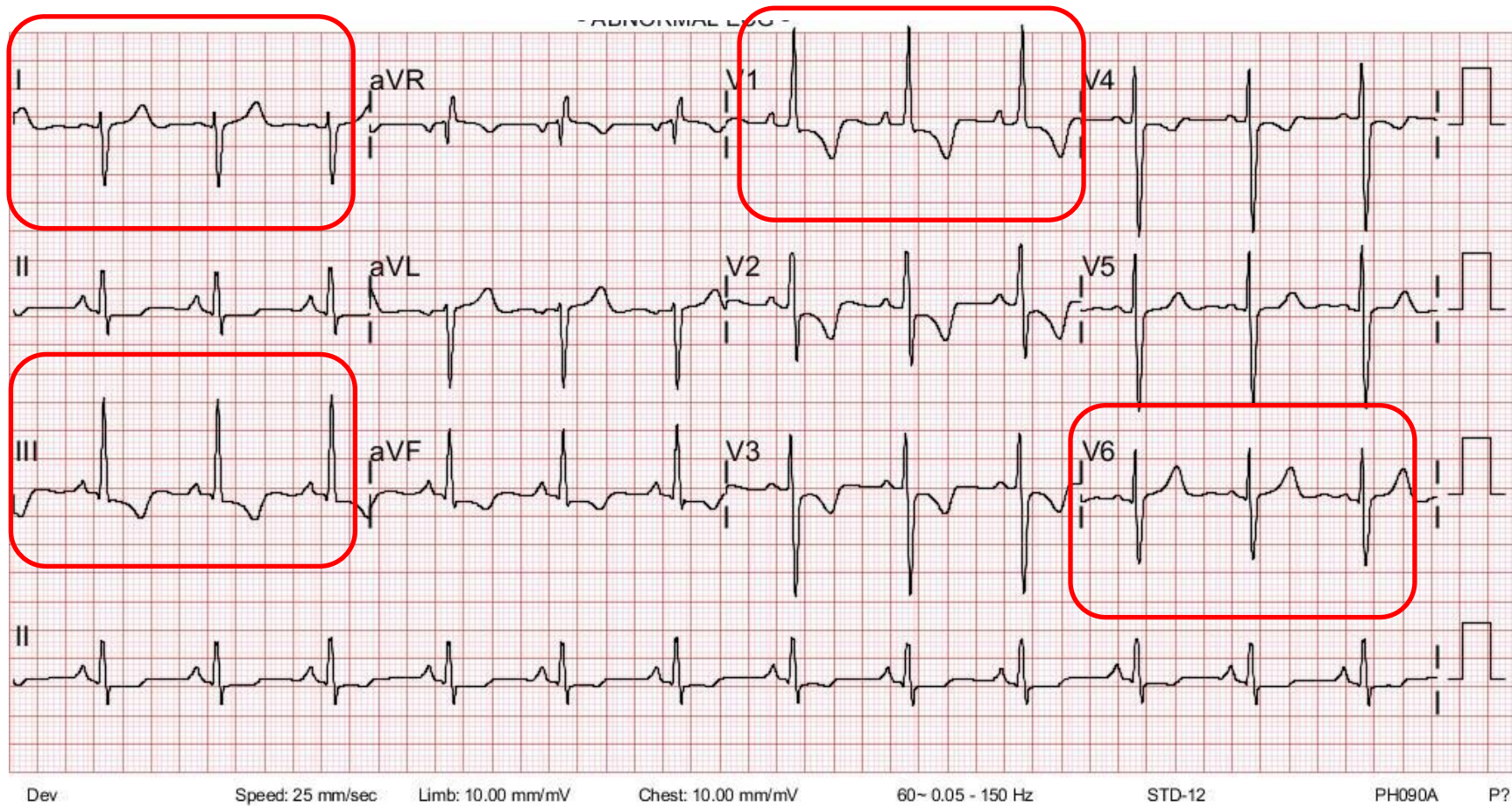
Criteria for RVH

- R in V1 ≥ 0.7 mV
- QR in V1
- R/S in V1 > 1 with R > 0.5 mV
- R/S in V5 or V6 < 1
- S in V5 or V6 > 0.7 mV
- R in V5 or V6 ≥ 0.4 mV with S in V1 ≤ 0.2 mV
- Right axis deviation (> 90 degrees)
- S1Q3 pattern
- S1S2S3 pattern
- P pulmonale



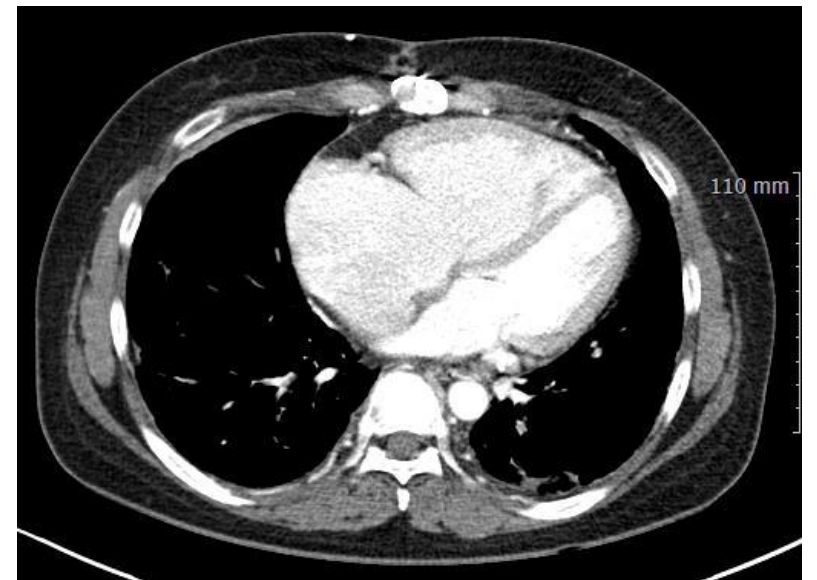
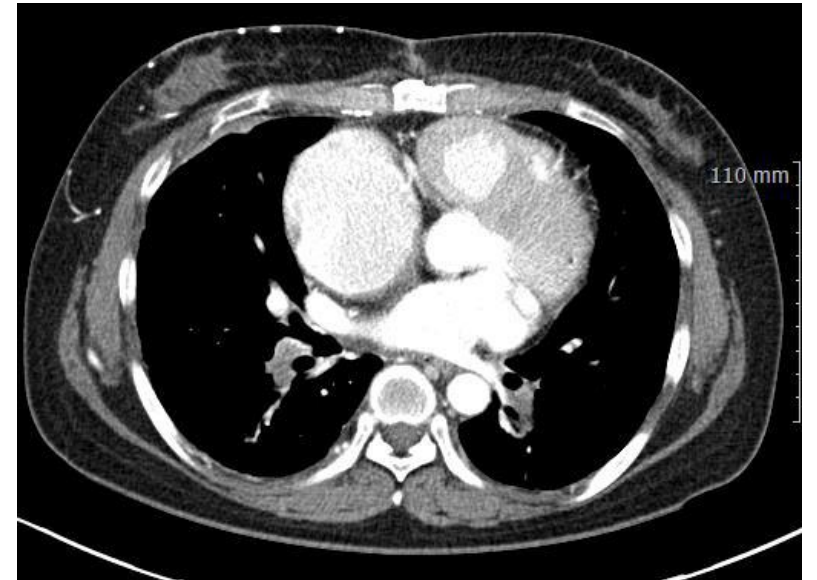
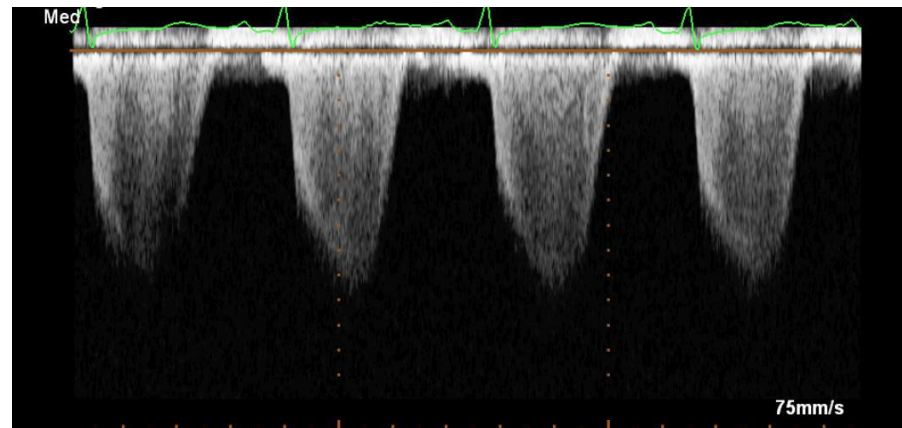
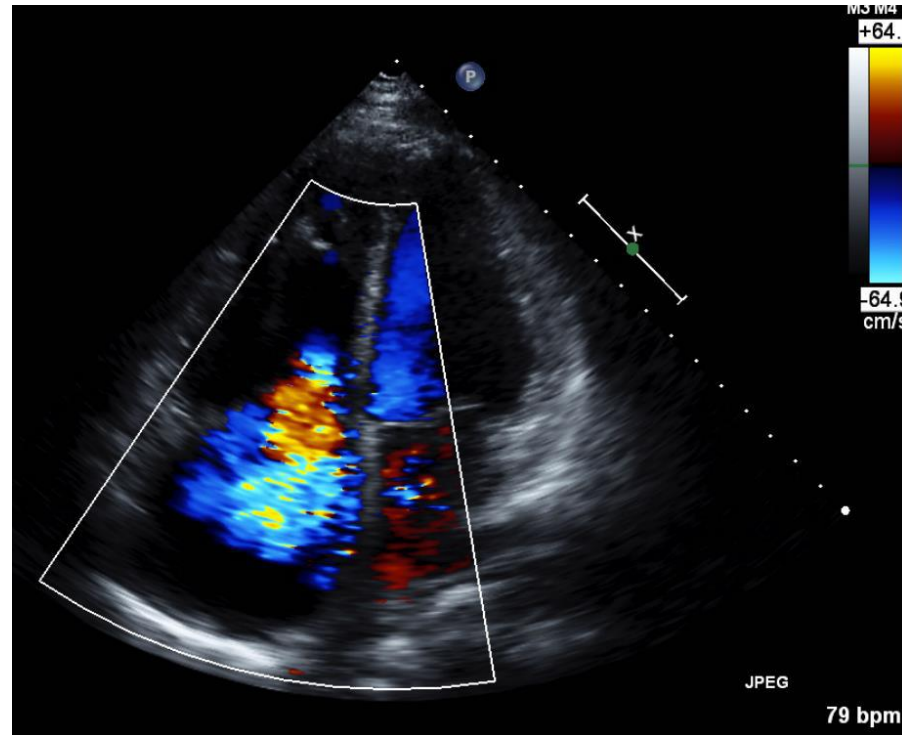
RVE, RVH

42세/여자 호흡곤란



Chronic Thromboembolic Pulmonary Hypertension

RVH and enlarged RV and RA
Severe TR
Estimated RVSP = 110

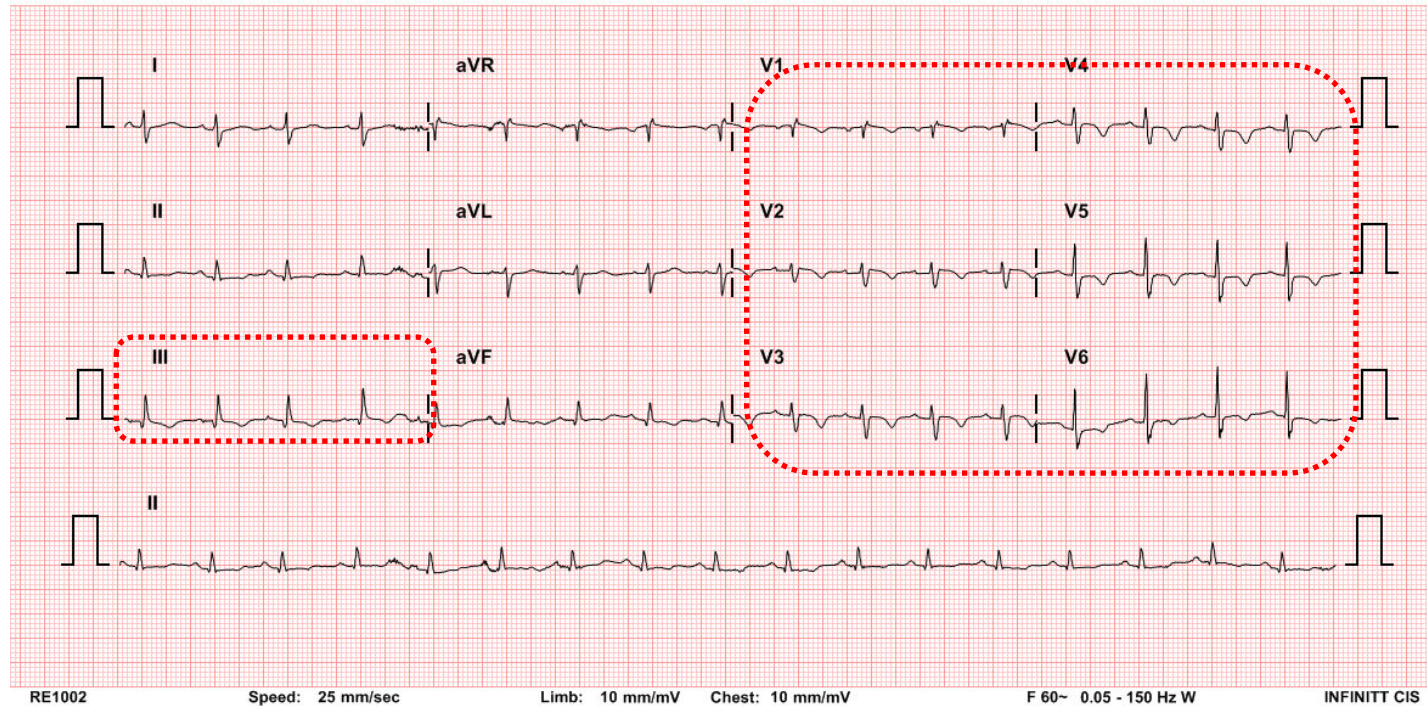


F/65 chest pain, dyspnea

Rate	102	Age not entered, assumed to be 50 years old for purpose of ECG interpretation
RR	588	Sinus tachycardia rate > 99
PR interval	145	Left posterior fascicular block trm axis(110,210), init force sup
QRSD	100	Abnrm T, consider ischemia, anterolateral lds T < -0.20mV, I aVL V2-V6
QT	349	Baseline wander in lead(s) V5,V6
QTcB	455	
QTcF	417	
..... AXIS		
P	44	
QRS	106	
T	-43	

