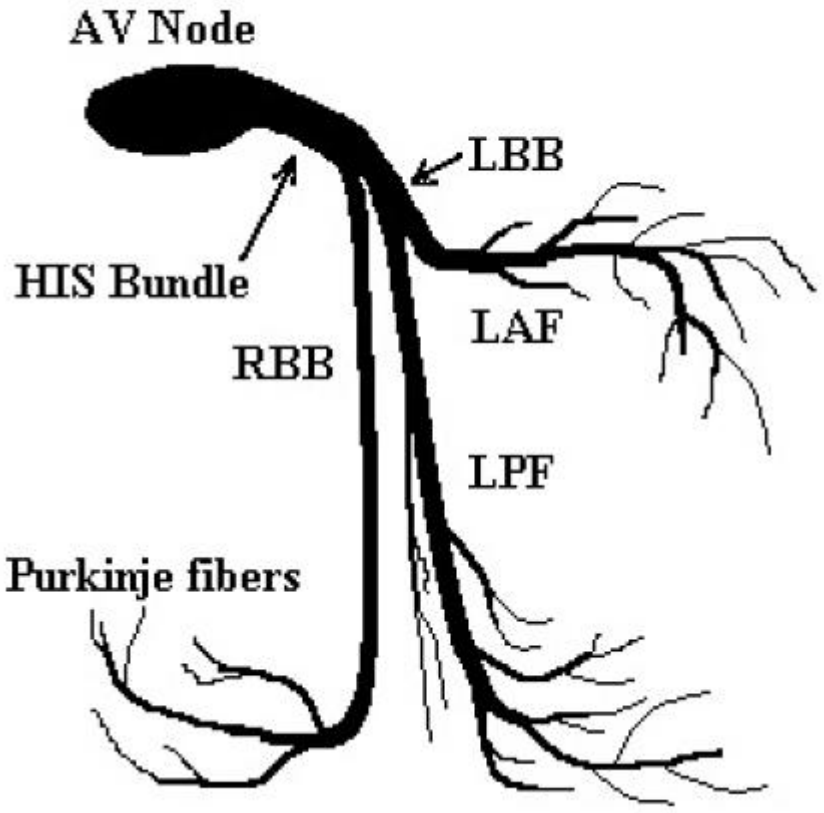
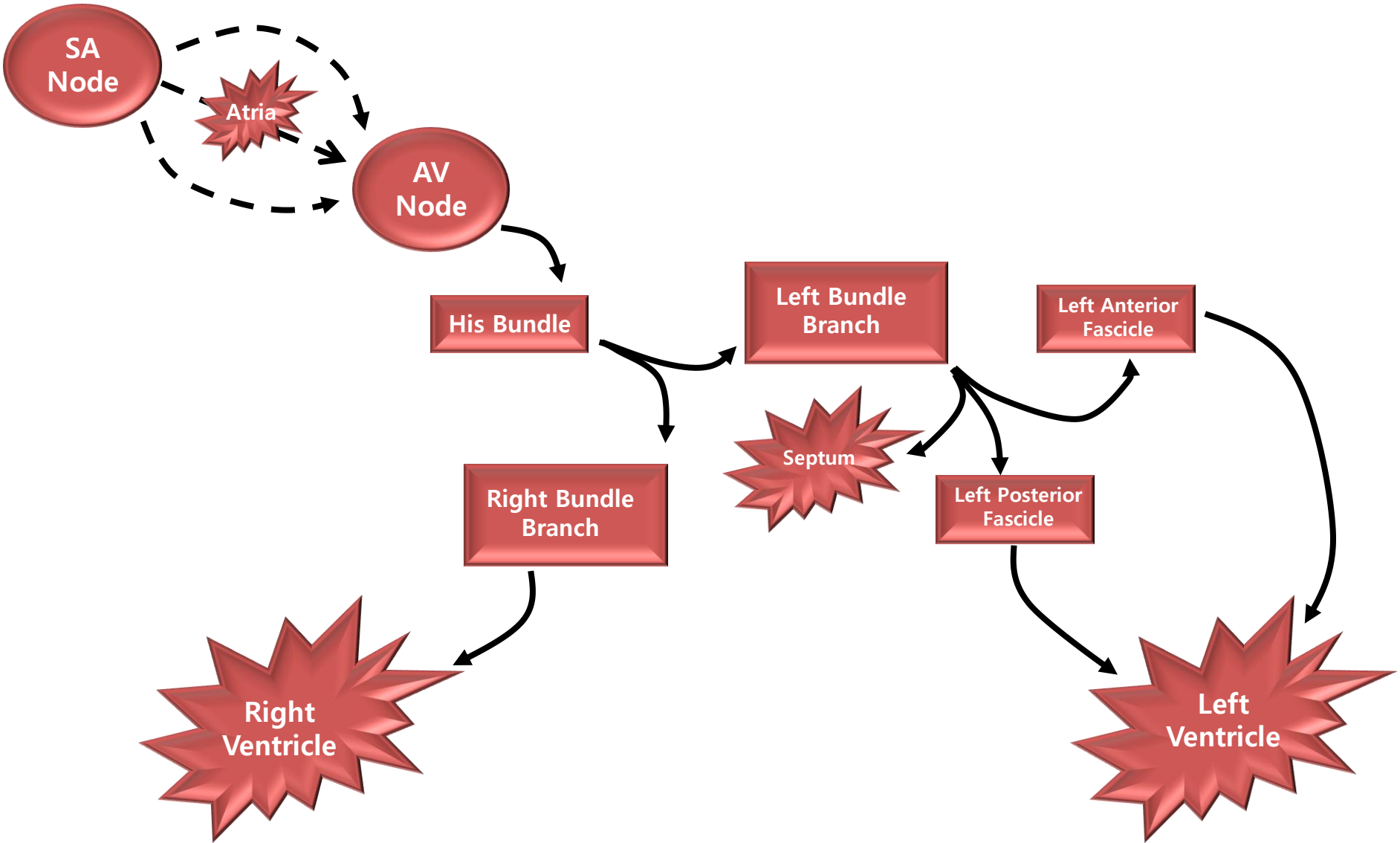
# From His to Ventricle: normal and abnormal conducrion -Bundle branch and fascicle