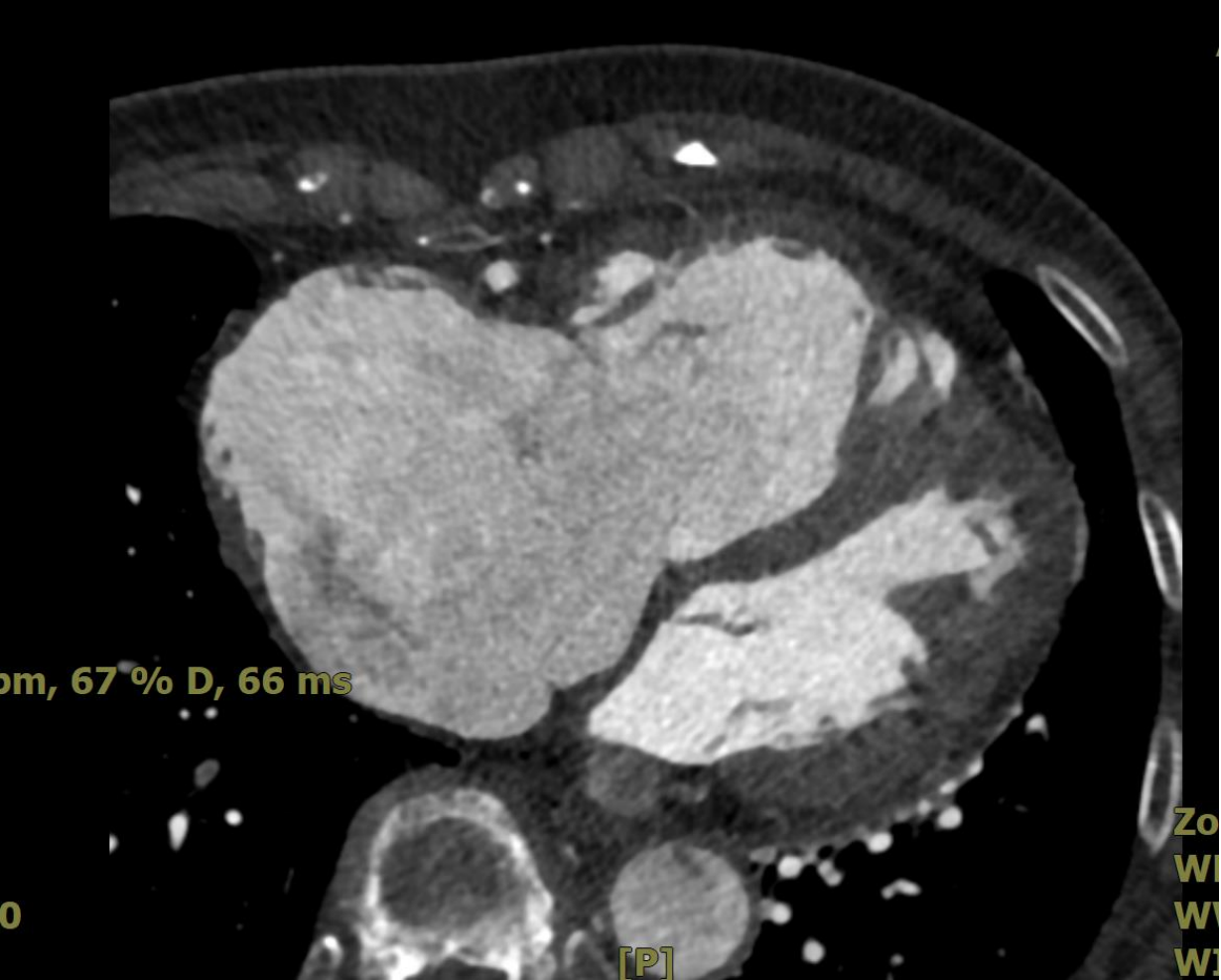
- ABNORMAL ECG -

Unconfirmed Diagnosis



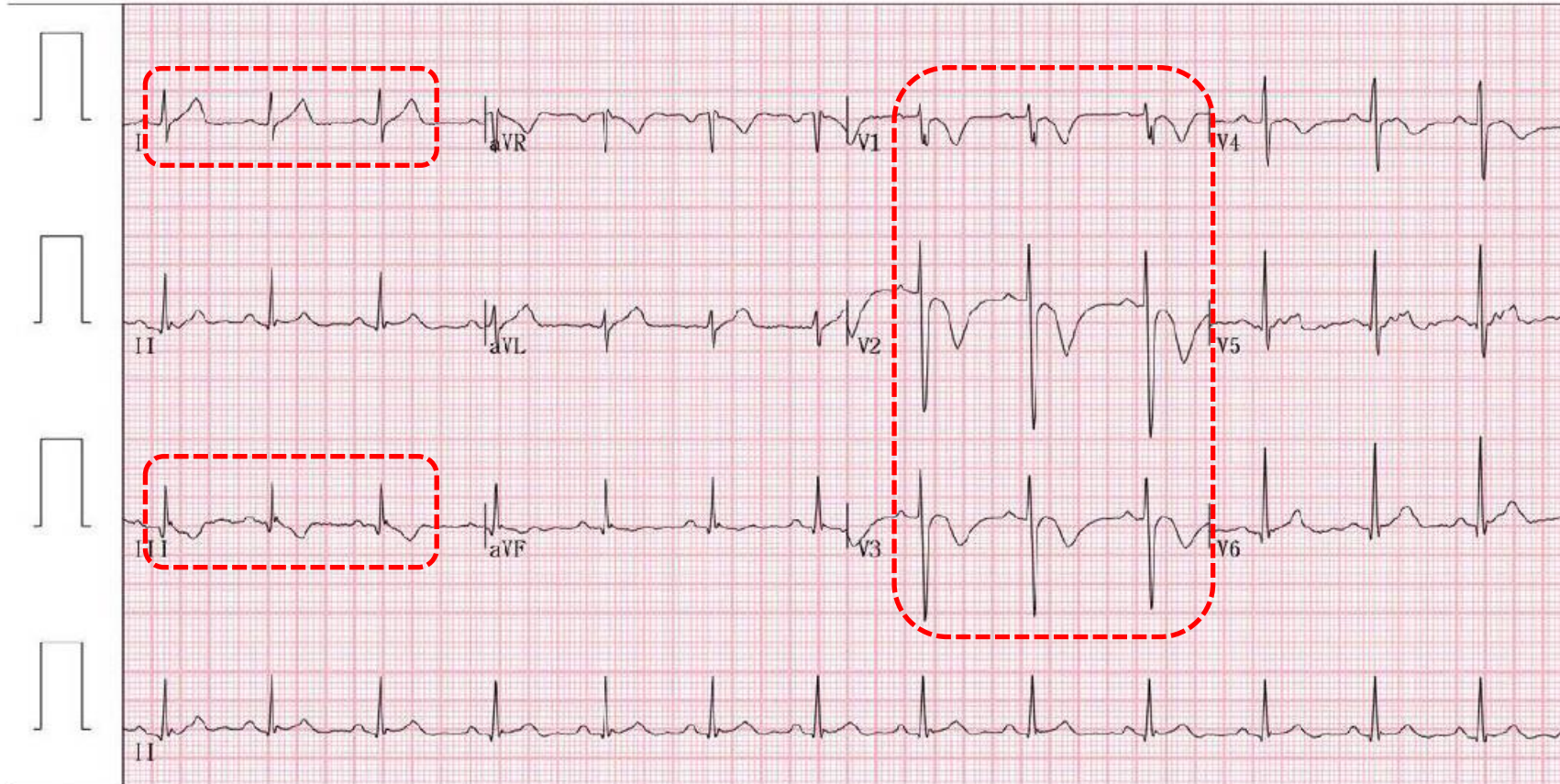
✓	2021-06-07 17:05	CK-MB	6.8	H	ng/ml	0.6-6.3	Serum	-
✓	2021-06-07 17:05	Troponin I	0.601	H	ng/ml	0.0-0.5	Serum	-
✓	2021-06-07 17:05	Pro BNP	411.7	H	pg/ml	0-125	Serum	-

Bilateral Pulmonary thromboembolism



F/65 chest pain, dyspnea

S1Q3T3, T-wave inversion in leads V1-4 (RV strain or ischemia)



GE MAC3.5K V008B(1)
25mm/s 10mm/mV 16-150Hz 60Hz

Attending MD:

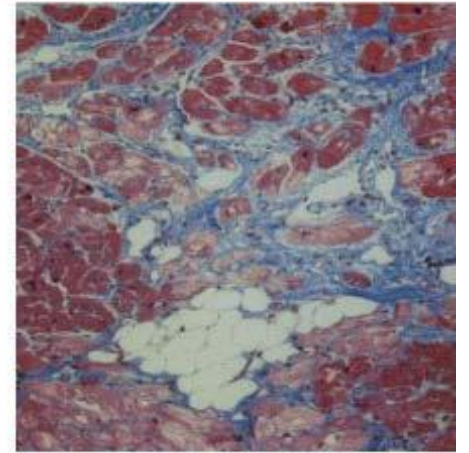
ECG in Pulmonary Embolism

- The most frequently cited abnormality, in addition to sinus tachycardia, is the **S1Q3T3** sign: an S wave in lead I, a Q wave in lead III, and an inverted T wave in lead III.
- This finding is relatively specific but insensitive. RV strain and ischemia cause the most common abnormality, **T-wave inversion in leads V1 to V4.**
- **RBBB**
- 심전도 변화의 원인
 - Right-sided intraventricular conduction disturbance
 - The posterior displacement of the initial QRS vector due to right ventricular dilation
 - Subacute transmural right ventricular ischemia or increased hemodynamic burden

Epsilon wave



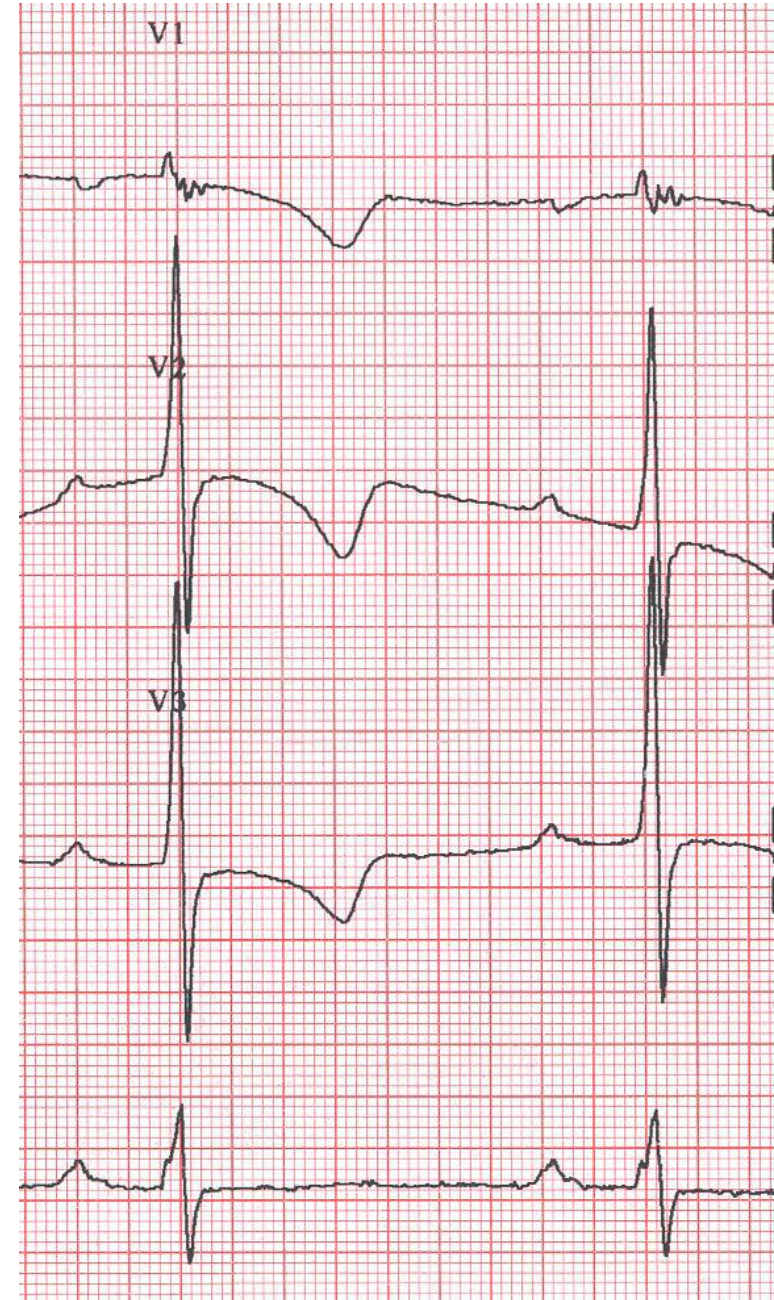
ARVC/D



	N-cadherin	Plakoglobin	Connexin 43	Desmoplakin	Plakophilin 2
Control					
ARVC (A3)					
ARVC (A5)					

Epsilon wave

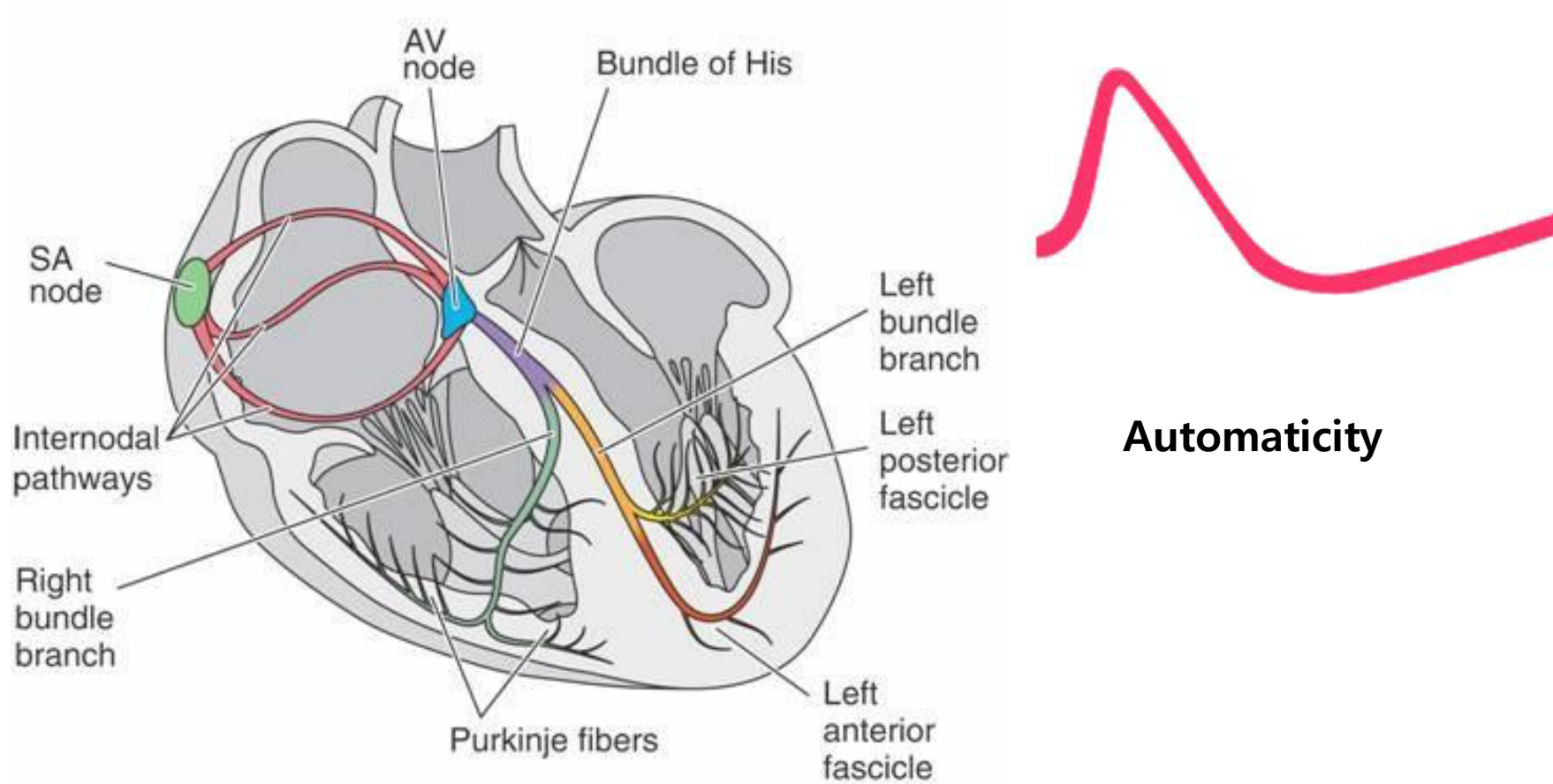
- Reproducible low-amplitude signal between end of QRS complex to onset of the T wave in the right precordial leads (V1 to V3).
- Major diagnostic criterion for ARVC.



Premature Complex

- **Atrial premature complex :**
 - PAC, APC, APB
- **Ventricular premature complex:**
 - PVC, VPC, VPB

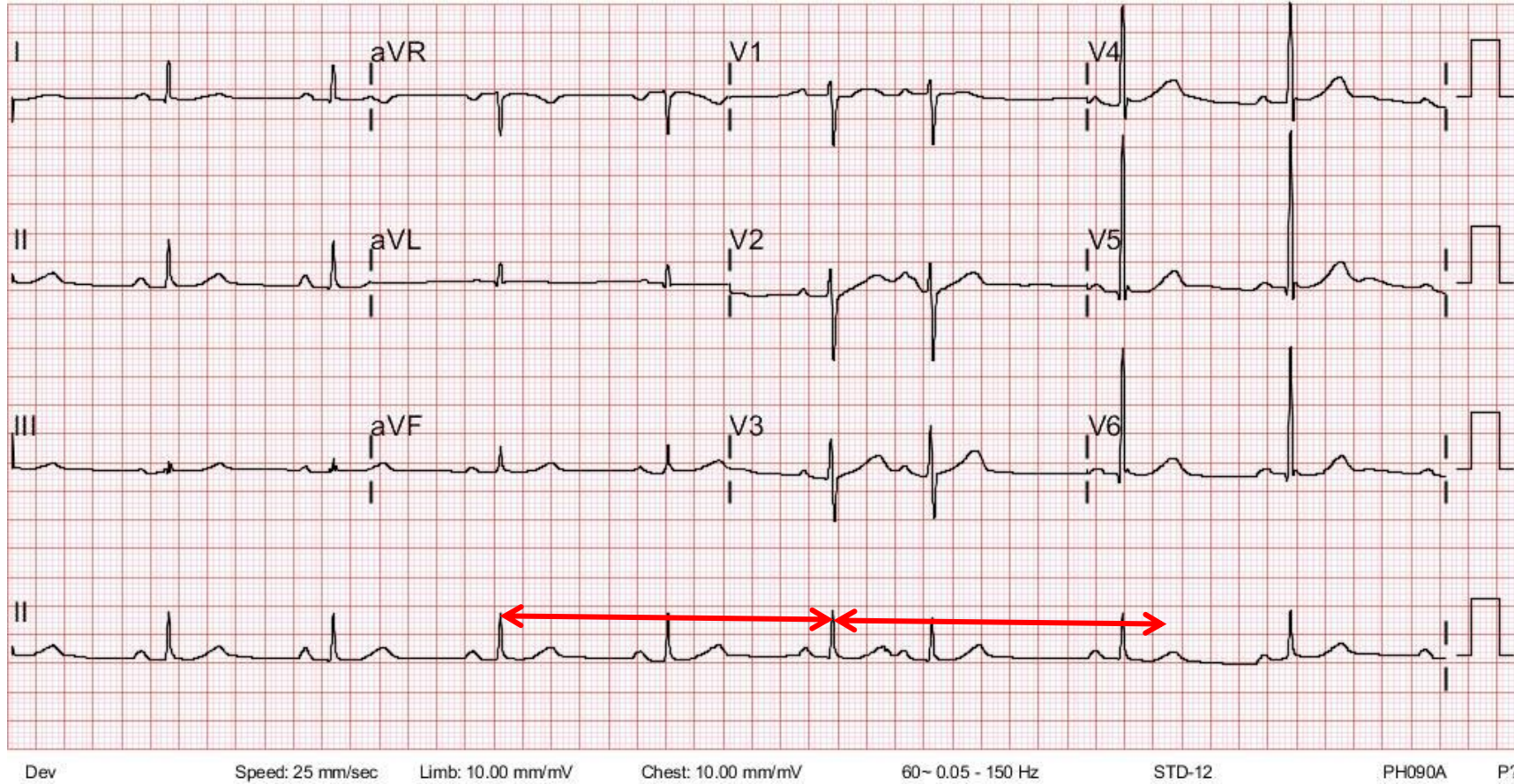
Ectopic automaticity



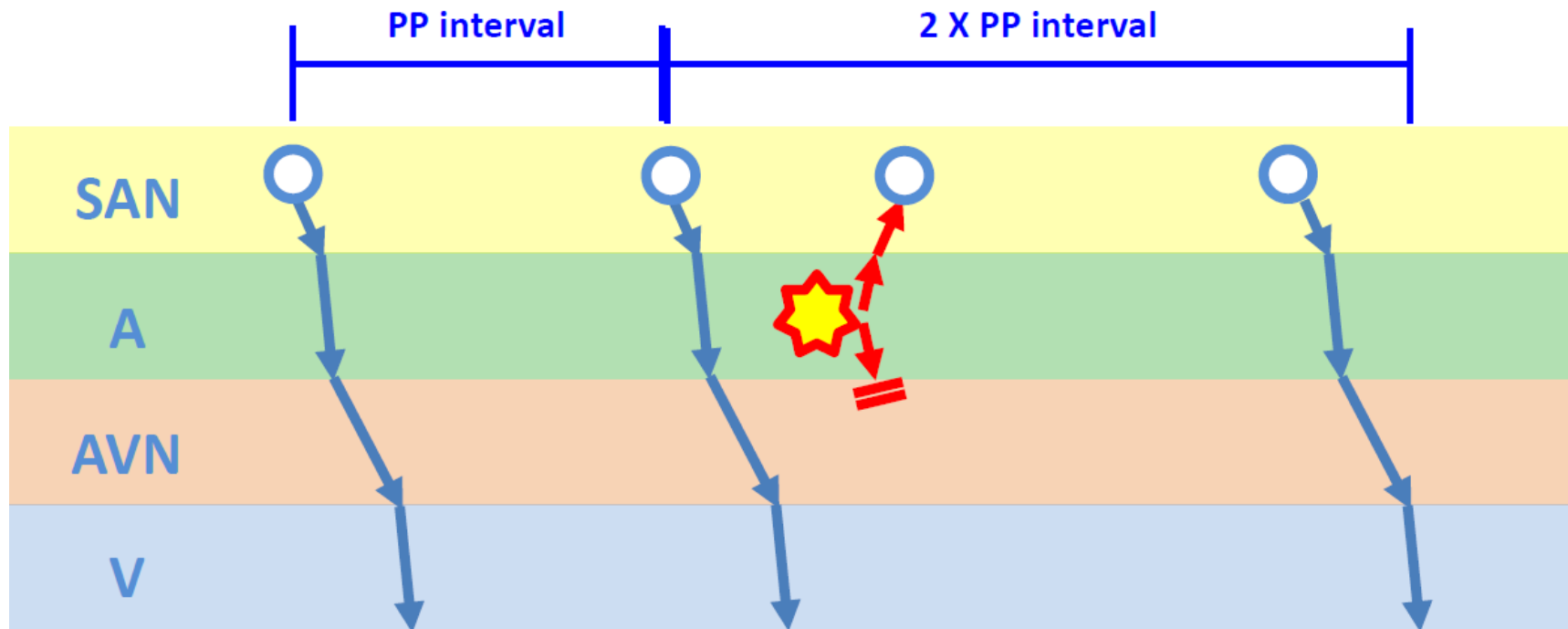
Premature Atrial Contraction (PAC)

- **Rate** : That of the underlying rhythm.
- **Regularity** : Irregular when PACs are present.
- **P' wave** : Occur earlier than the next expected P sinus.
 - The size, shape, direction depend on the location of pacemaker site
- **P-P Intervals** :
 - P-P' interval is usually shorter, P'-P interval is the same or slightly longer than P-P interval of underlying rhythm
 - Commonly, a non-compensatory pause is present
- **P'R Intervals** : may vary between PACs
- **R-R Intervals** : Unequal
- **QRS complex** : Usually normal (0.12 second or less)