인하대 병원
김대혁

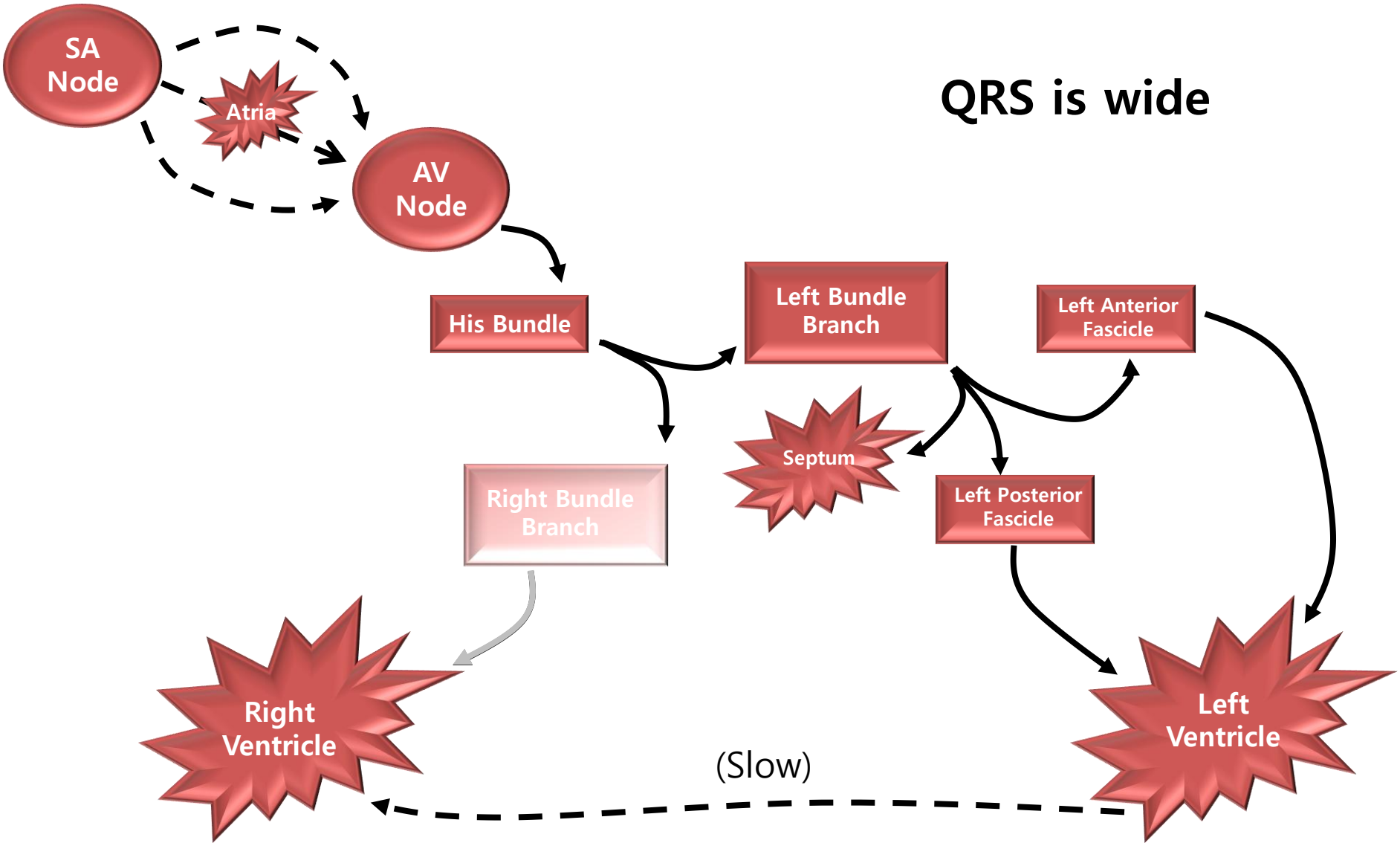
# Anatomy of the Conduction System



# Anatomy of the Conduction System

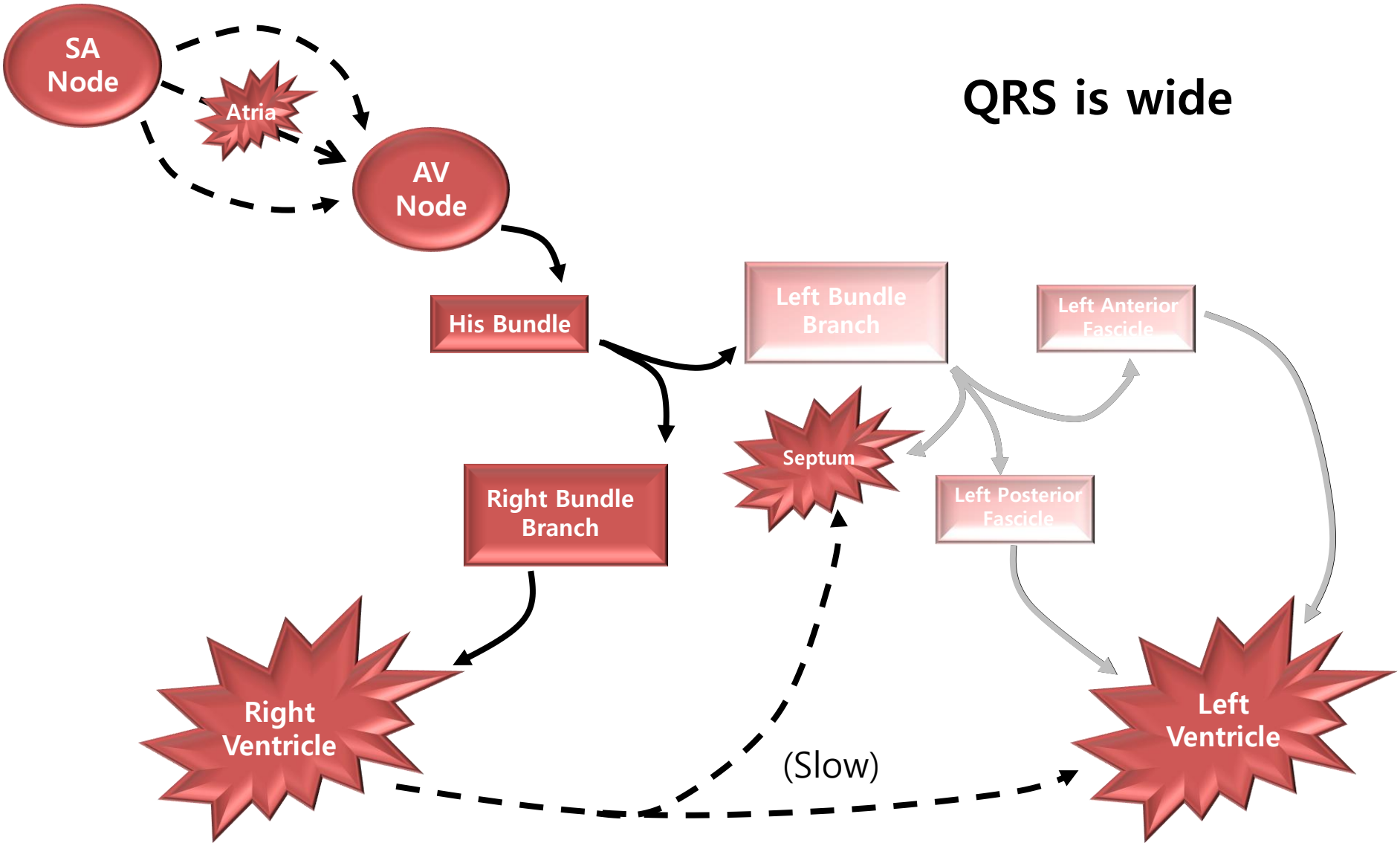


# Right Bundle Branch Block



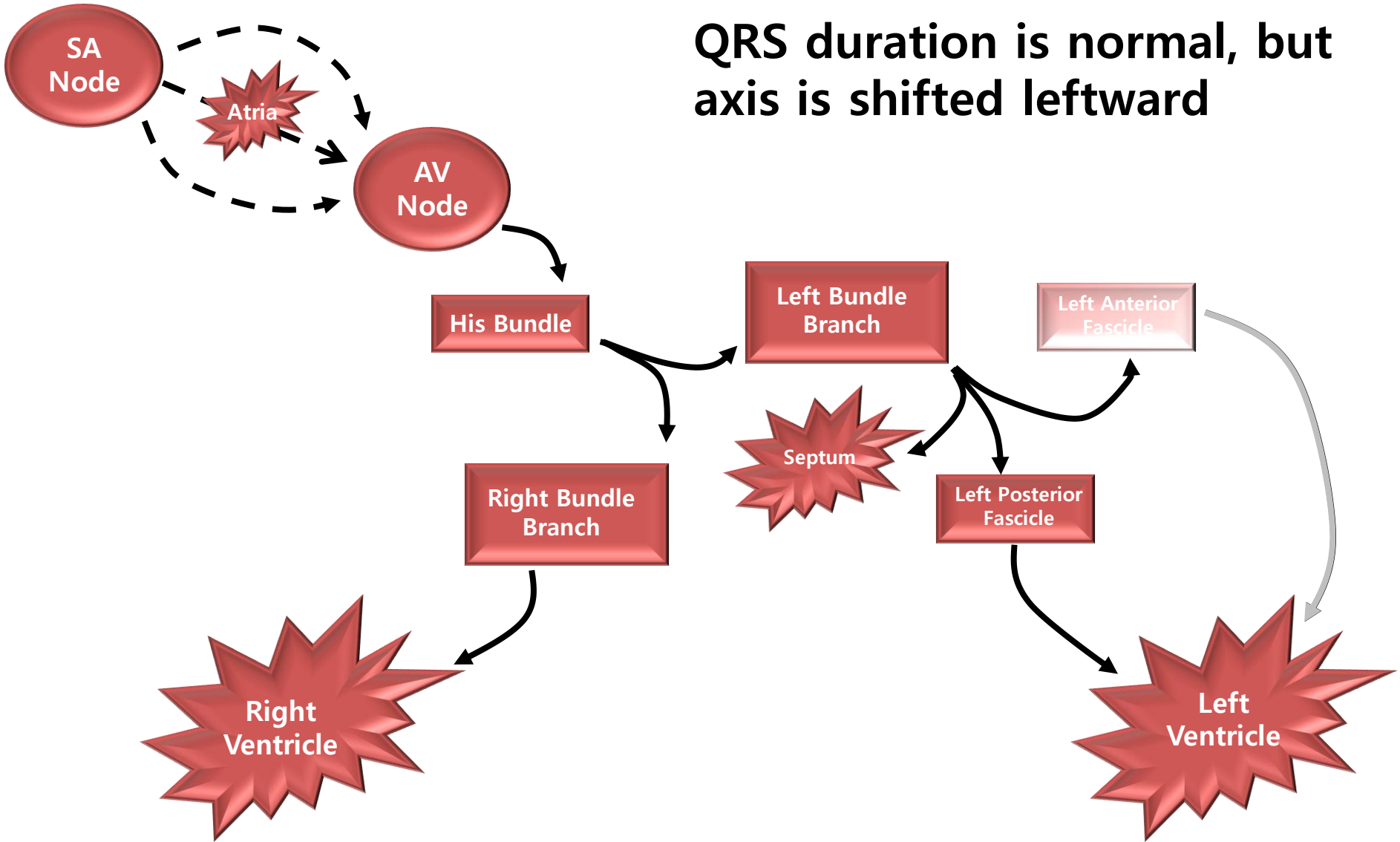

**QRS is wide**

# Left Bundle Branch Block



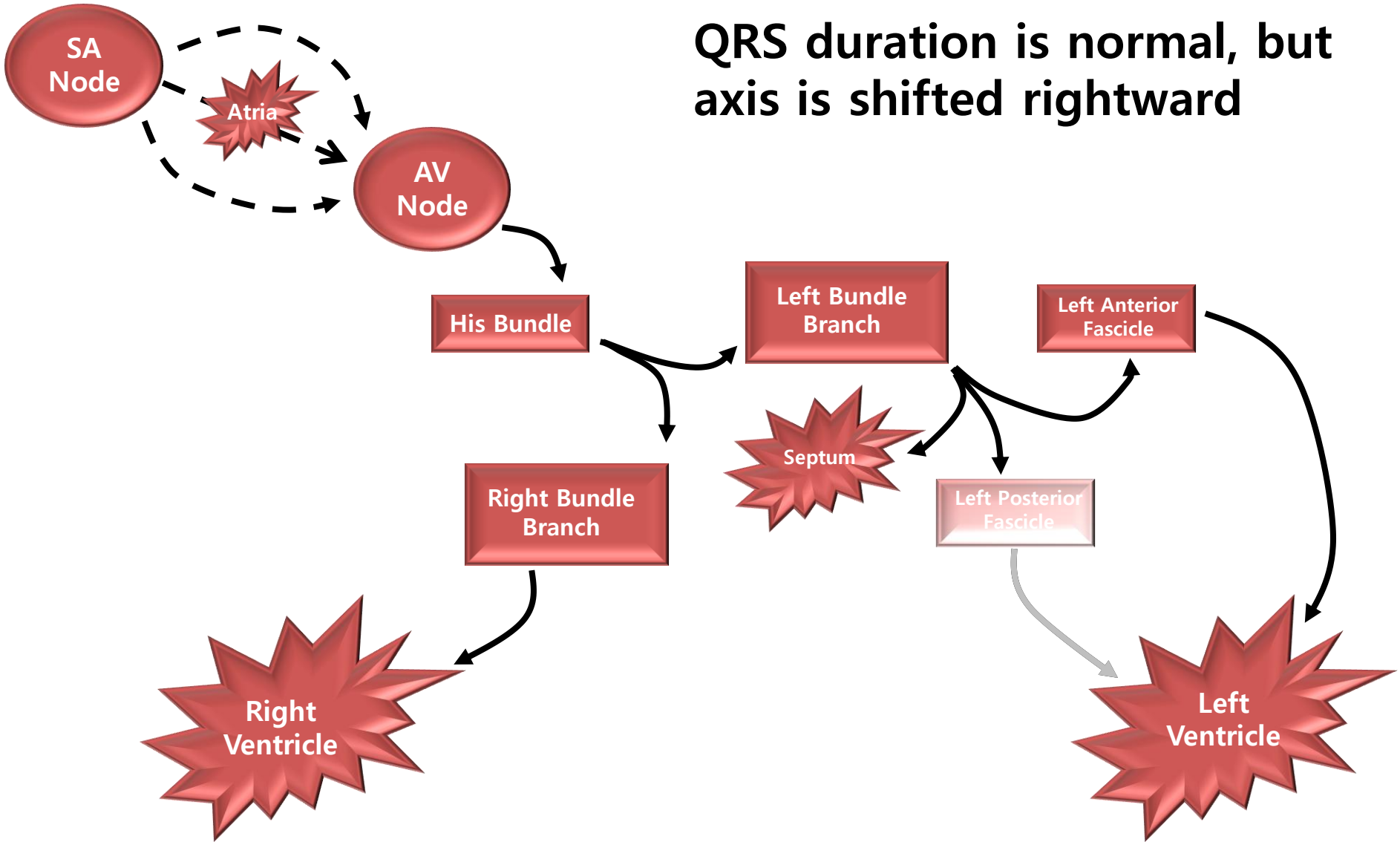

**QRS is wide**

# Left Anterior Fascicular Block




**QRS duration is normal, but axis is shifted leftward**

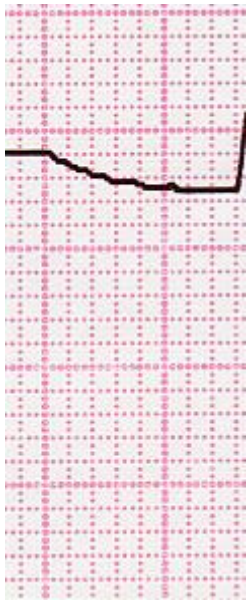
# Left Posterior Fascicular Block

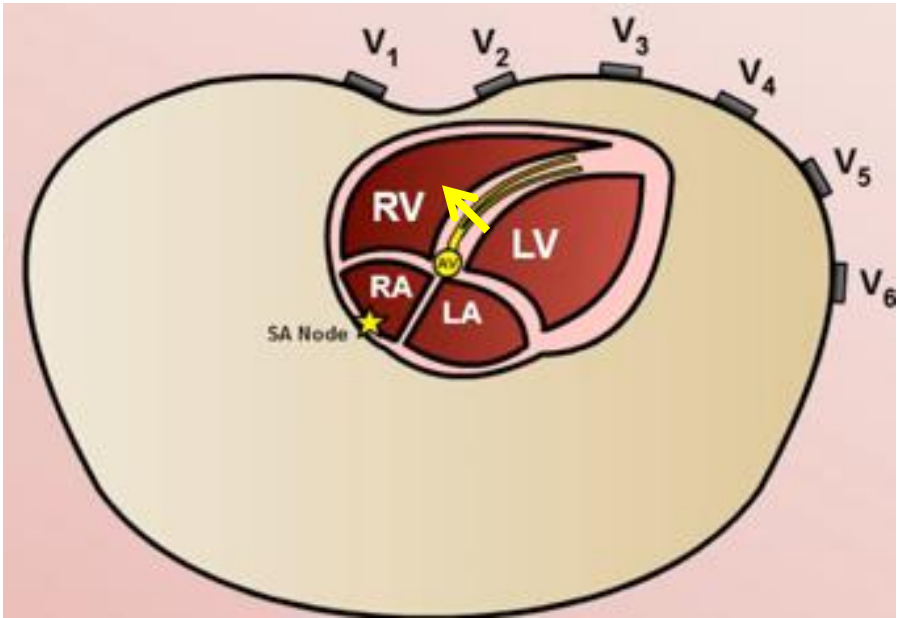



**QRS duration is normal, but axis is shifted rightward**

# Normal Conduction

**V1**

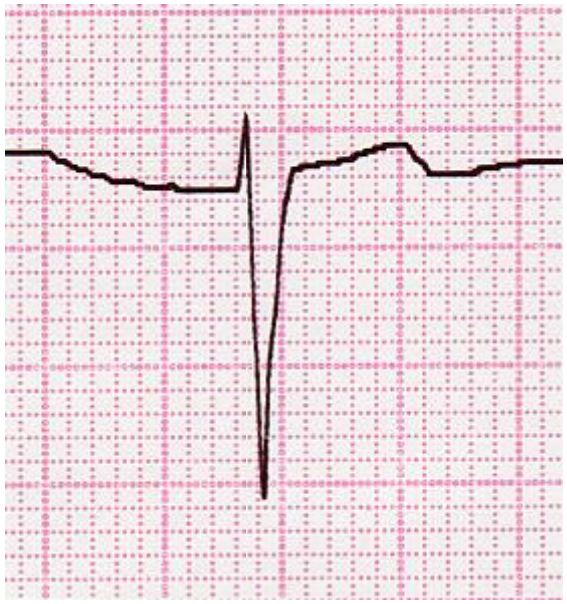