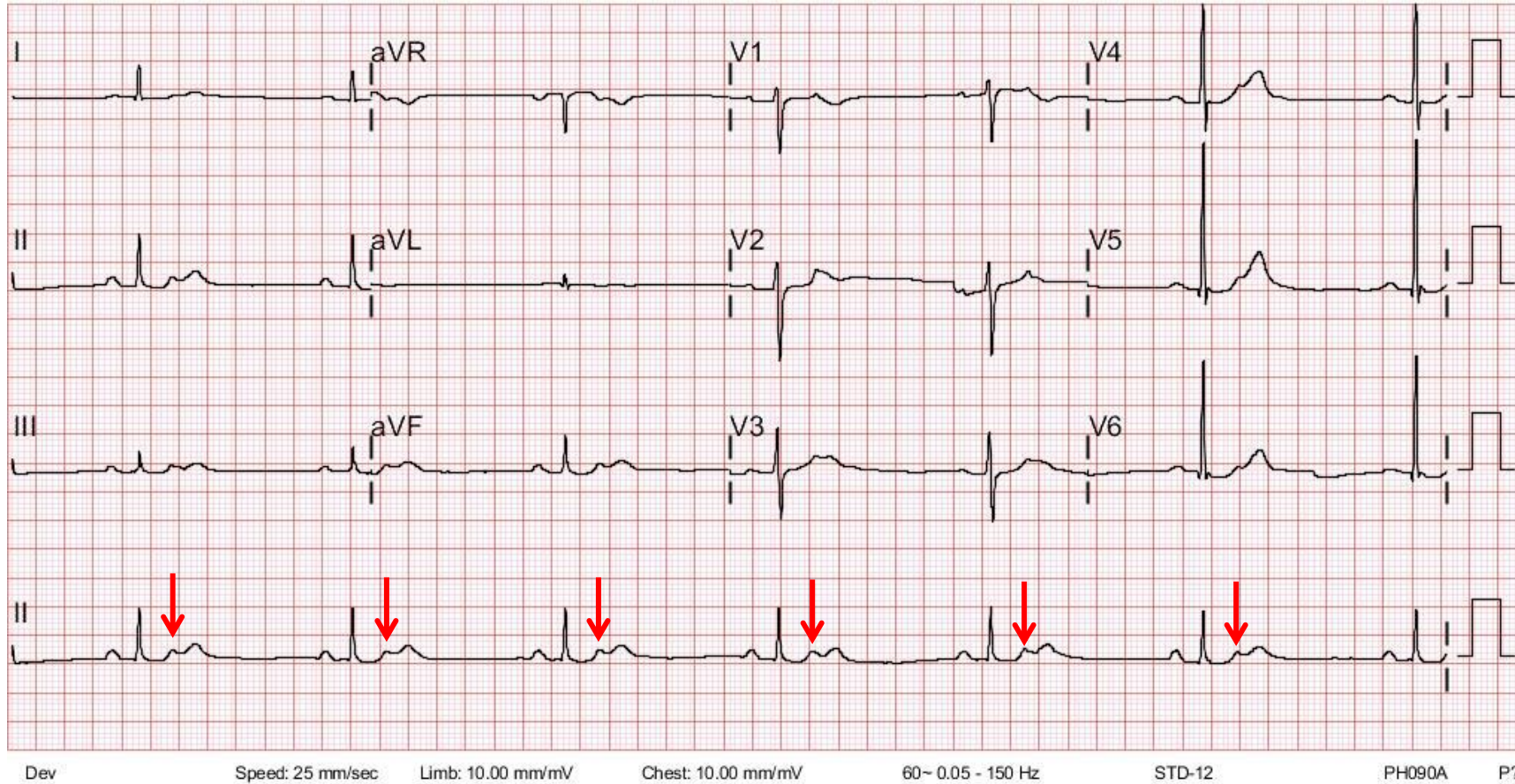
APC reset sinus cycle



APC : SA node reset



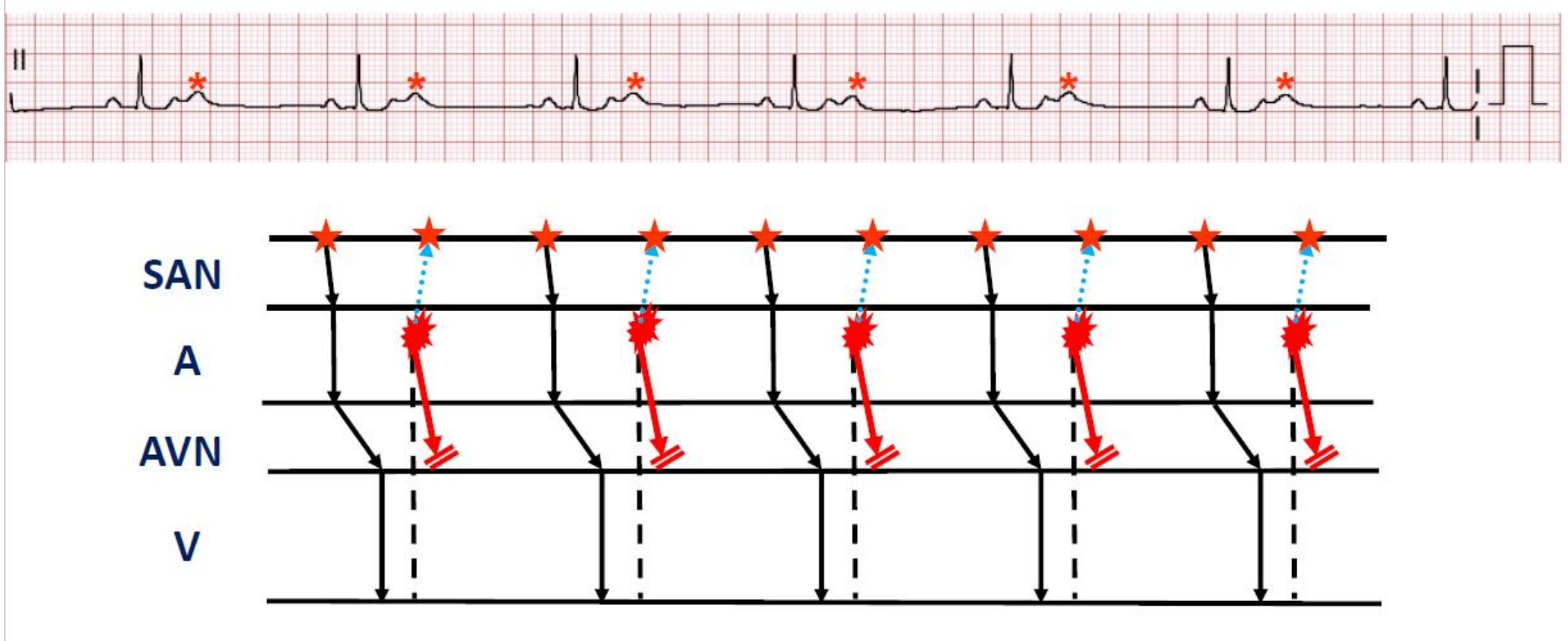
Nonconducted PAC



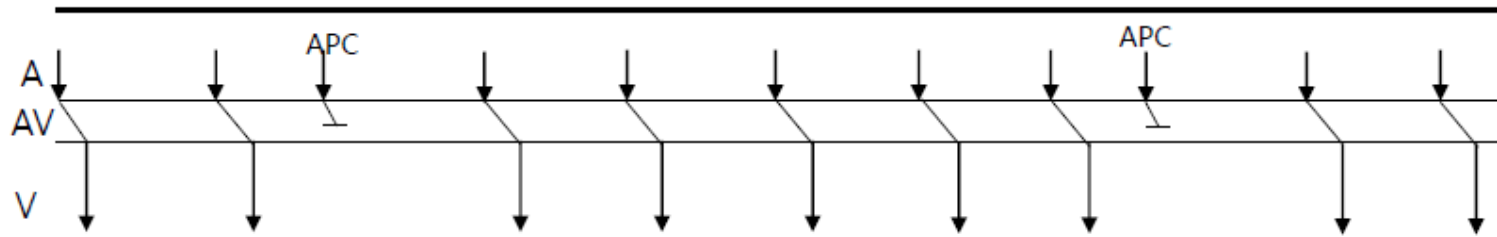
63세/남자

- 약간 어지럽다.
- 심방세동으로 부정맥약 드시다 2개월 전 중단.

Nonconducted APC



Nonconducted Premature Atrial contraction (PAC)



*Non-conducted atrial premature beat

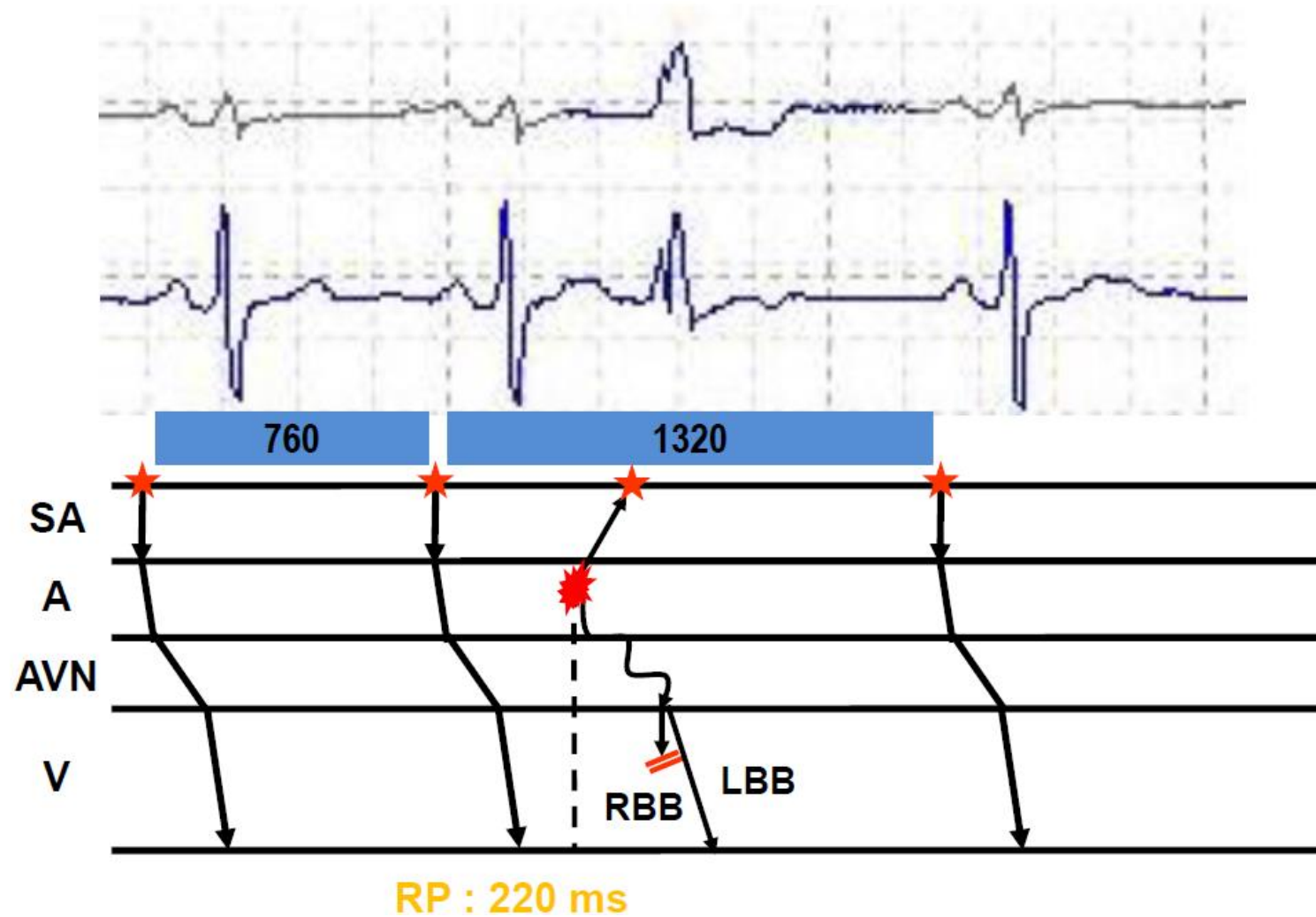
PP interval이 선행하는 PP interval 보다 짧아 지는 것이 AV block과 감별점

APC with aberrant conduction

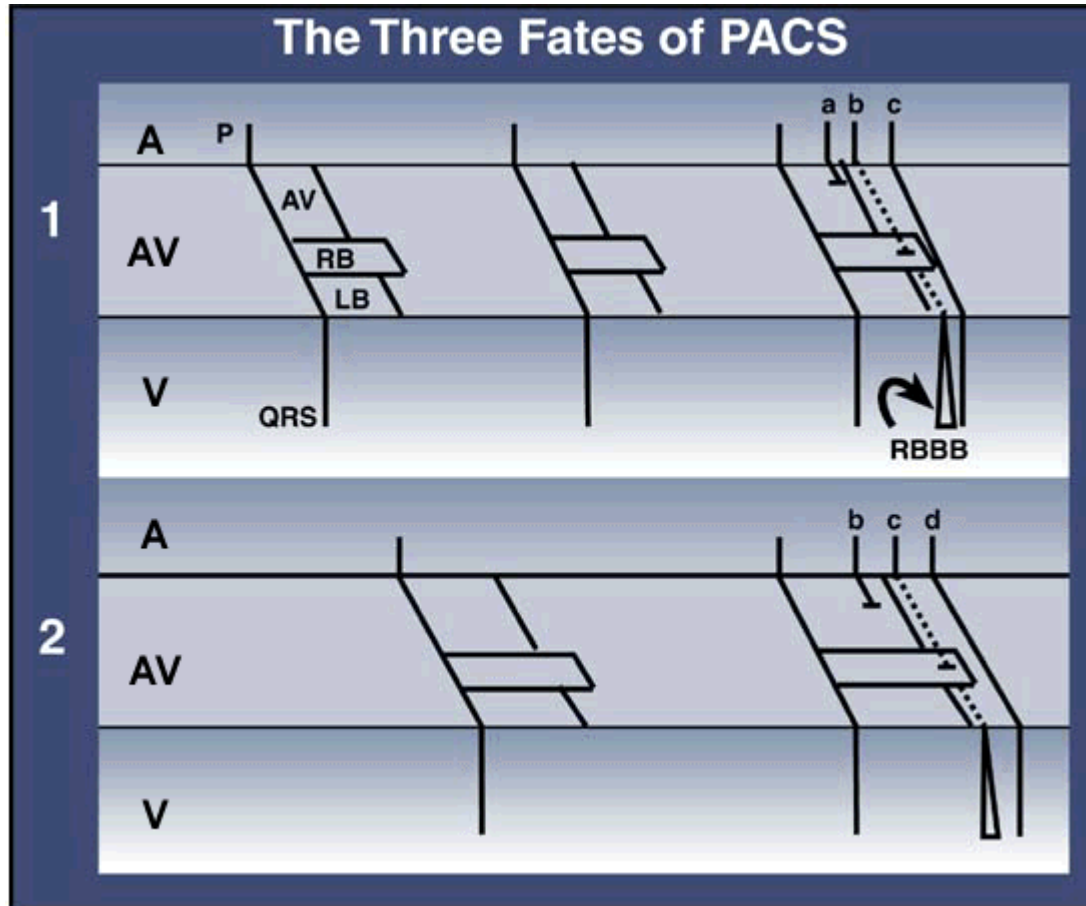
56세/여자
두근거림
홀터 심전도



APC with aberrant conduction



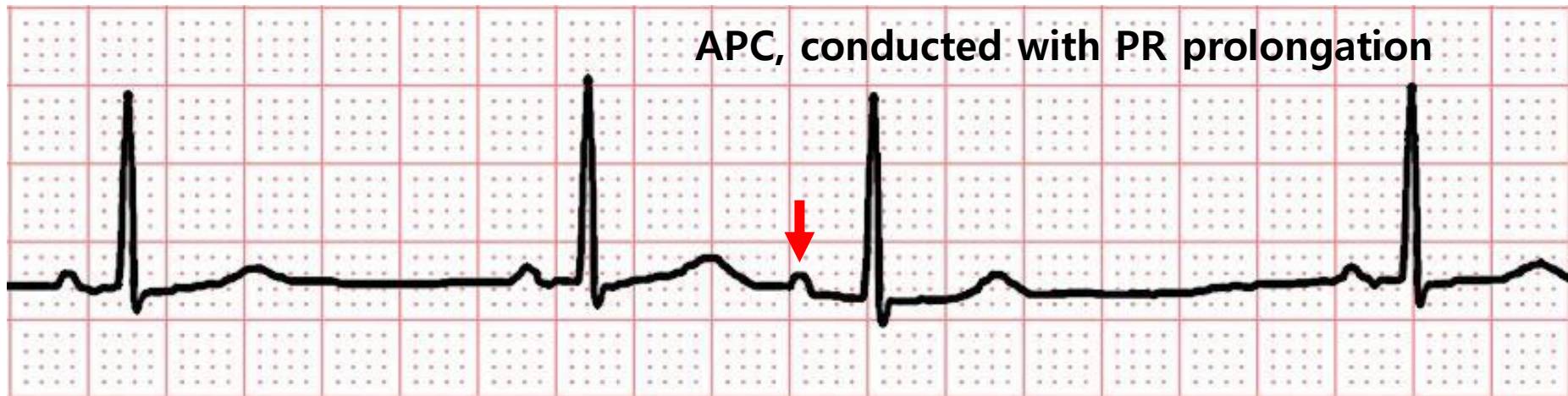
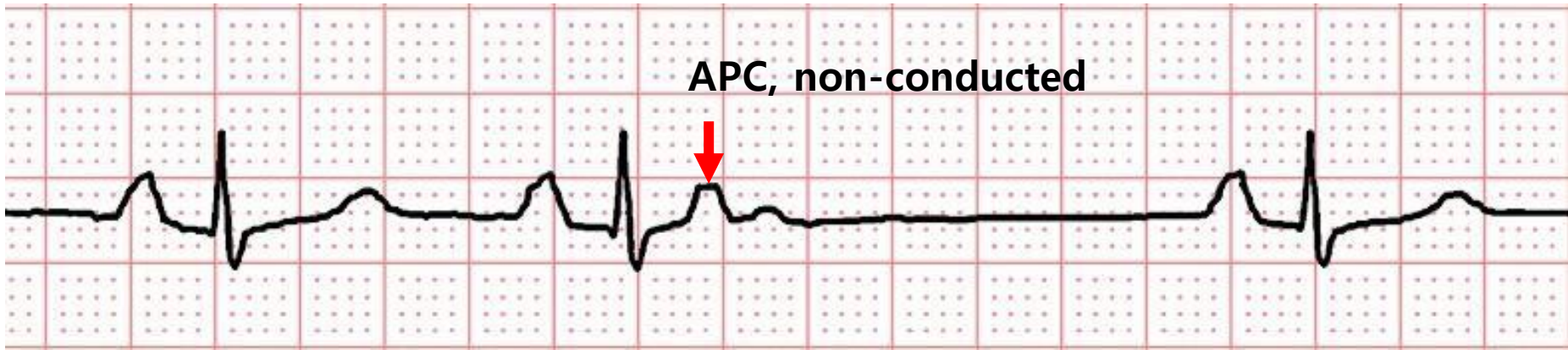
Three fates of atrial premature beats



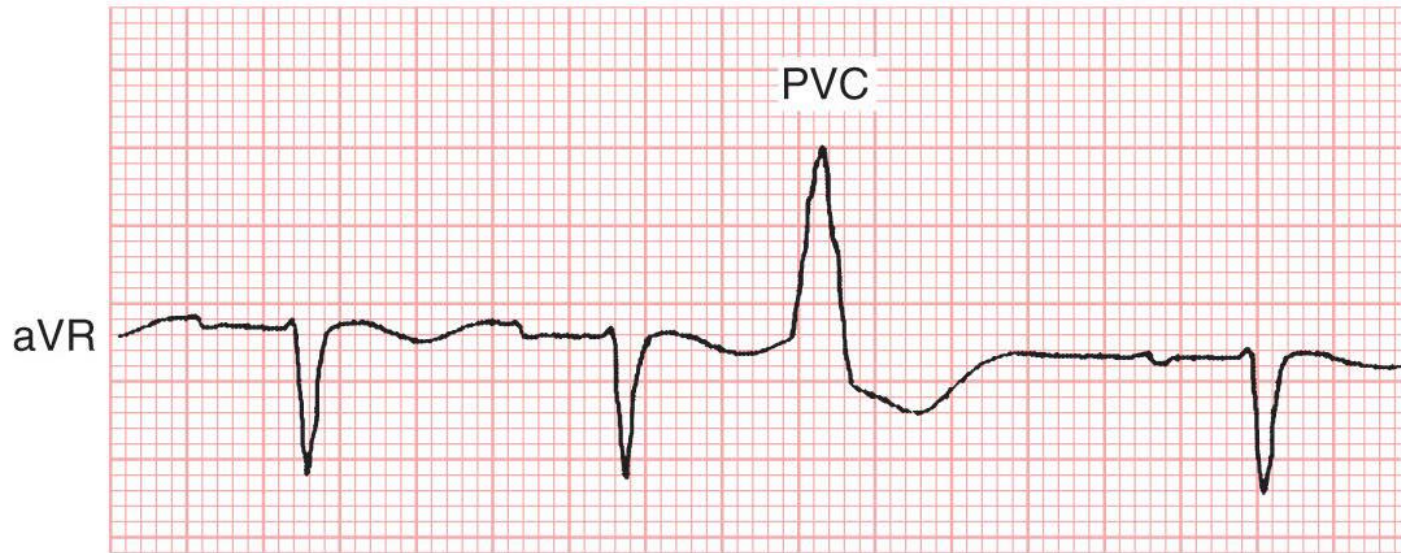
A. Non-conduction

B. Conduction with aberration

C. Normal conduction



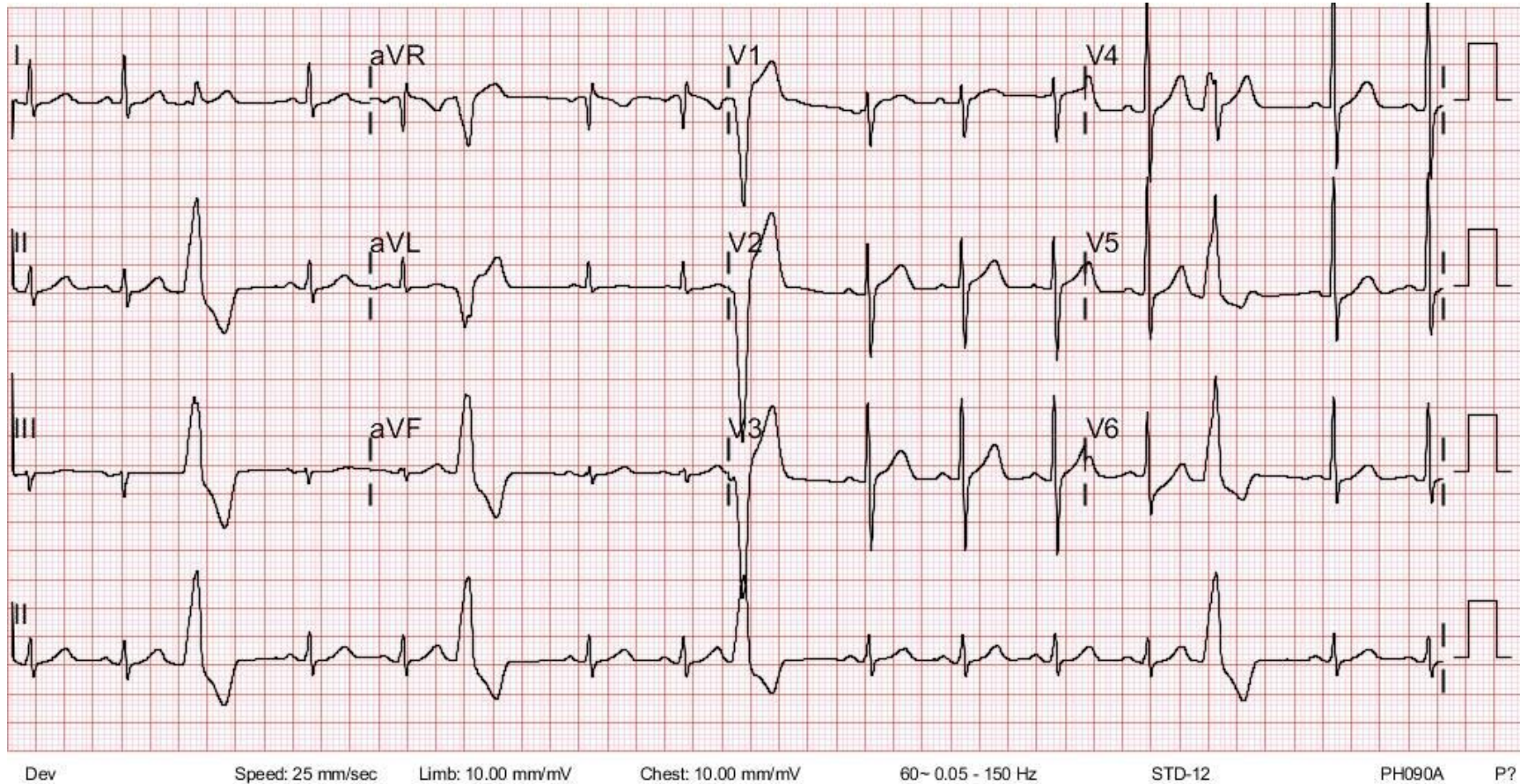
Premature Ventricular Contraction (VPC)



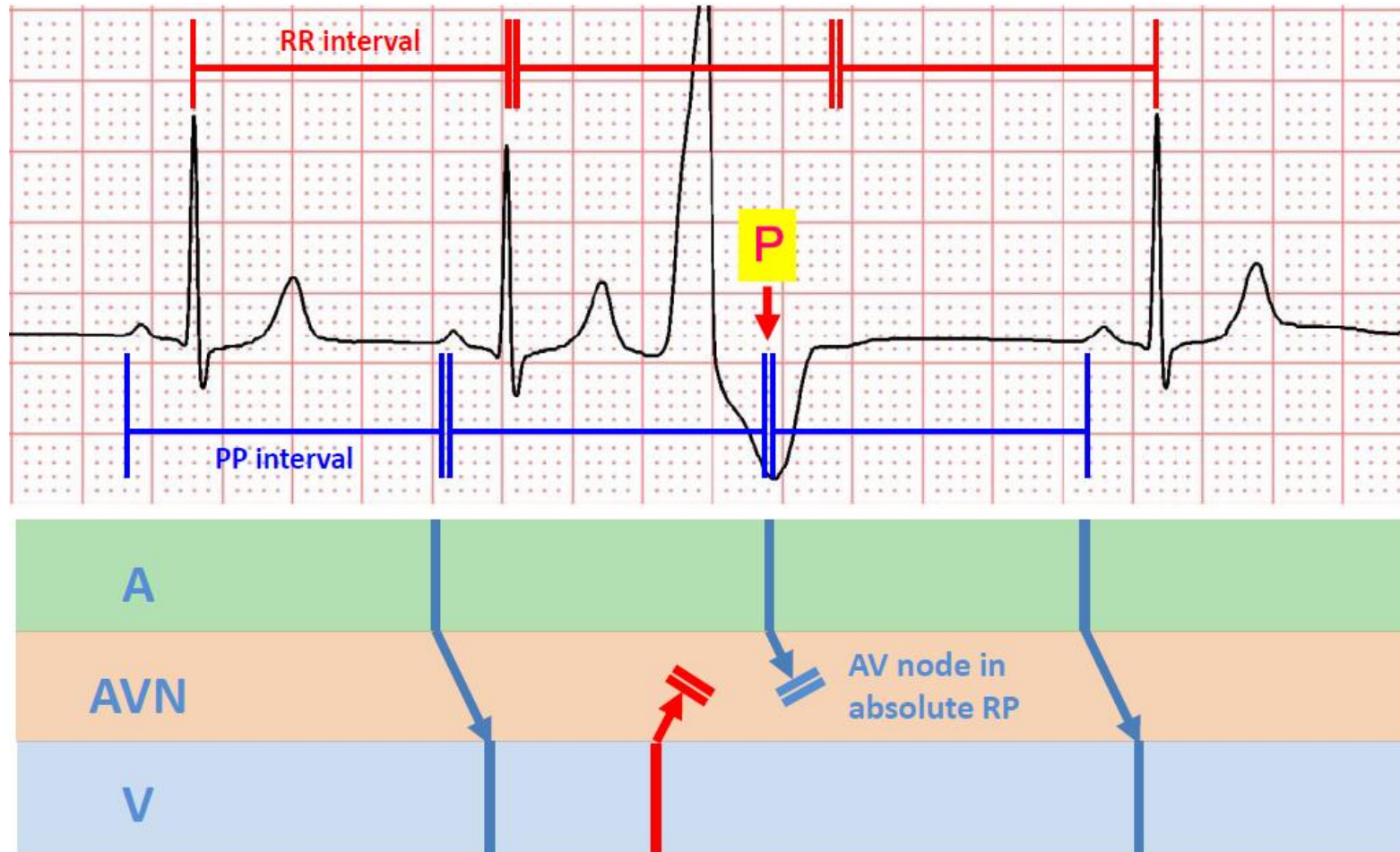
- Originate in ectopic foci in the ventricles
- Comes before the next normal beat is expected.
- Not preceded by P wave
- Bizarre QRS morphology (QRS duration $>120\text{ms}$), T wave discordant
- Full compensatory pause
- Fixed coupling interval