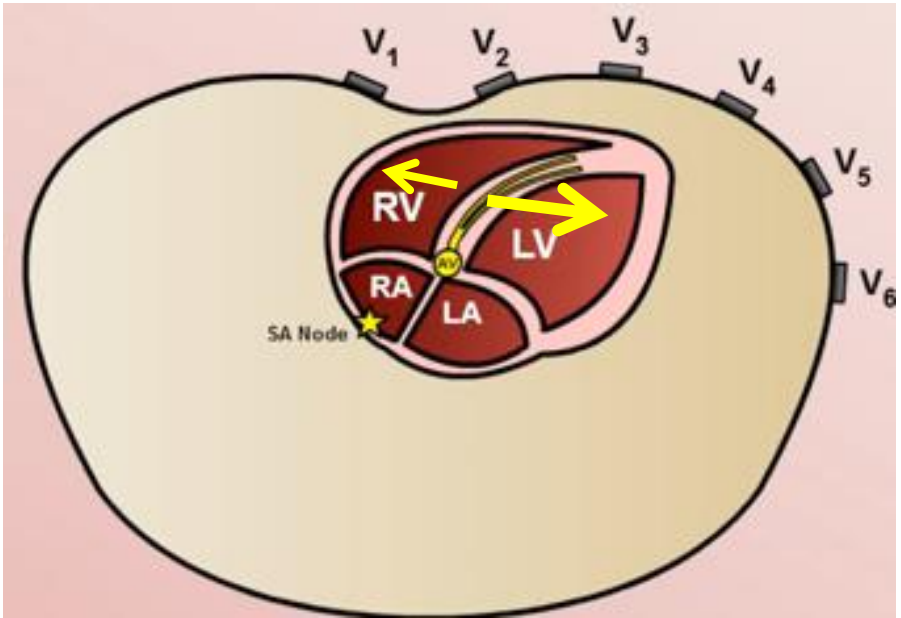



**V6**

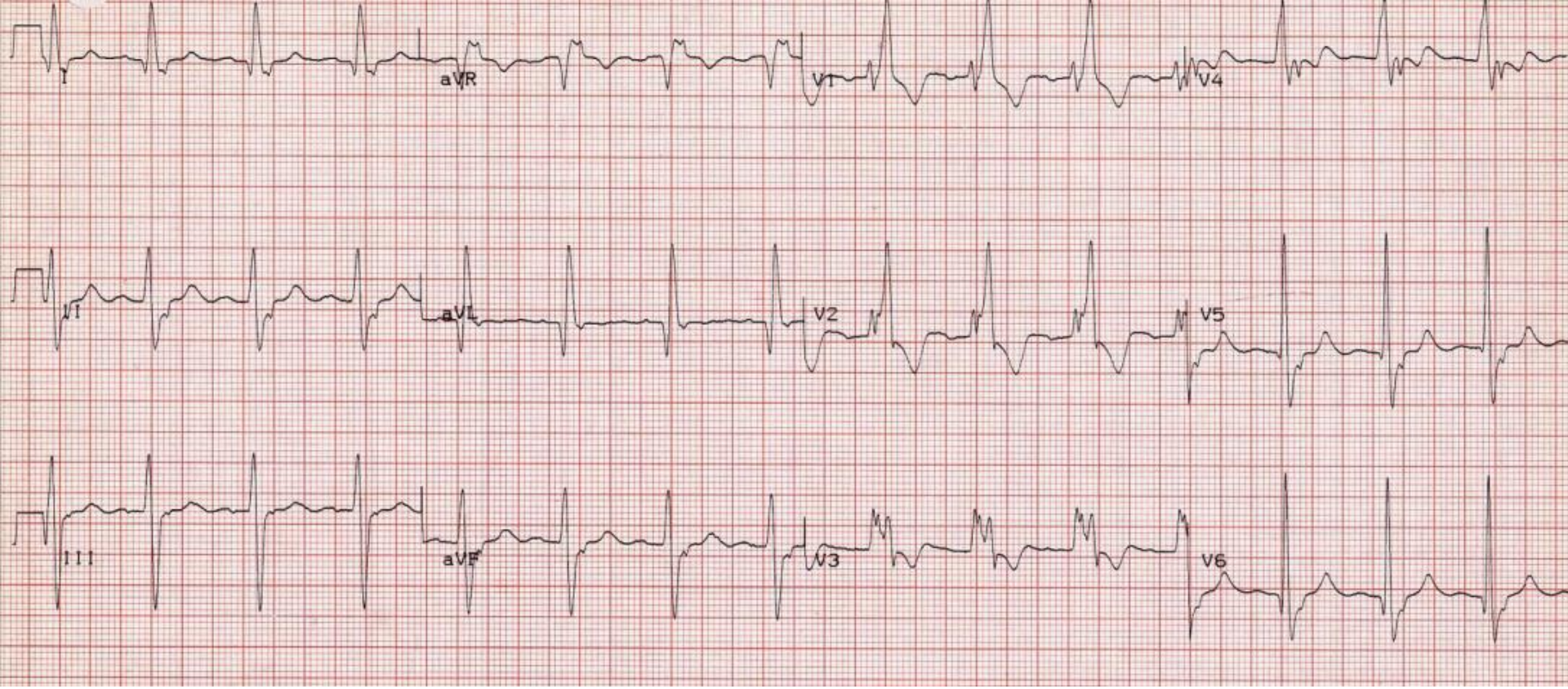
# Normal Conduction

**V1**





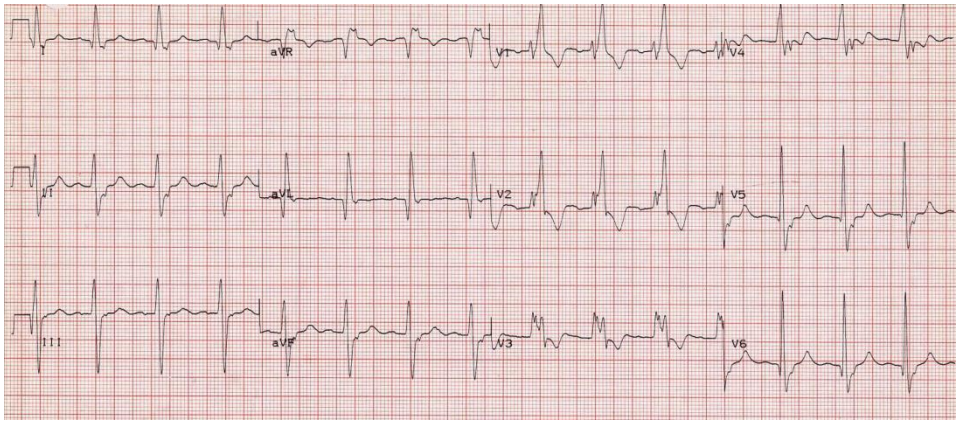

**V6**



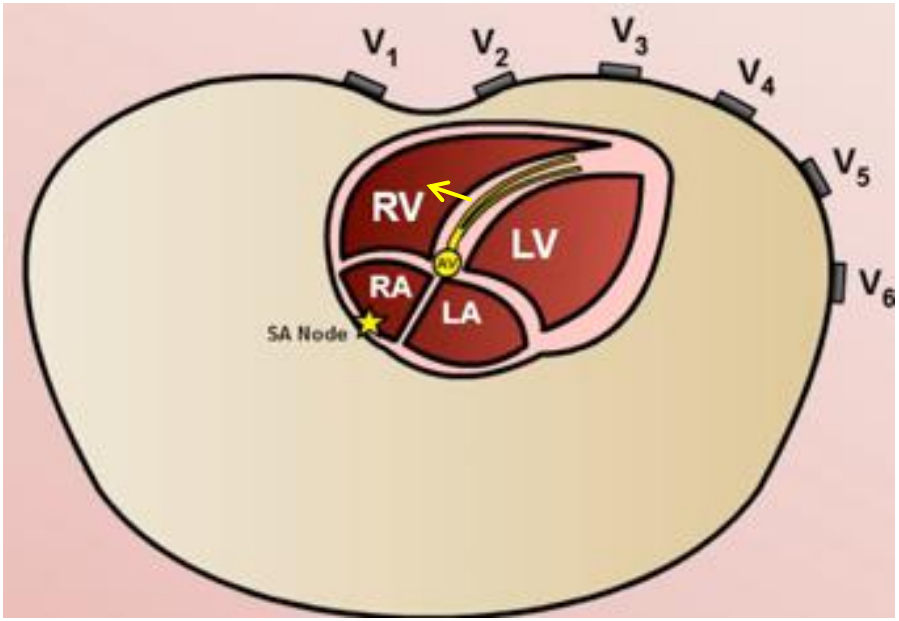

1) LBBB
2) RBBB
3) RVH
4) LVH
5) WPW syndrome

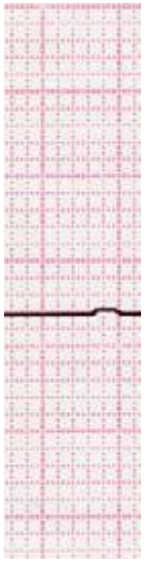
# RBBB

**V1**


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

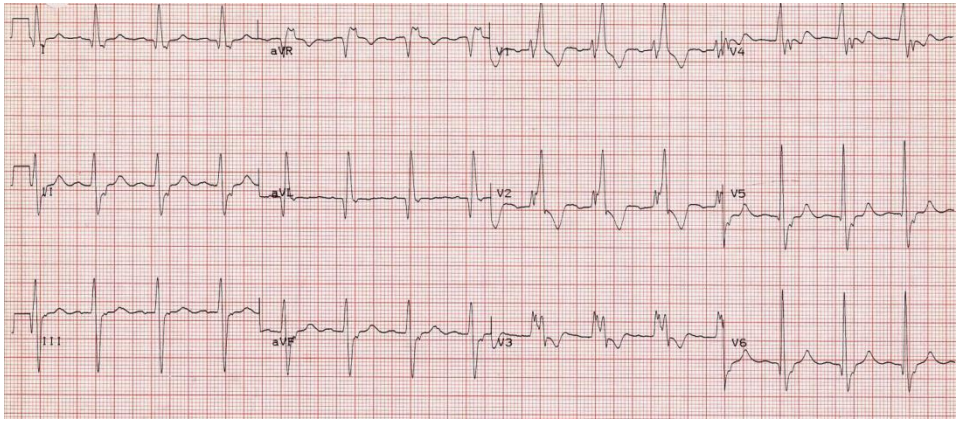
**V6**


V1
V2
V3
V4
V5
V6
RV
LV
AV
RA
LA
SA Node

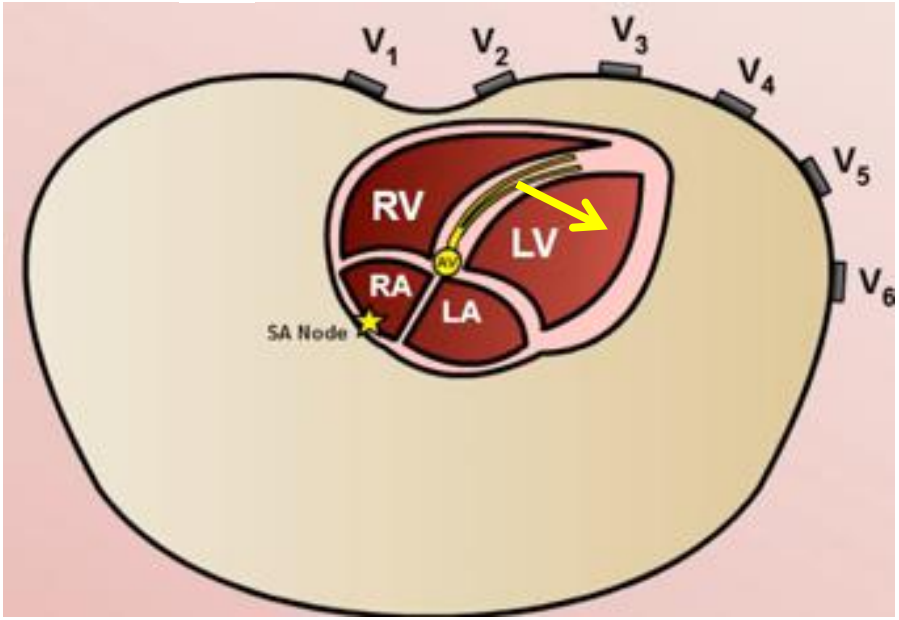


# RBBB

**V1**

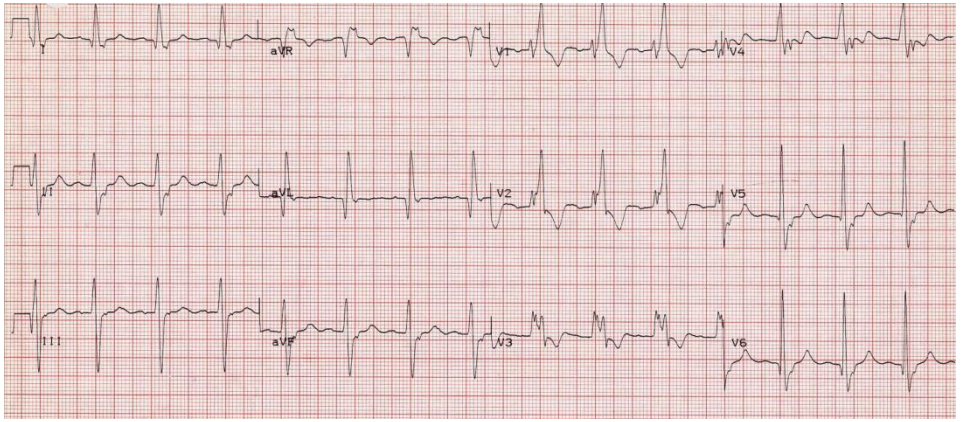

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

**V6**

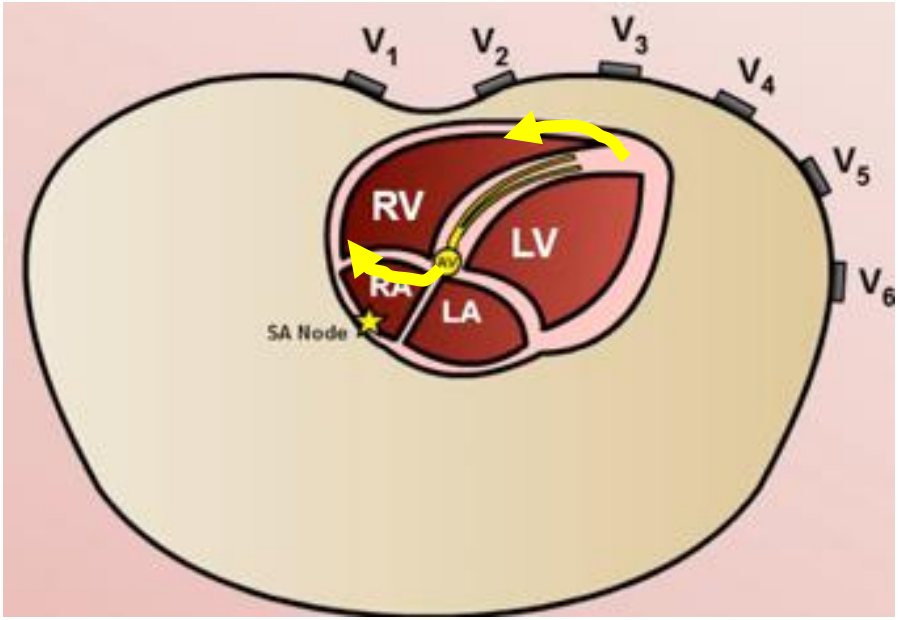

V1
V2
V3
V4
V5
V6
RV
LV
AV
RA
LA
SA Node

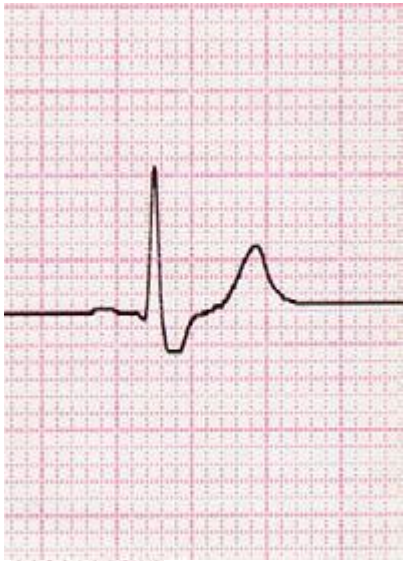
# RBBB

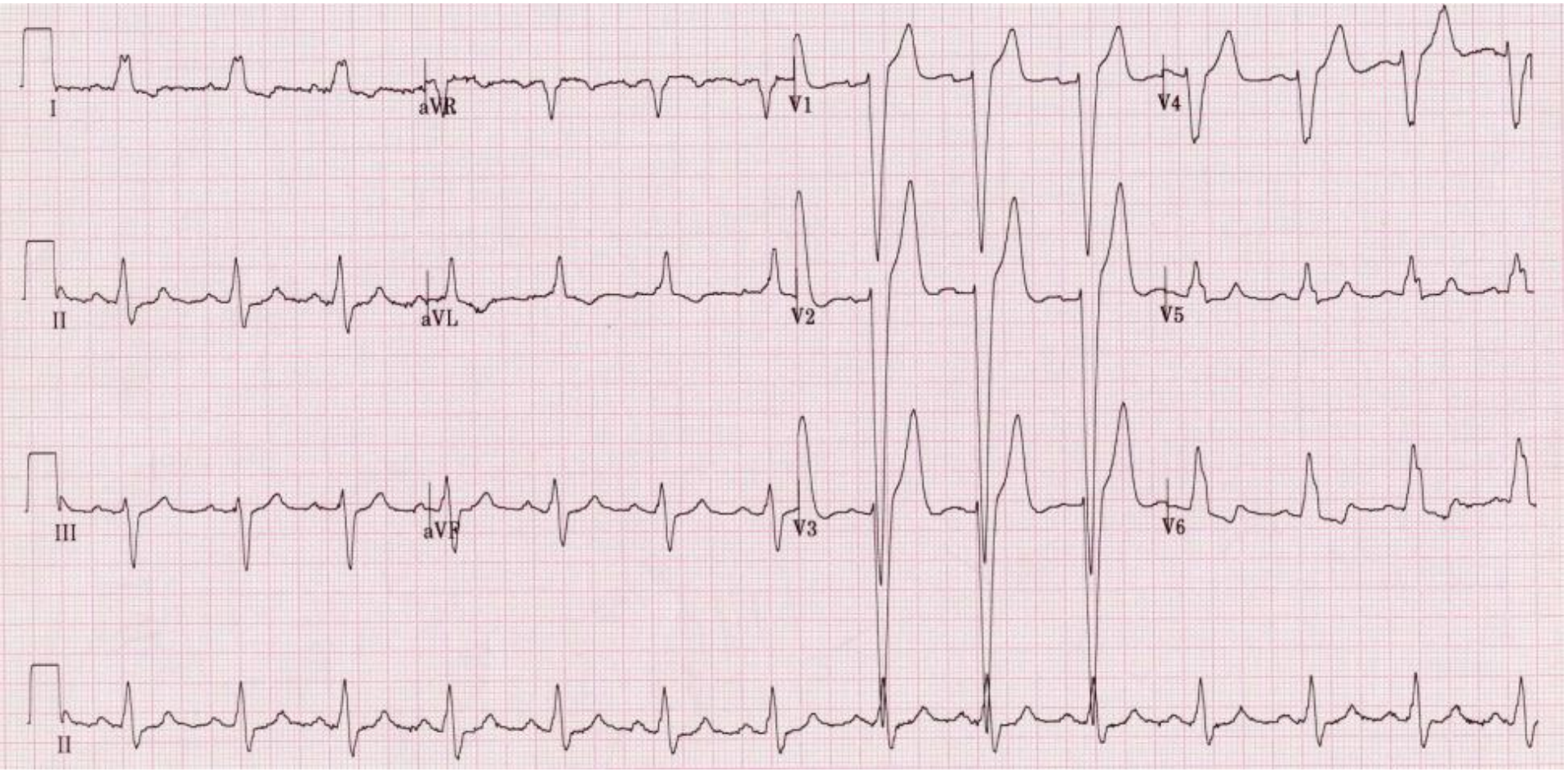
**V1**


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

**V6**


V1
V2
V3
V4
V5
V6
RV
LV
RA
LA
AV
SA Node

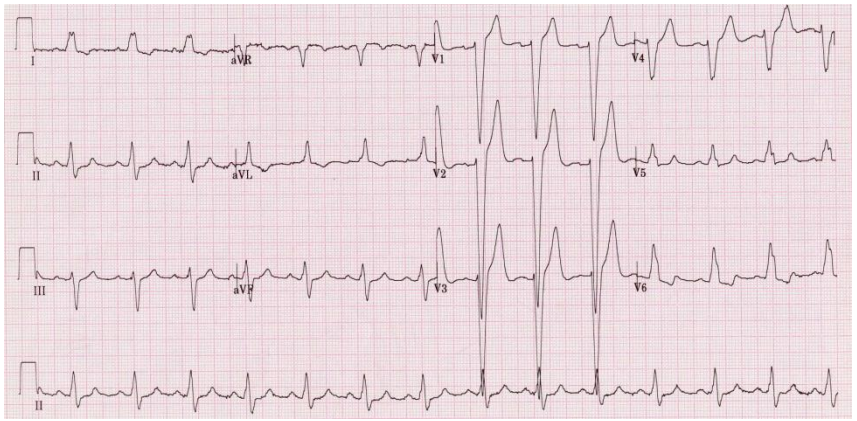




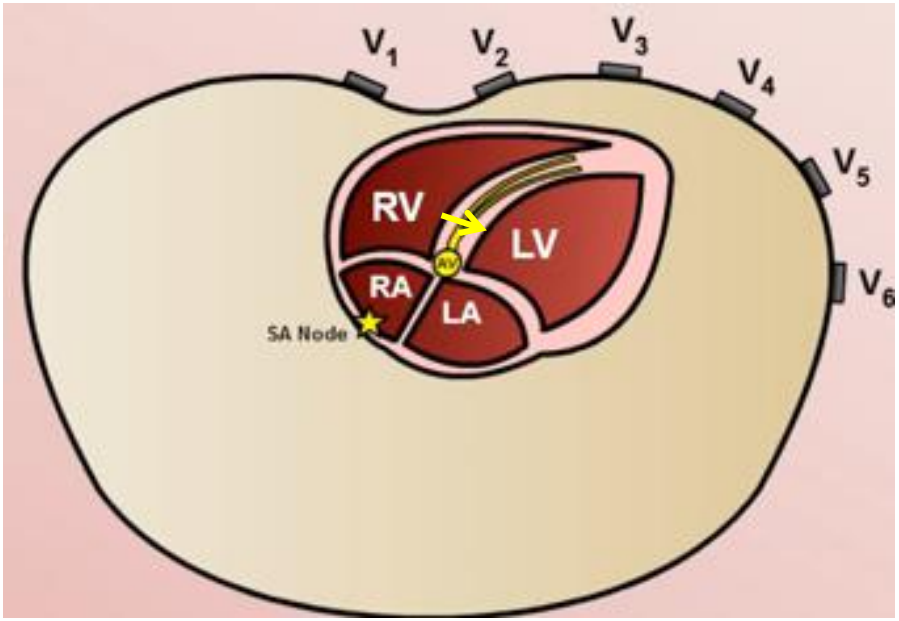

1) LBBB
2) RBBB
3) RVH
4) LVH
5) WPW syndrome

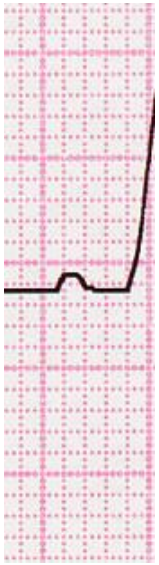
# LBBB

**V1**


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

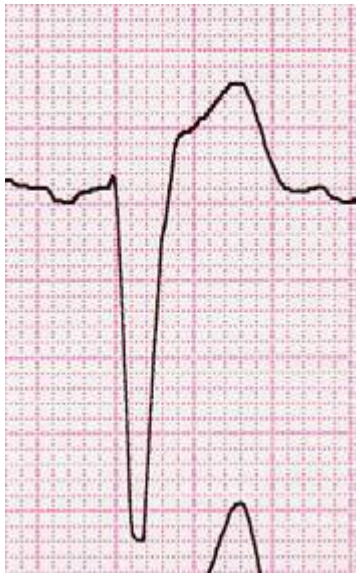