PVC with full compensatory pause

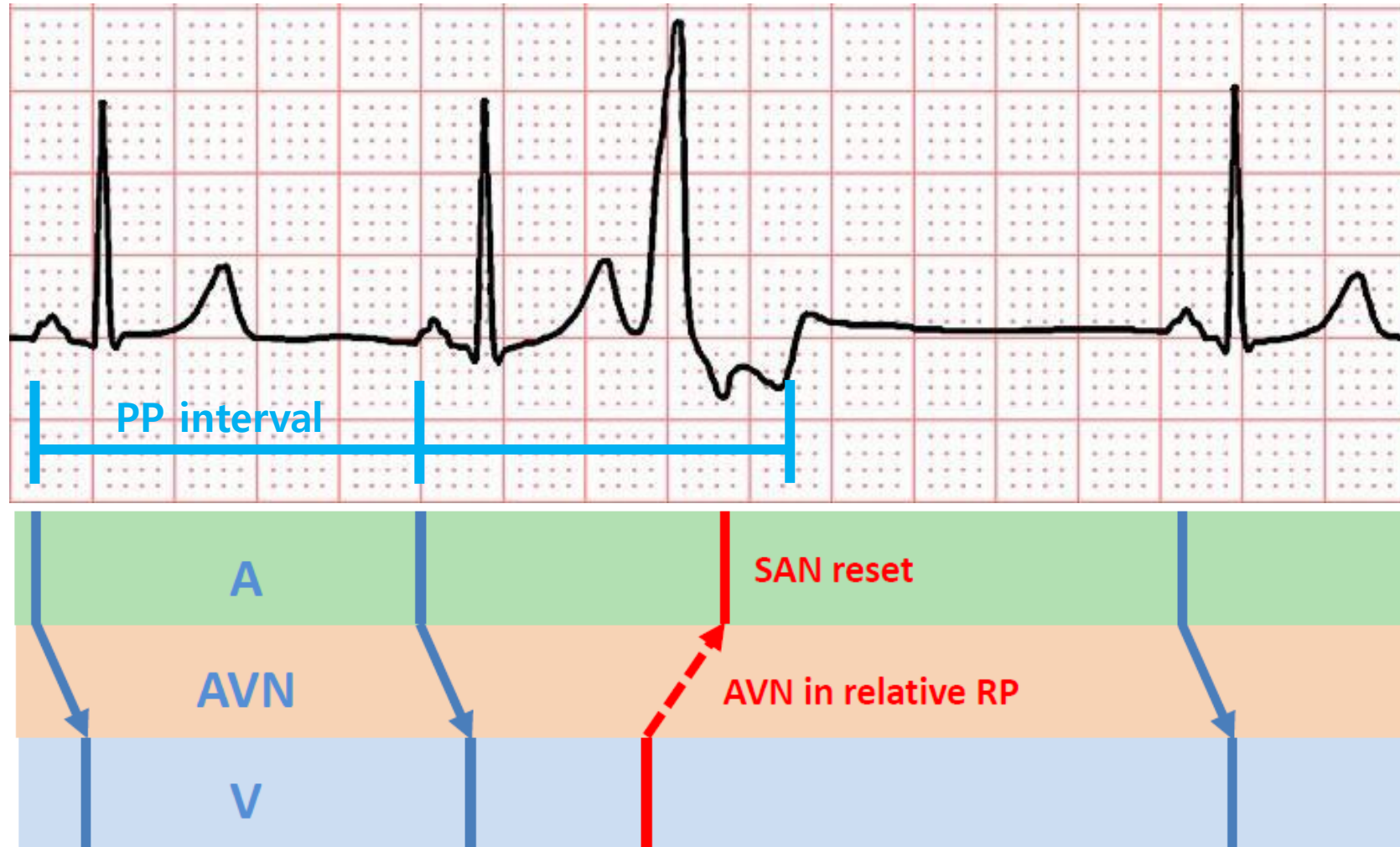
55세/남자 무증상, 건강검진 심전도 이상



VPC, full compensatory pause

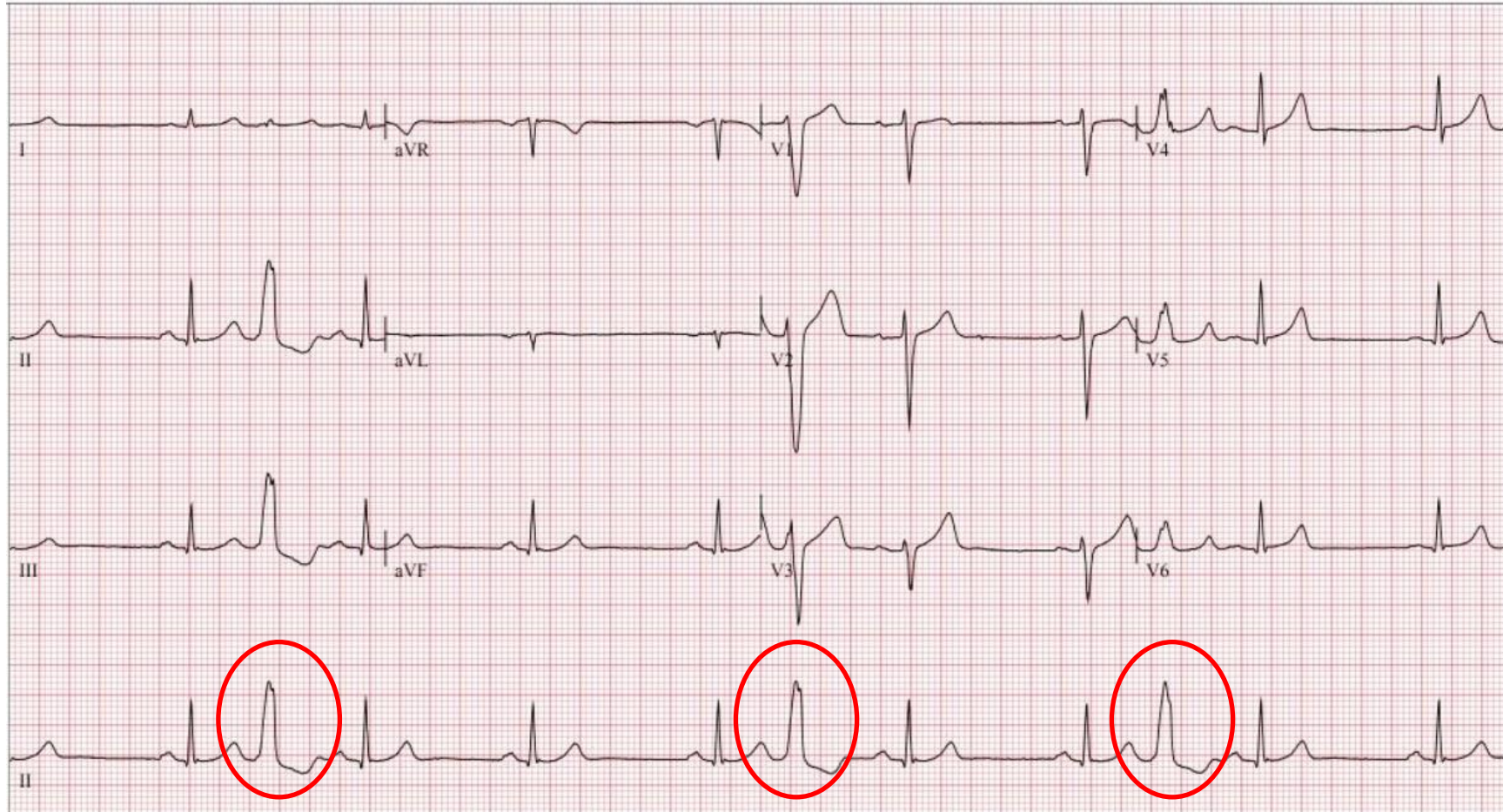


VPC, without compensatory pause

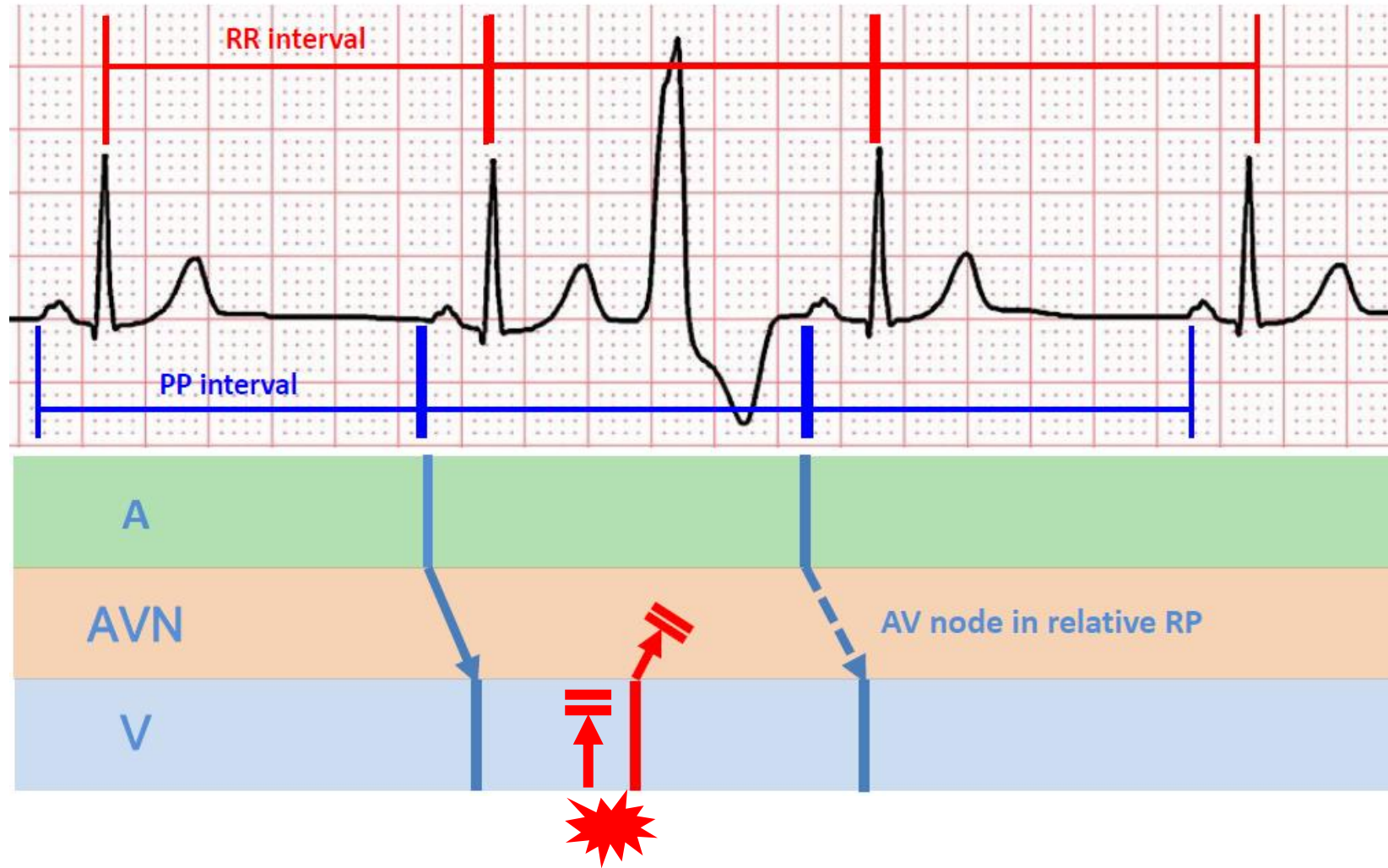


Interpolated VPC

46세/남자
무증상, 건강검진 심전도 이상



VPC, interpolated



Types of PVCs

TYPES OF PVCs

Infrequent PVCs: Less than five PVCs/min.