**V6**

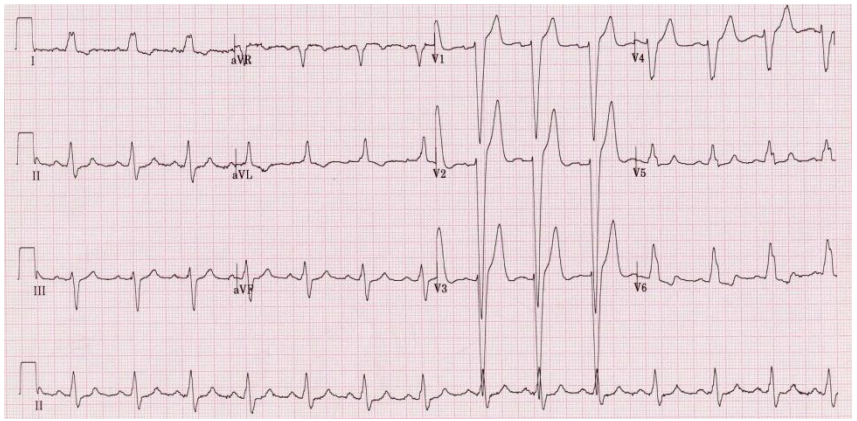

V1
V2
V3
V4
V5
V6
RV
LV
RA
LA
AV
SA Node

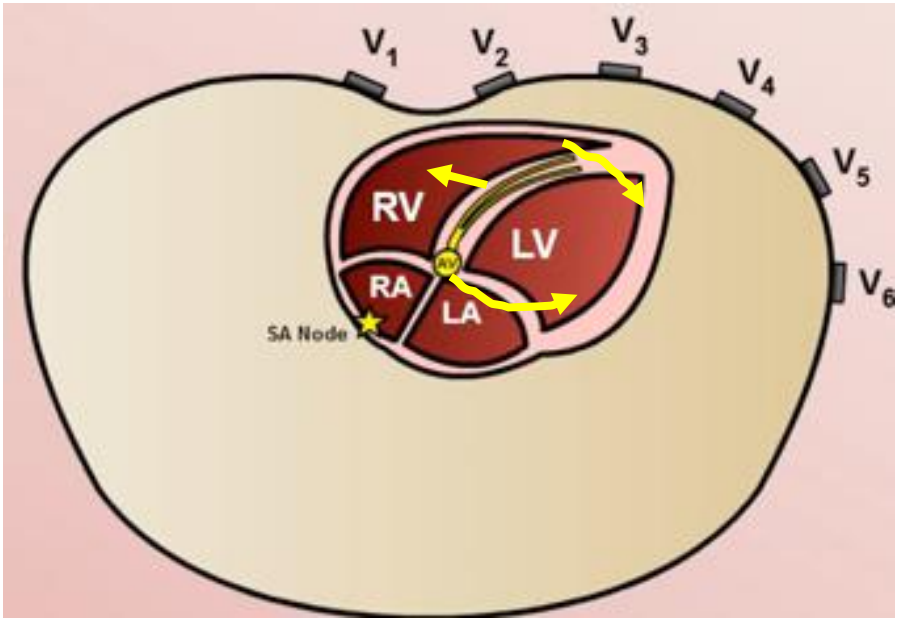


# LBBB

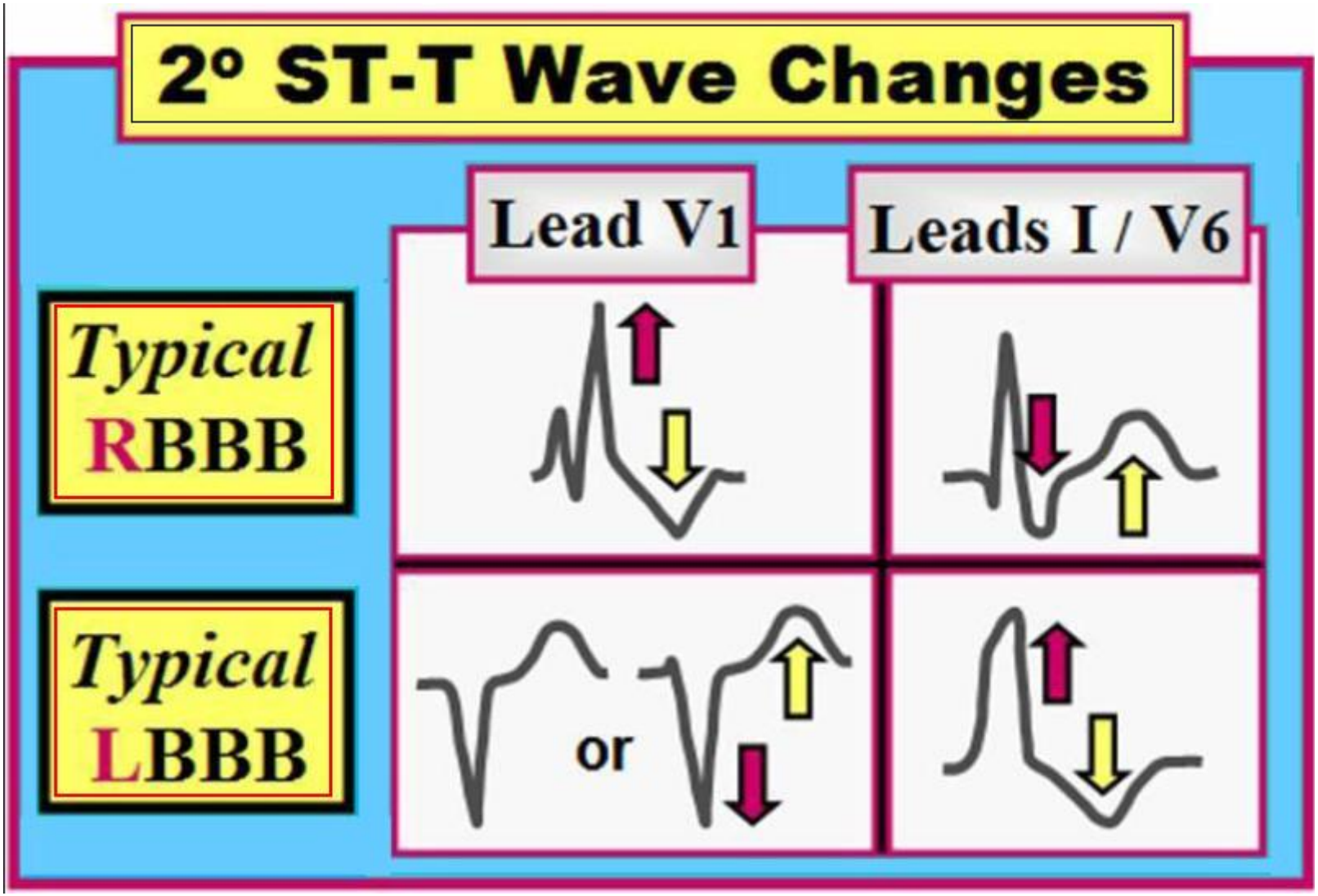
**V1**



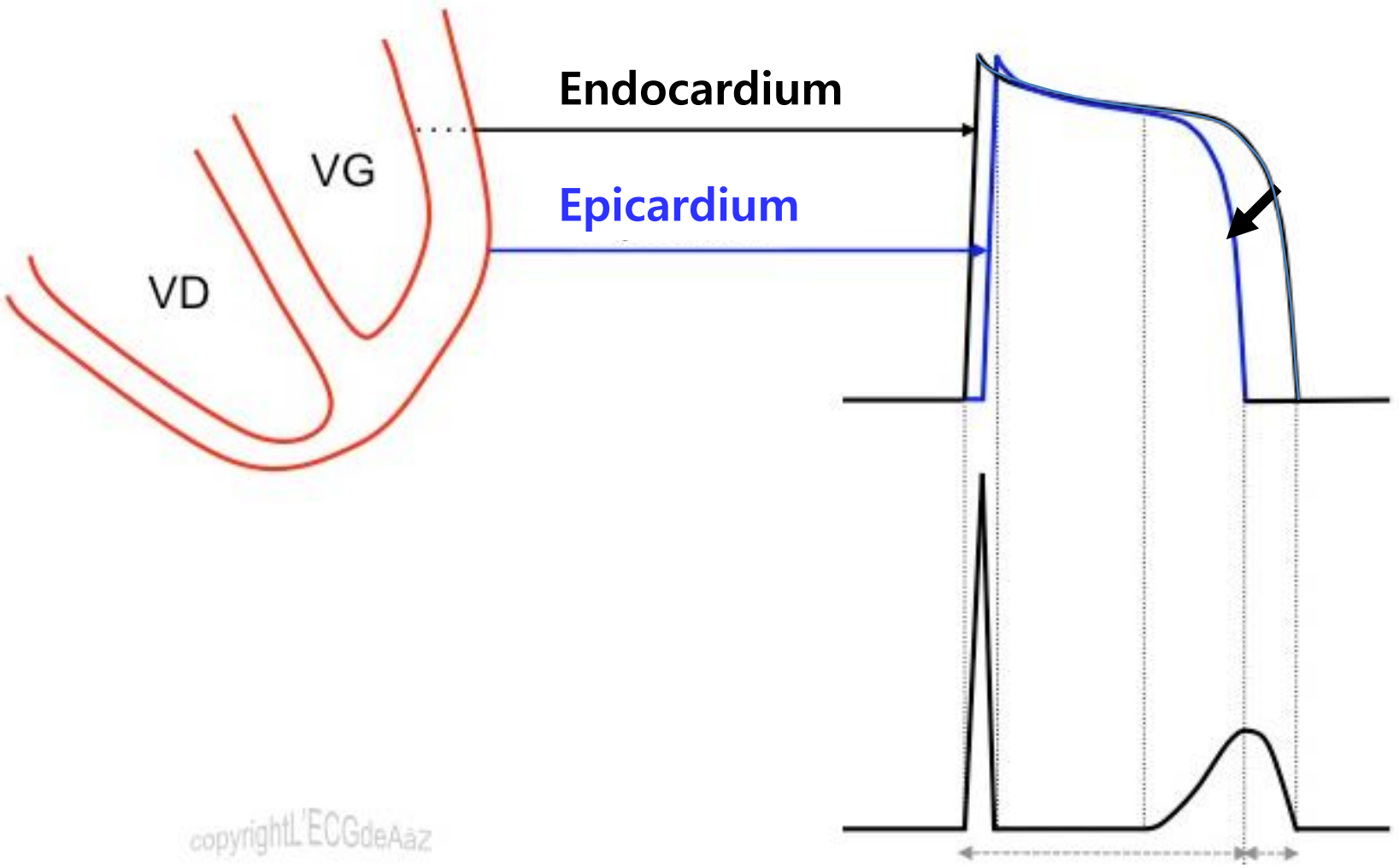

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II


V1
V2
V3
V4
V5
V6
RV
LV
RA
LA
SA Node

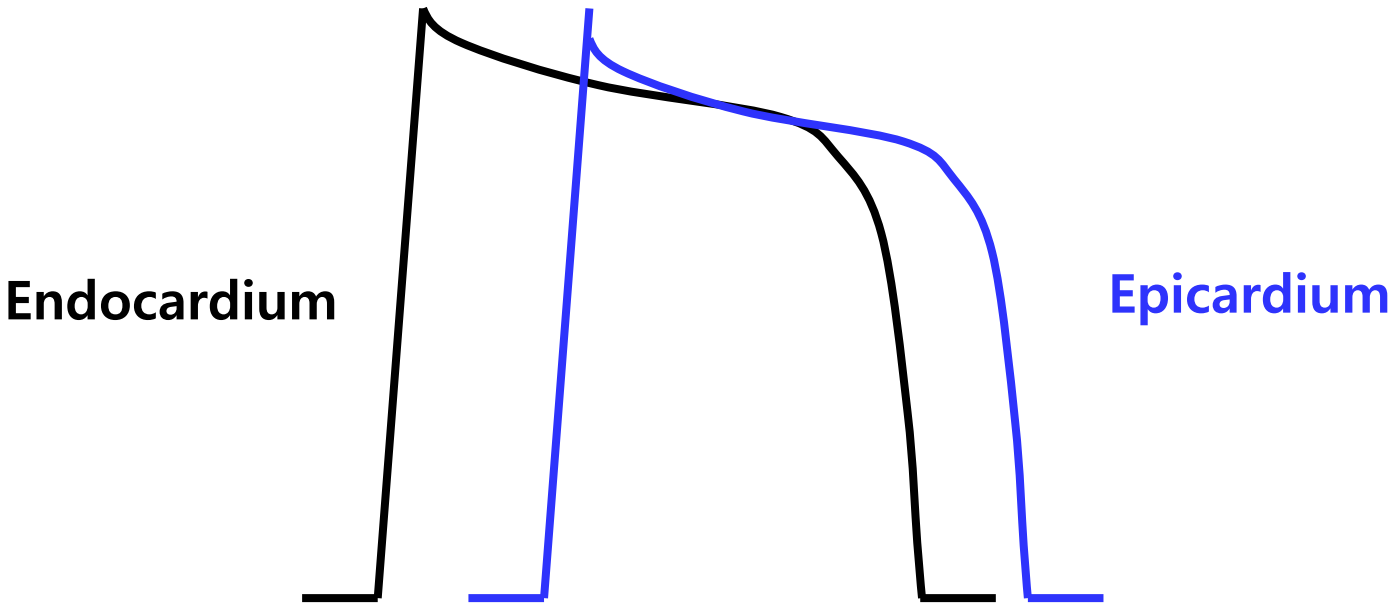
**V6**

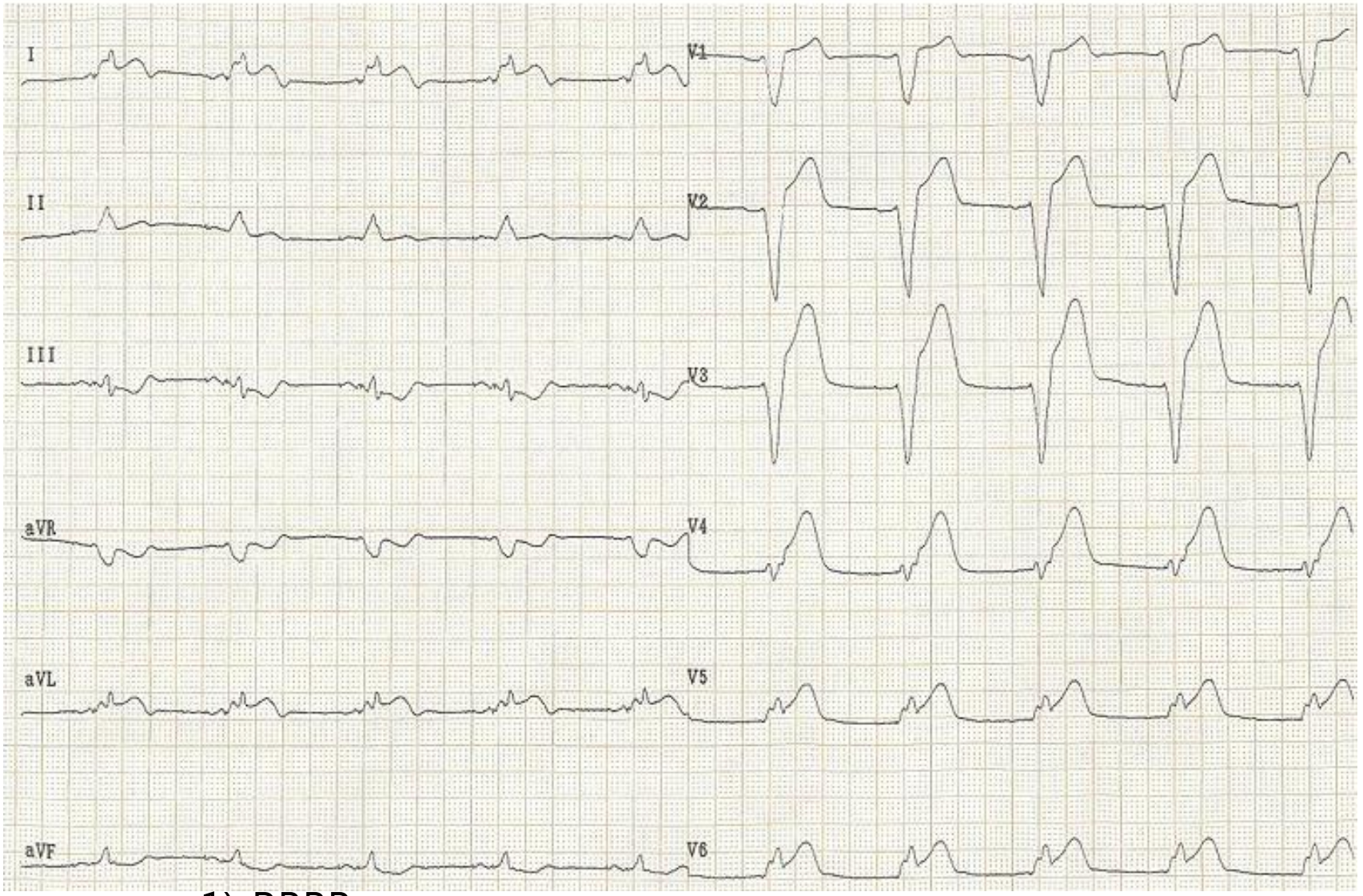

2° ST-T Wave Changes
Lead V1
Leads I / V6
Typical RBBB
Typical LBBB
or

# QRS – T Formation



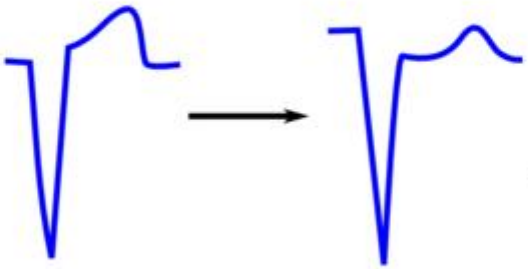
# A certain site of chamber which was delayed activated such as of BBB



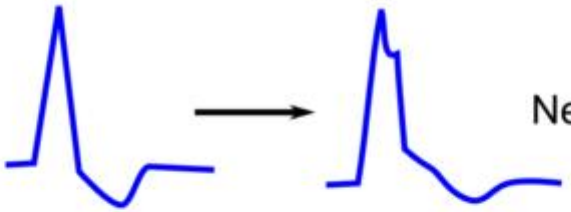



1) RBBB
2) LBBB
3) LBBB + Inferior MI
4) LBBB + Anterolataral MI
5) WPW syndrome

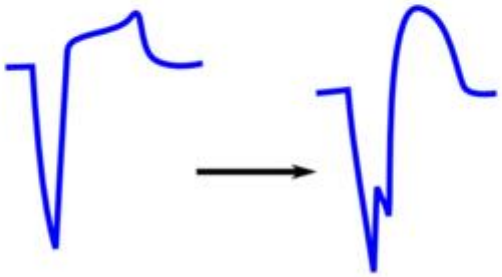
# Ischemia in LBTB



Concordant ST shifts



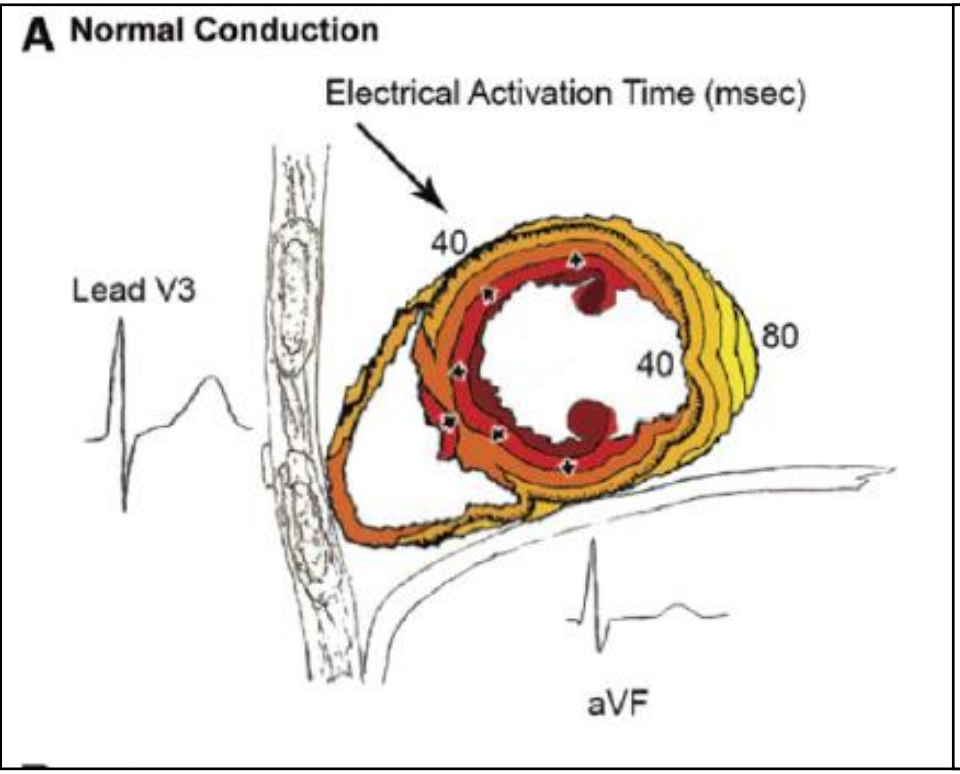
New QRS notching

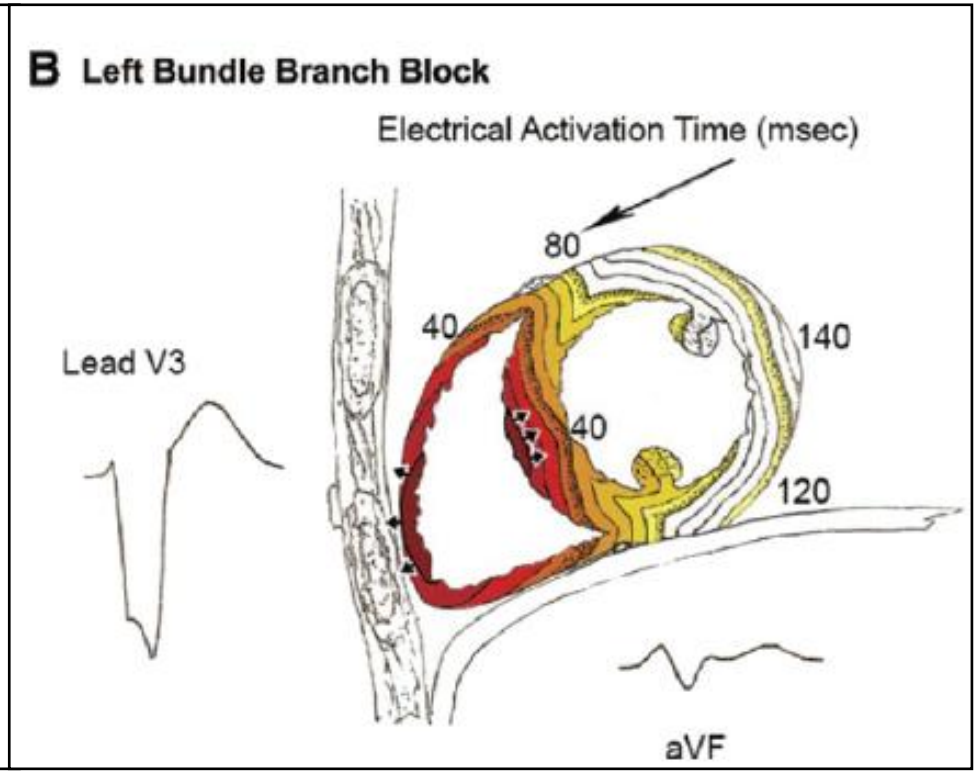


QRS notching and ST elevation > 5 mm

# True LBBB

# Normal Conduction vs LBBB




- During LBBB development

  1) QRS duration prolongs by more than 40ms

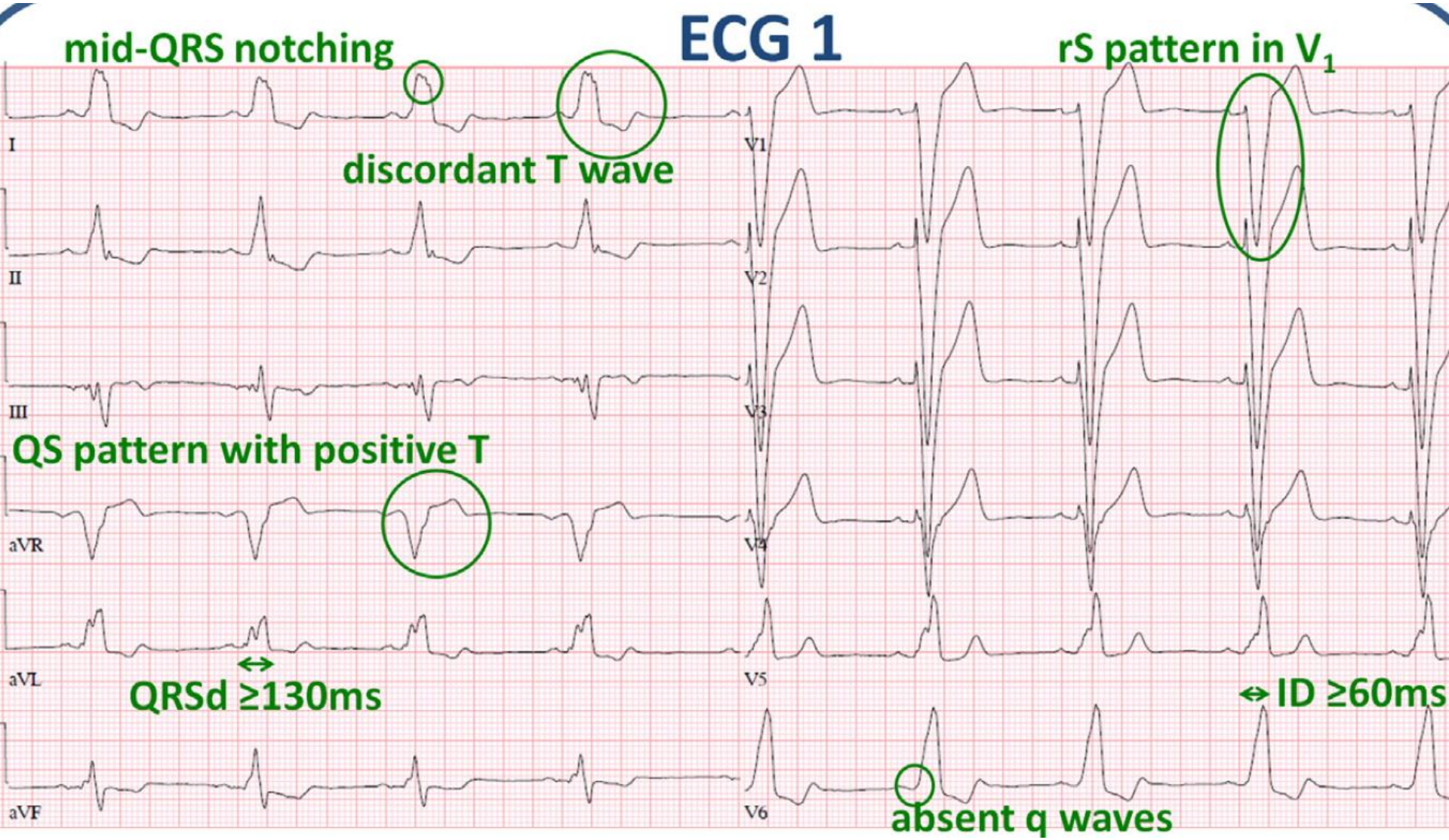
  2) Initial electrical force(QRS morphology) must change because of the different activation of septum