Frequent PVCs: Five or more PVCs/min.

Isolated PVCs (Beats): PVCs occurring singly.

Group Beats, Bursts, Salvos: PVCs occurring in groups of two or more.

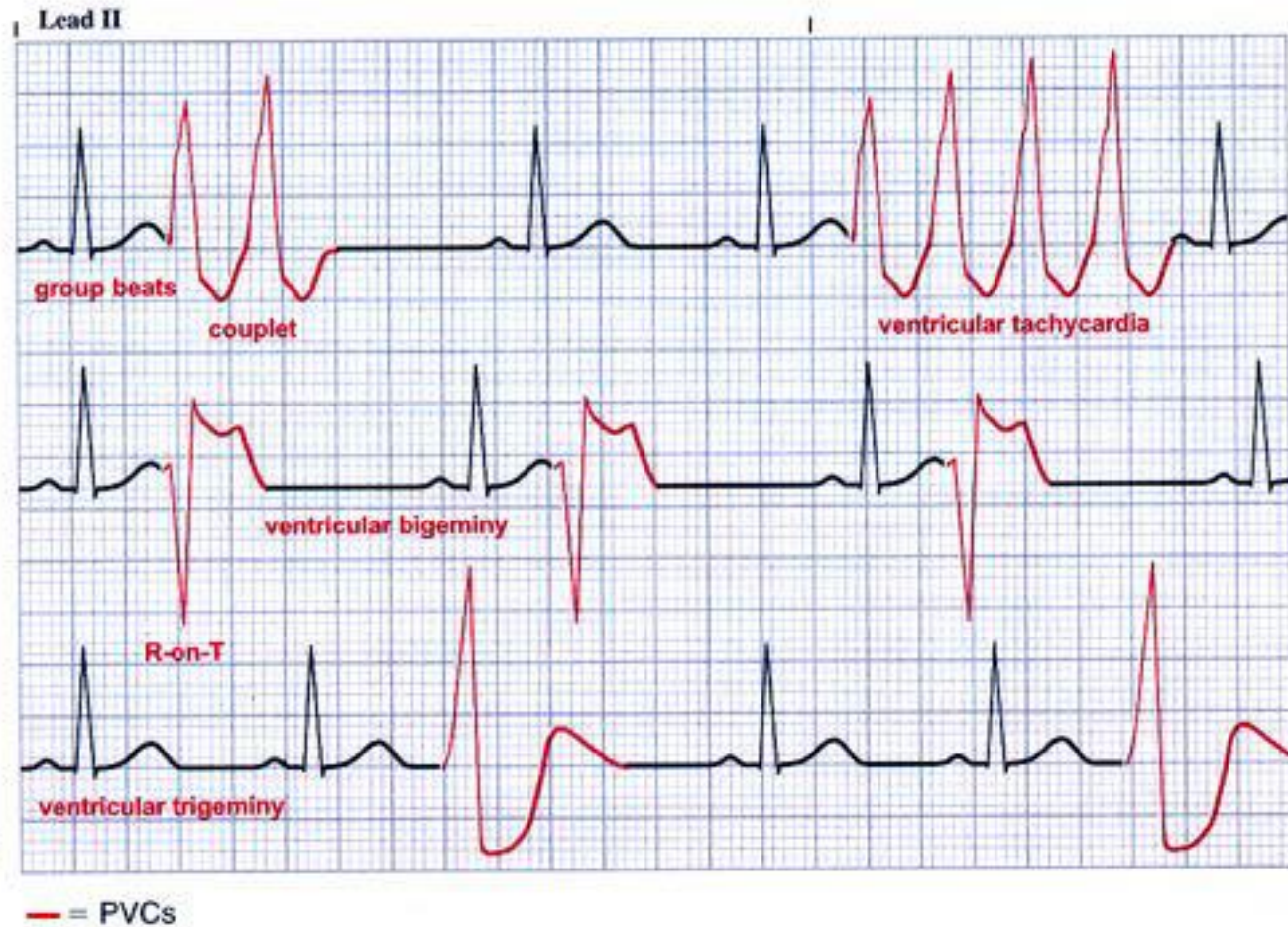
Paired PVCs (Couplet): Two PVCs in a row.

Ventricular Tachycardia: Three or more PVCs in a row.

Ventricular Bigeminy: PVCs alternating with the QRS complexes of the underlying rhythm.

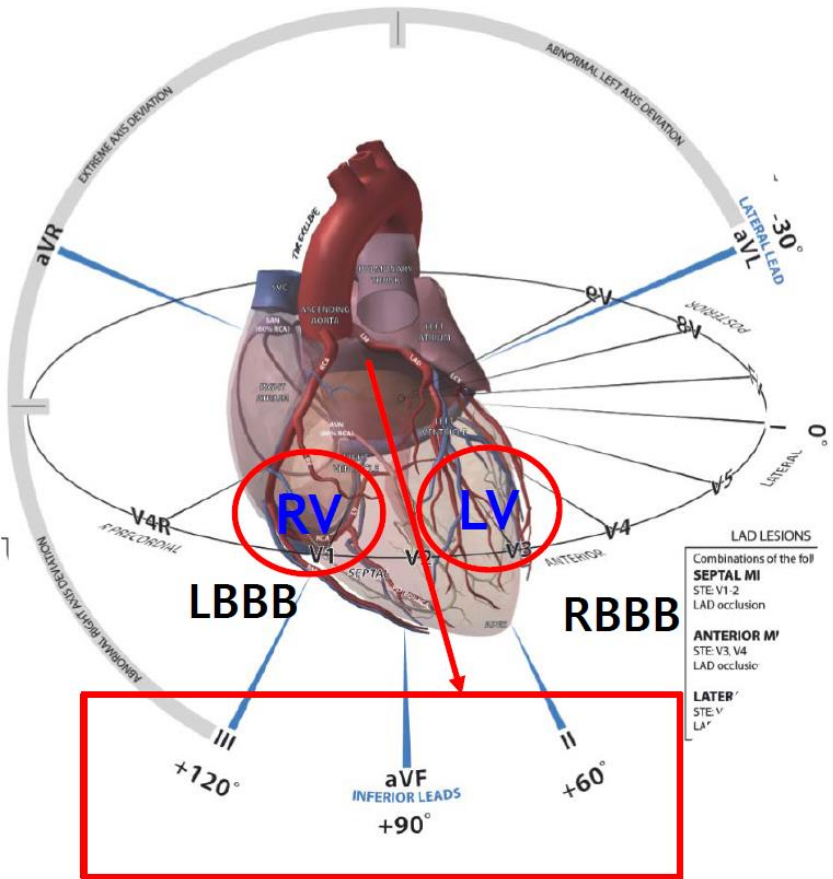
Ventricular Trigeminy/Ventricular Quadrigeminy: PVCs following every two or three QRS complexes of the underlying rhythm, respectively.

R-on-T Phenomenon: A PVC occurring during the downslope of the preceding T wave (vulnerable period of ventricular repolarization).



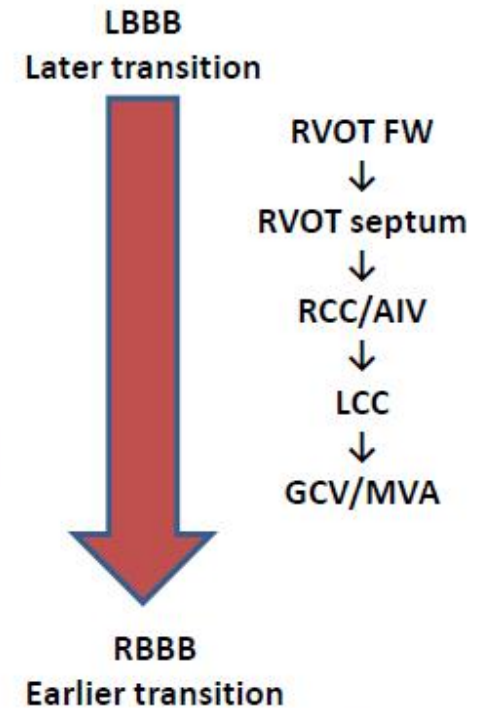
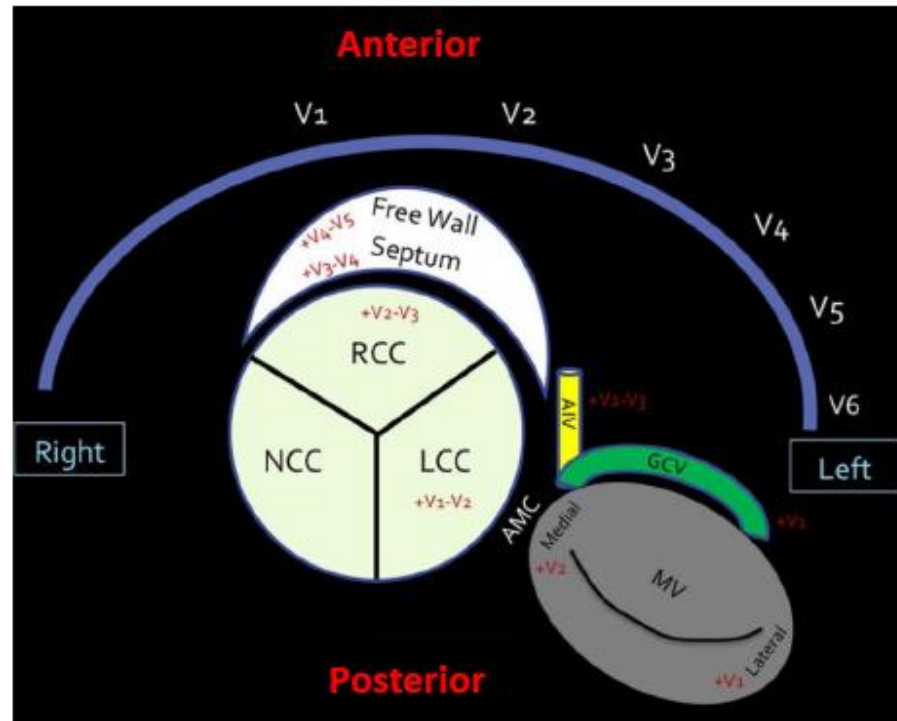
ECG morphology of outflow tract VPC

Approximately 60% to 80% of idiopathic VAs arise from the ventricular outflow regions, including myocardium around the aortic and pulmonic cusps, as well as the summit of the LV. Although the RVOT has been the most common site of origin of OT VAs, a significant proportion (20% to 50%) arise from the LVOT and adjacent structures.

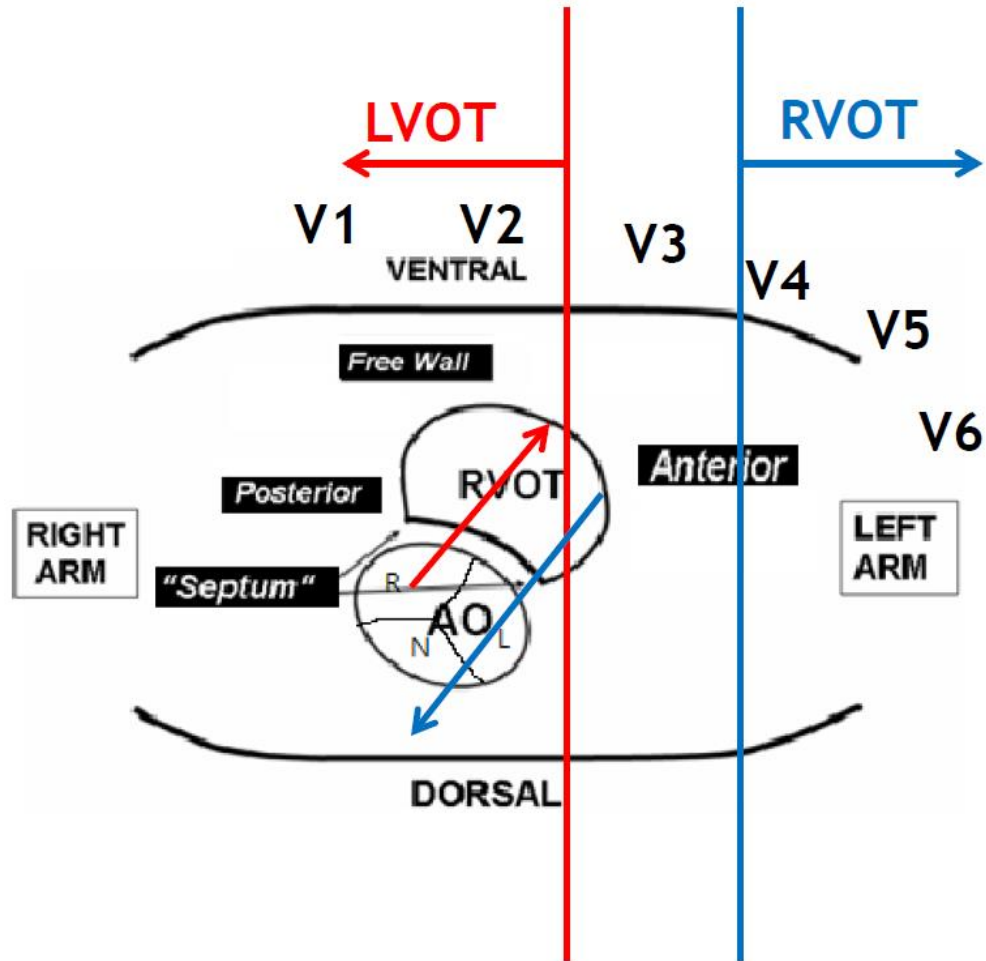


Inferior axis

Precordial Transition



ECG morphology of outflow tract VPC



- Sinus: RV & LV simultaneously activation transition V3 or 4
- RVOT : late transition $\geq V4$ (later than sinus)
- LVOT : early transition $\leq V2$ (earlier than sinus)