# Criteria of LBBB

ECG parameters for complete LBBB according to guidelines of European Society of Cardiology (ESC) [11], American Heart Association (AHA)/American College of Cardiology Foundation (ACCF)/Heart Rhythm Society (HRS) [12], Strauss et al. [13], MADIT-CRT [14] and REVERSE [15] clinical CRT trials.

| ECG parameter for complete LBBB | ESC | AHA | Strauss | MADIT | REVERSE |
|---|---|---|---|---|---|
| QRS duration (ms) ≥ | 120 | 120 | ♀130 ♂140 | 130 | 120 |
| QS or rS in $V_1$ | Yes | Yes | Yes | Yes | Yes |
| Positive T in $V_1$ | Yes | No | No | No | No |
| Normal ID R in $V_1$–$V_3$ | No | Yes | No | No | No |
| ID R in $V_5$ ≥60 ms | No | Yes | No | No | No |
| ID R in $V_6$ ≥60 ms | Yes | Yes | No | No | No |
| ID R in I ≥60 ms | Yes | No | No | No | No |
| Notch-/slurred R in I, aVL and $V_5$–$V_6$ | No | Yes | No | No | No |
| Mid-QRS notch/slurring in ≥2 leads of $V_1$–$V_2$, $V_5$–$V_6$, I, aVL | No | No | Yes | No | No |
| RS pattern allowed in $V_5$–$V_6$ | No | Yes | Yes | Yes | Yes |
| Absent q in $V_5$–$V_6$ | No | Yes | No | Yes | Yes |
| Absent q in I | No | Yes | No | No | No |
| QS with positive T in aVR | Yes | No | No | No | No |
| Usually discordant T | Yes | Yes | No | No | No |

ID : intrinsicoid deflection defined as time from start QRS to R peak


ECG 1
mid-QRS notching
discordant T wave
rS pattern in V1
QS pattern with positive T
QRSd ≥130ms
ID ≥60ms
absent q waves
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

# 3D contact and Noncontact mapping of patients with LBBB by conventional ECG criteria

| Location of LV Breakthrough Site | Site of Line of Block | | | | Pathogenesis: DCM/CAD | QRS Duration | | Time to LV Breakthrough | | Time of Total LV Activation | | Distance From LV Breakthrough Site to Line of Block |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | None | Ant | Lat | Inf | | Automatic, ms | Maximum, ms | NCM, ms | CM, ms | NCM, ms | CM, ms | NCM, mm |
| Anterior (n=2) | | | 2 | | 2/0 | 100±9 | 136±11 | 11±3 | 5±0 | 86±20 | 94±32 | 98±6 |
| Septal (n=22) | | | | | | | | | | | | |
| Basal (n=4) | | 1 | 2 | 1 | 2/2 | 149±20 | 168±24 | 16±25 | 13±18† | 107±30 | 114±28 | 92±35† |
| Middle (n=4) | 1 | 2 | | 1 | 3/1 | 149±35 | 167±34 | 38±25 | 25±36 | 82±20 | 99±16 | 63±15 |
| Apical (n=14) | | 9 | 4 | 1 | 10/4 | 168±17* | 195±29* | 59±25* | 62±22* | 101±20 | 106±17 | 63±10* |
| *P* | | | | | 0.681 | 0.03 | 0.035 | 0.010 | 0.001 | 0.346 | 0.648 | 0.009 |

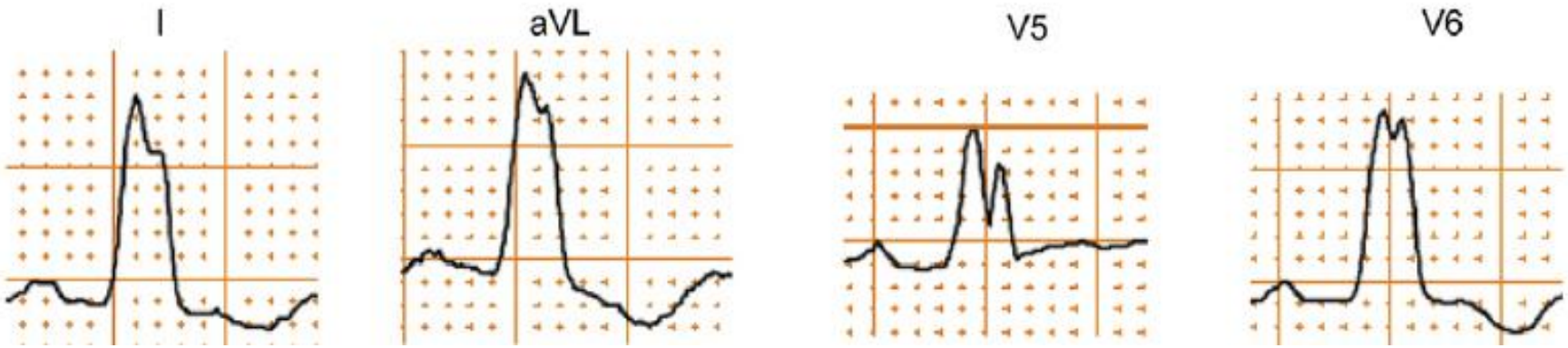
Ant indicates anterior; Lat, lateral; Inf, inferior; CAD, coronary artery disease; DCM, idiopathic dilated cardiomyopathy; CM, contact mapping; and NCM, noncontact mapping.

*Statistical difference between anterior and septal-apical at the level of significance $P<0.05$.

†Statistical difference between septal-basal and septal-apical at the level of significance $P<0.05$.

- 1/3rd of patients did not have significant delay between the start of activation of the RV endocardium and the start of activation of the LV endocardium

*Circulation 2004;109:1133-1139*



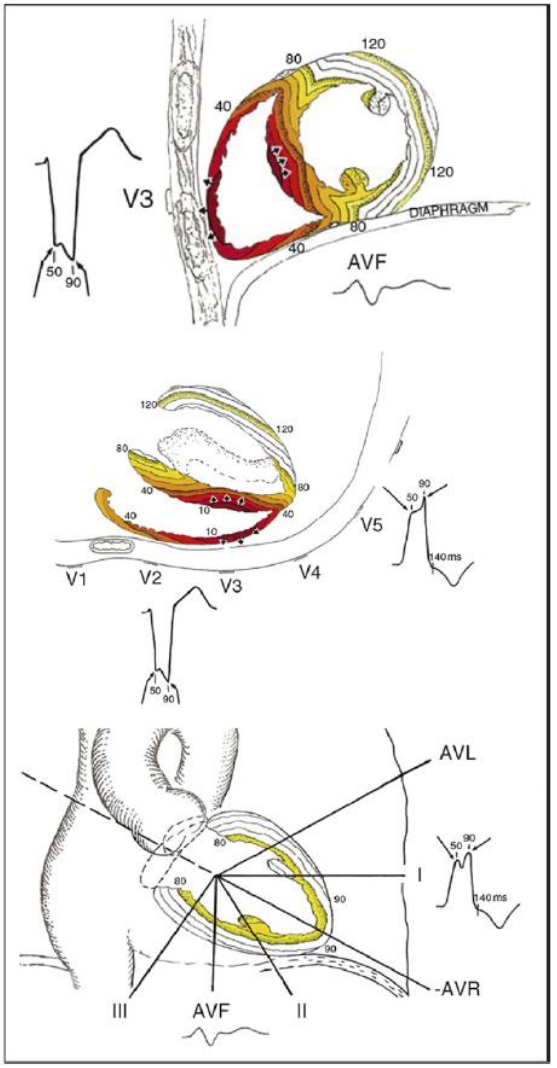

ECG parameters for complete LBBB according to guidelines of European Society of Cardiology (ESC) [11], American Heart Association (AHA)/American College of Cardiology Foundation (ACCF)/Heart Rhythm Society (HRS) [12], Strauss et al. [13], MADIT-CRT [14] and REVERSE [15] clinical CRT trials.

| ECG parameter for complete LBBB | ESC | AHA | Strauss | MADIT | REVERSE |
|---|---|---|---|---|---|
| QRS duration (ms) ≥ | 120 | 120 | ♀130 ♂140 | 130 | 120 |
| QS or rS in $V_1$ | Yes | Yes | Yes | Yes | Yes |
| Positive T in $V_1$ | Yes | No | No | No | No |
| Normal ID R in $V_1$–$V_3$ | No | Yes | No | No | No |
| ID R in $V_5$ ≥60 ms | No | Yes | No | No | No |
| ID R in $V_6$ ≥60 ms | Yes | Yes | No | No | No |
| ID R in I ≥60 ms | Yes | No | No | No | No |
| Notch-/slurred R in I, aVL, and $V_5$–$V_6$ | No | Yes | No | No | No |
| Mid-QRS notch/slurring in ≥2 leads of $V_1$–$V_2$, $V_5$–$V_6$, I, aVL | No | No | Yes | No | No |
| RS pattern allowed in $V_5$–$V_6$ | No | Yes | Yes | Yes | Yes |
| Absent q in $V_5$–$V_6$ | No | Yes | No | Yes | Yes |
| Absent q in I | No | Yes | No | No | No |
| QS with positive T in aVR | Yes | No | No | No | No |
| Usually discordant T | Yes | Yes | No | No | No |

ID : intrinsicoid deflection defined as time from start QRS to R peak

# Notch at QRS

- First notch : time when the electrical depolarization wave front reaches the endocardium of the LV(after proceeding through the septum)
- Second notch : occur when the depolarization wave front begins to reach the epicardium of the posterolateral wall.
- These notches are best seen in lead I, aVL, $V_1$, $V_2$, $V_5$ and $V_6$




*Am J Cardiol 2011;107:927-934*

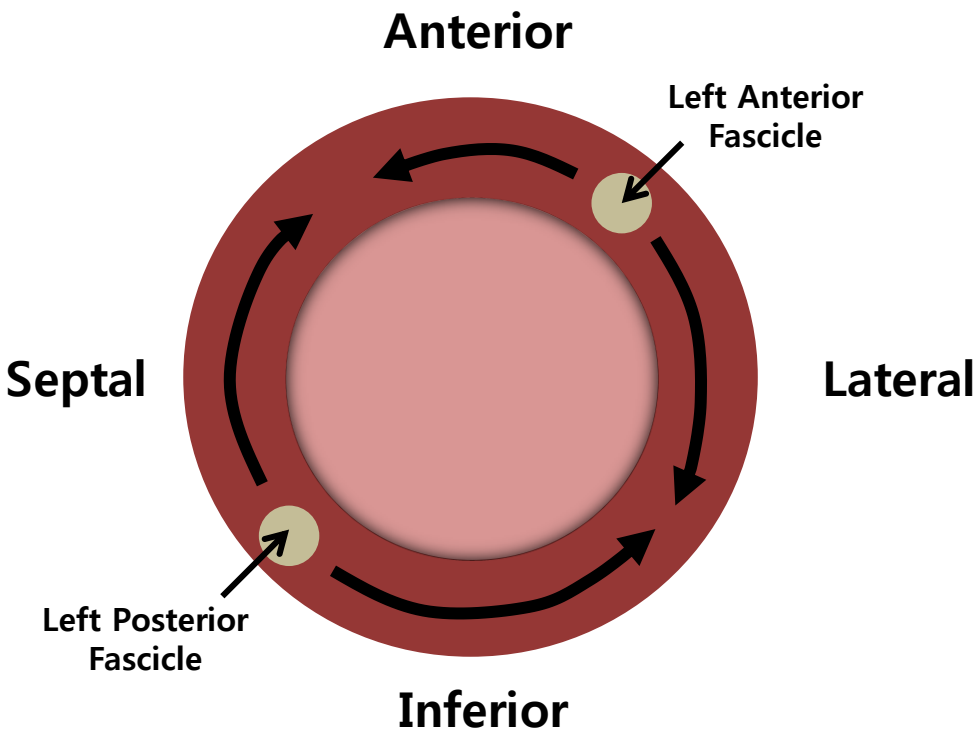
# Diagnostic performance of different LBBB definition for prediction of CRT response(>15% reduction in end-systolic LV volume

| LBBB definition | OR | 95% CI | *P*-value | Sensitivity | Specificity |
|---|---|---|---|---|---|
| ESC guideline | 3.225 | 1.285–8.095 | 0.011 | 64% | 64% |
| AHA/ACCF/HRS guideline | 3.700 | 1.386–9.871 | 0.007 | 55% | 75% |
| Strauss et al. | 11.813 | 3.359–41.544 | <0.001 | 94% | 43% |
| MADIT-CRT | 3.556 | 0.741–17.069 | 0.095 | 96% | 14% |
| REVERSE | 3.900 | 0.625–24.746 | 0.124 | 97% | 11% |