RVOT PVC

HR 69 . Sinus rhythm
. Ventricular trigeminy
PR 192
QRSD 102
QT 417
QTc 447

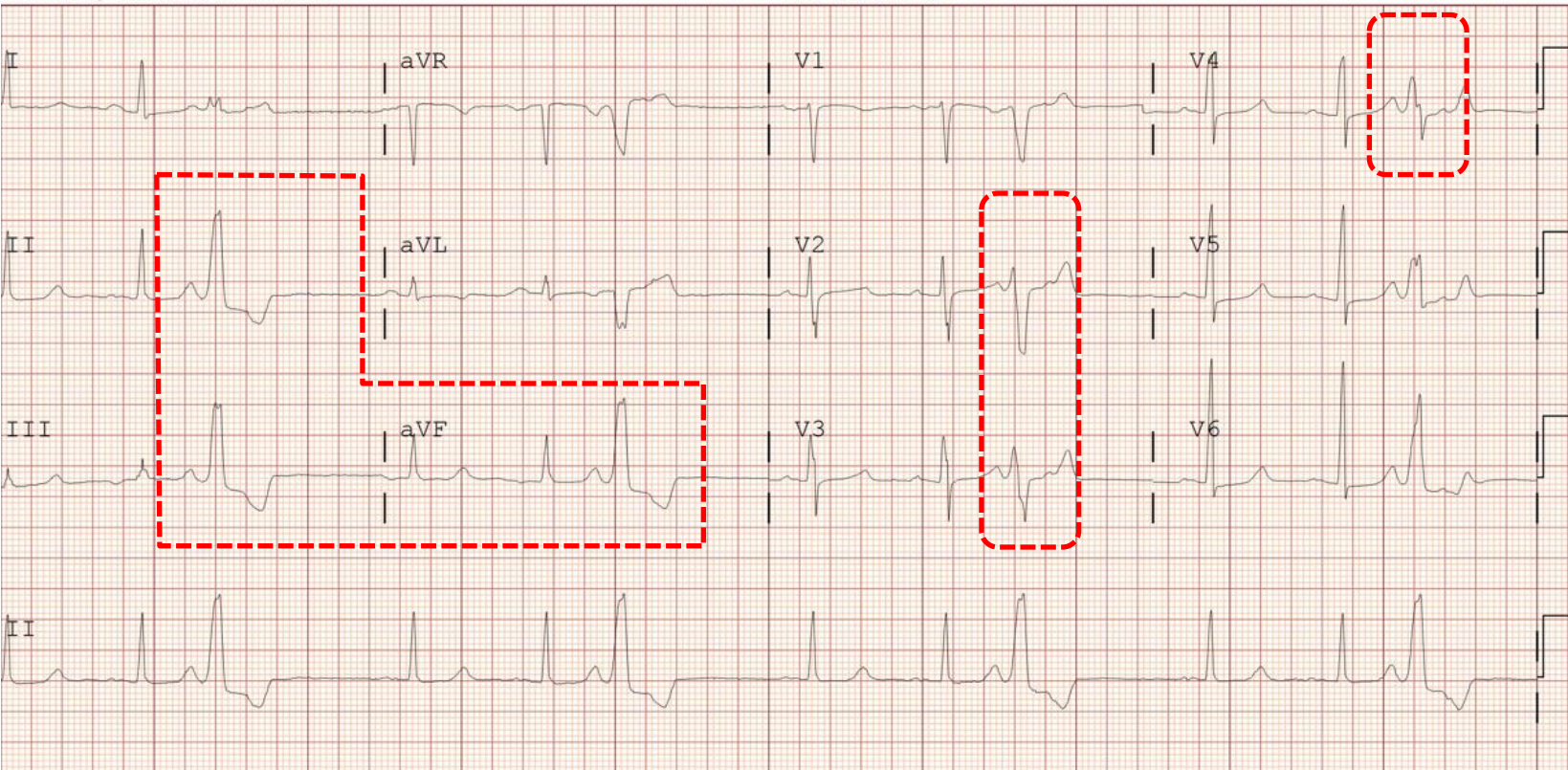
-- AXIS --
P -11
QRS 48
T 79

- ABNORMAL ECG -

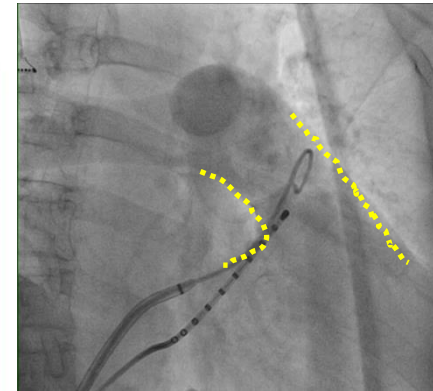
Previous Study:08-Feb-2022 08:46:54 - Abnormal Unconfirmed

12 Lead; Standard Placement

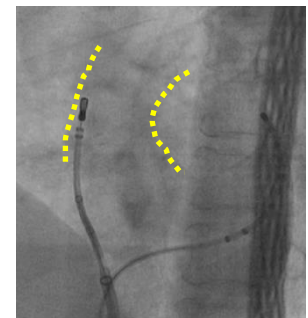
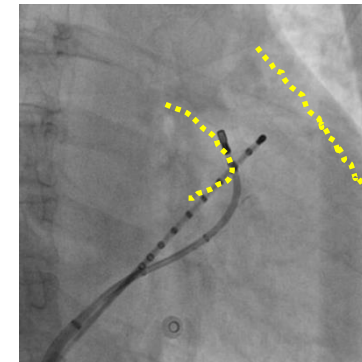
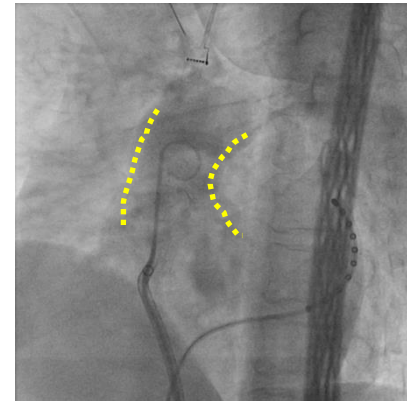
Not confirmed



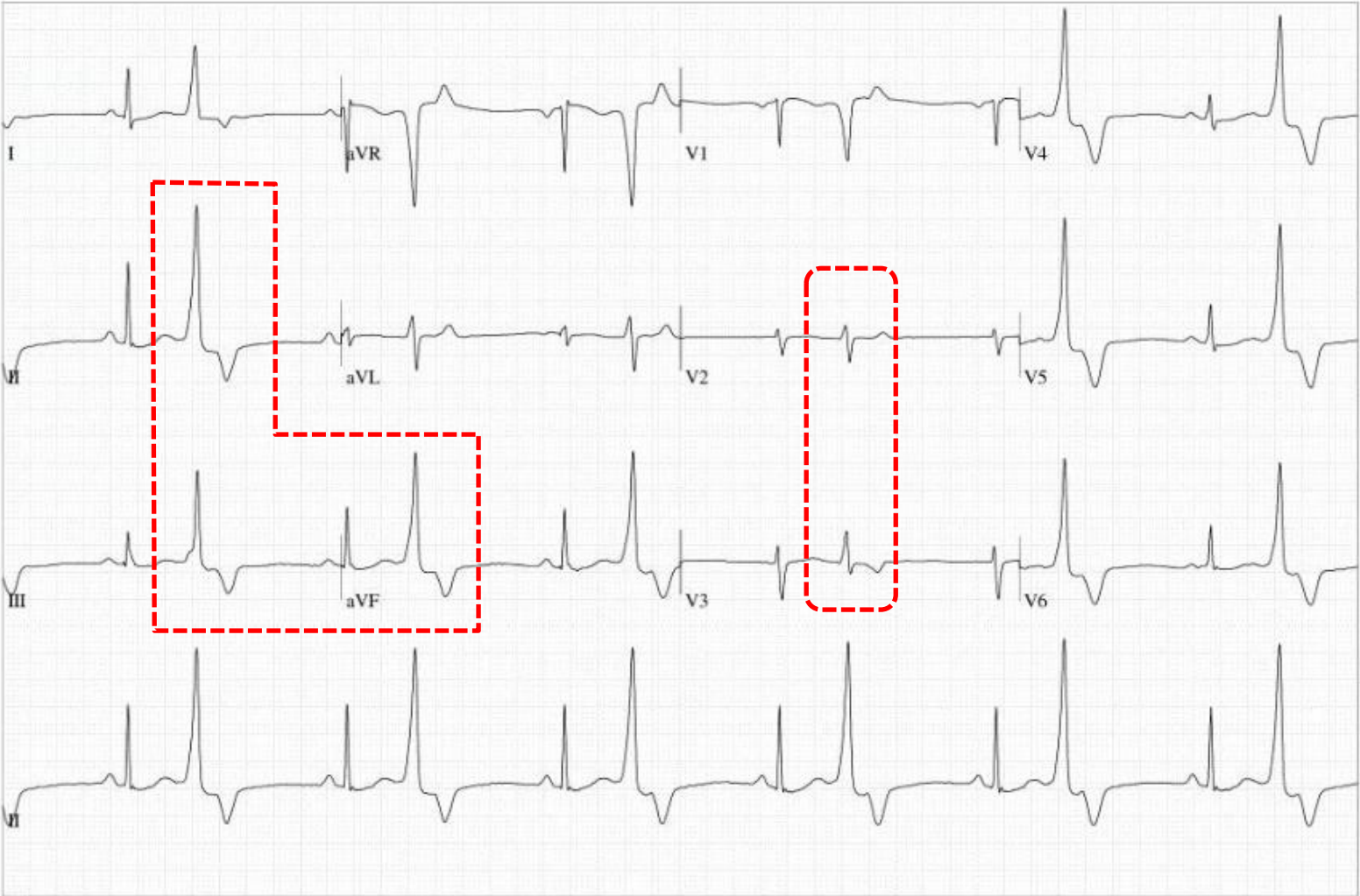
RAO



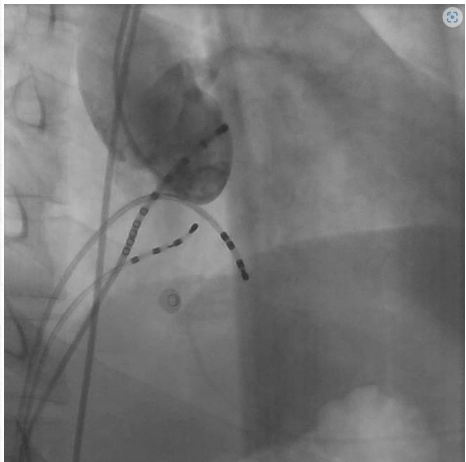
LAO



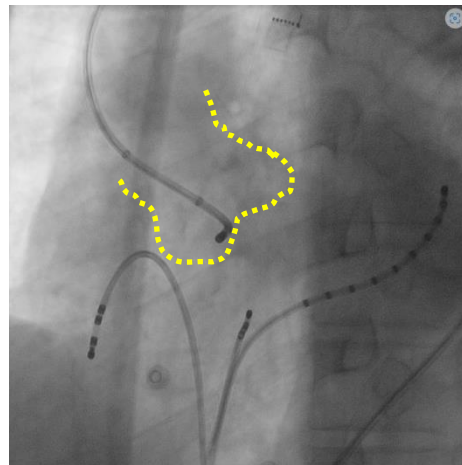
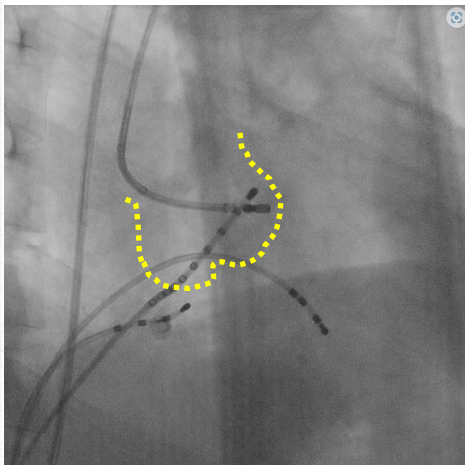
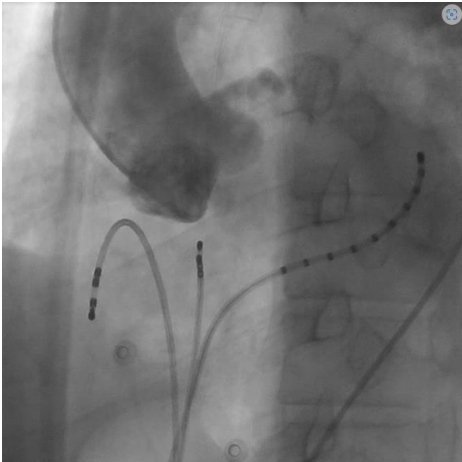
LVOT PVC



RAO



LAO



THANK YOU FOR YOUR ATTENTION!