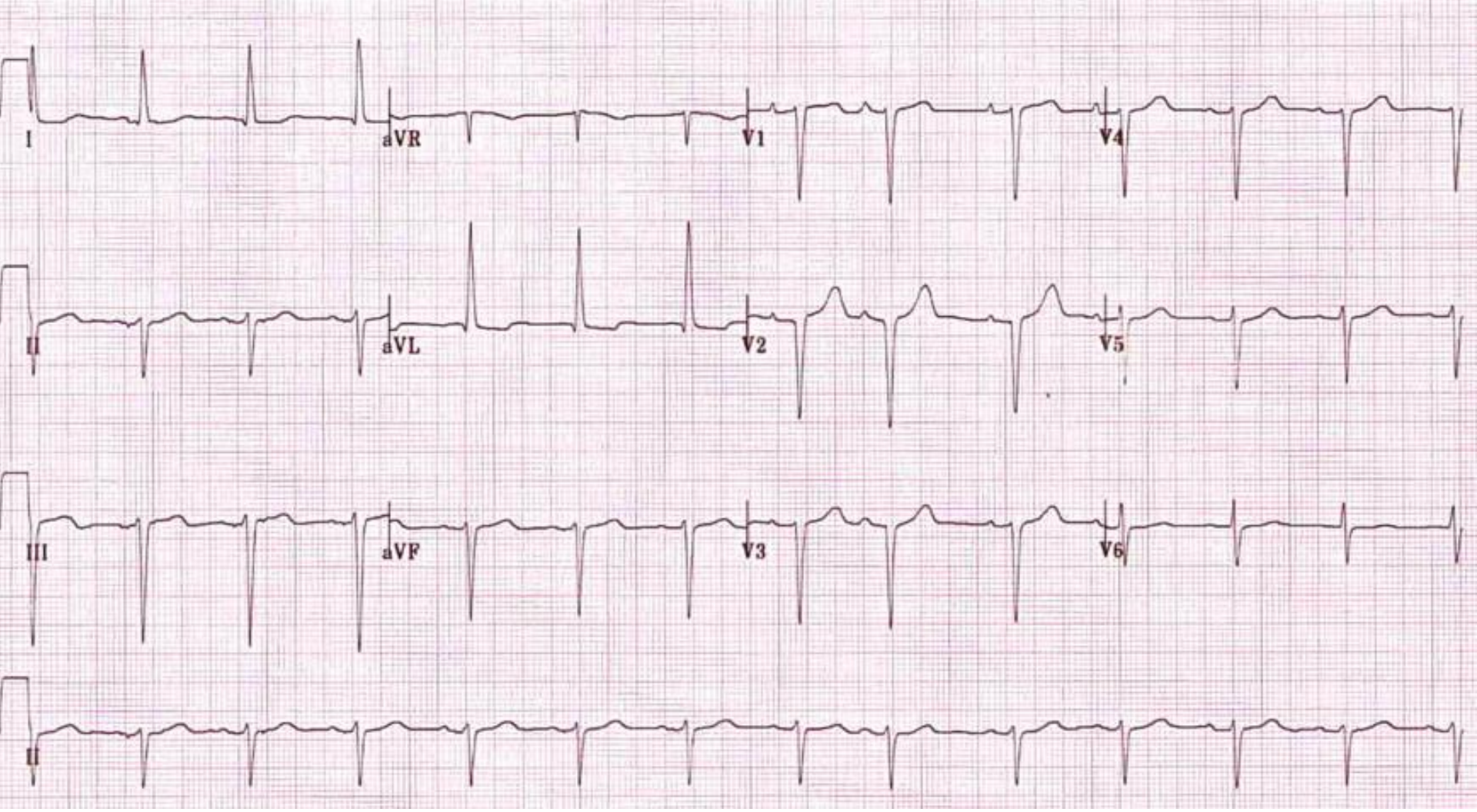
Presented are odds ratios (OR) with 95% confidence interval (CI) and, accordingly, *P*-values, sensitivity and specificity.

*J of electrocardiography 2014*

# Normal Depolarization of Fascicle

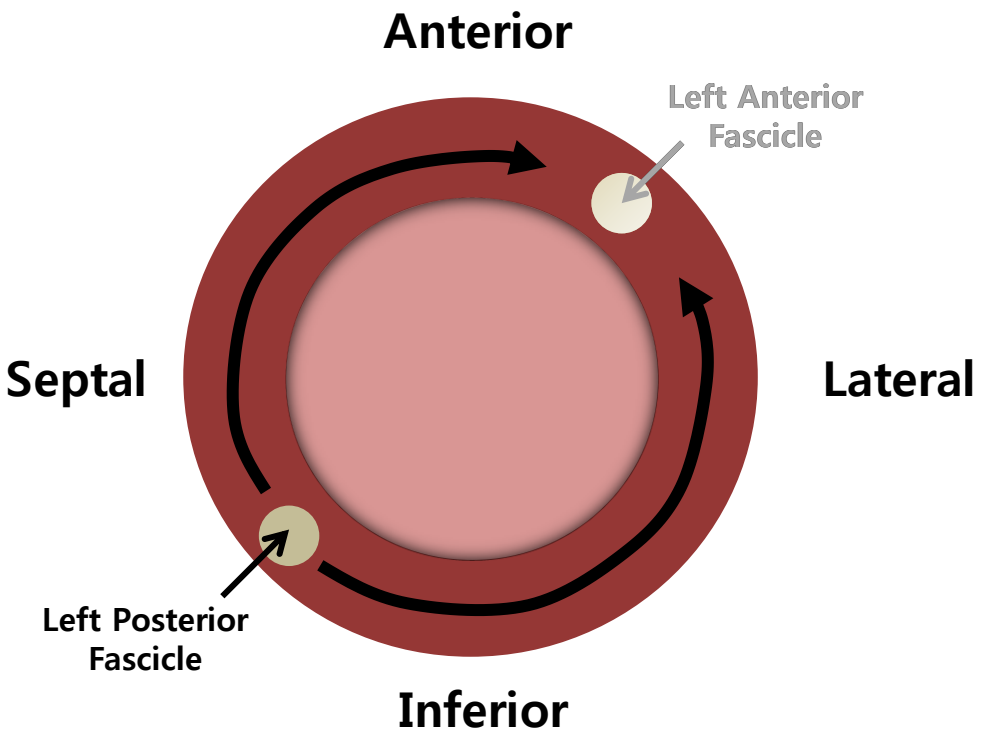



**Left Ventricle – Short Axis View**




1) Left anterior fascicular block
2) Left posterior fascicular block
3) Incomplete LBBB
4) Incomplete RBBB
5) WPW syndrome

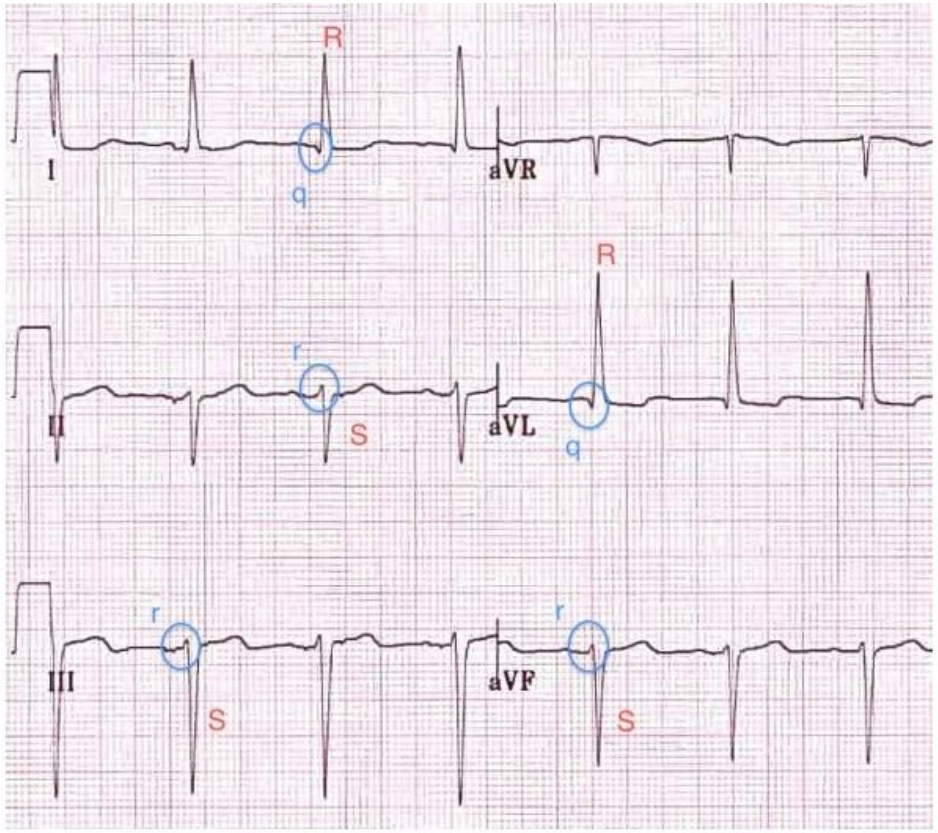
# Left Anterior Fascicular Block(LAFB)




**LAFB → Left axis deviation**

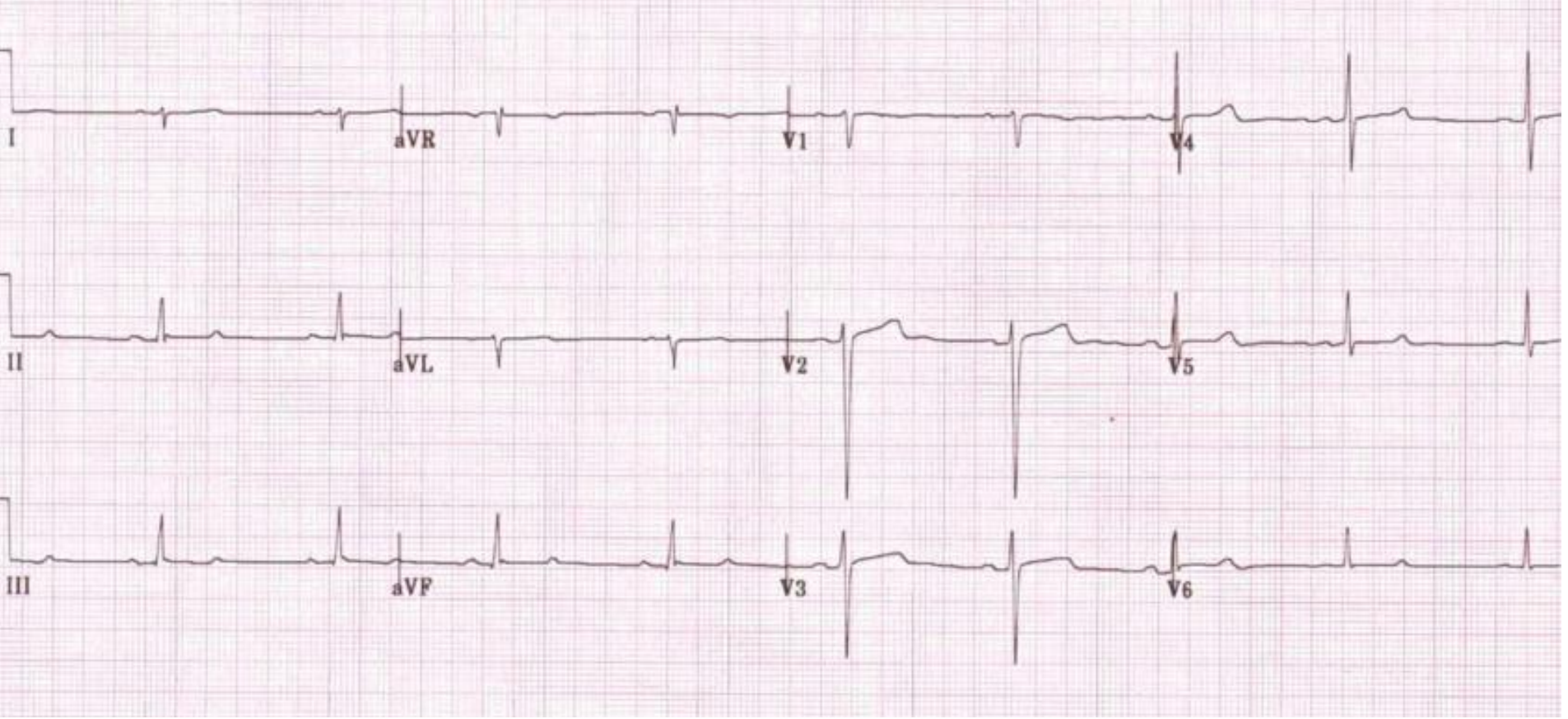
**Left Ventricle – Short Axis View**

# Left Anterior Fascicular Block(LAFB) -Criteria



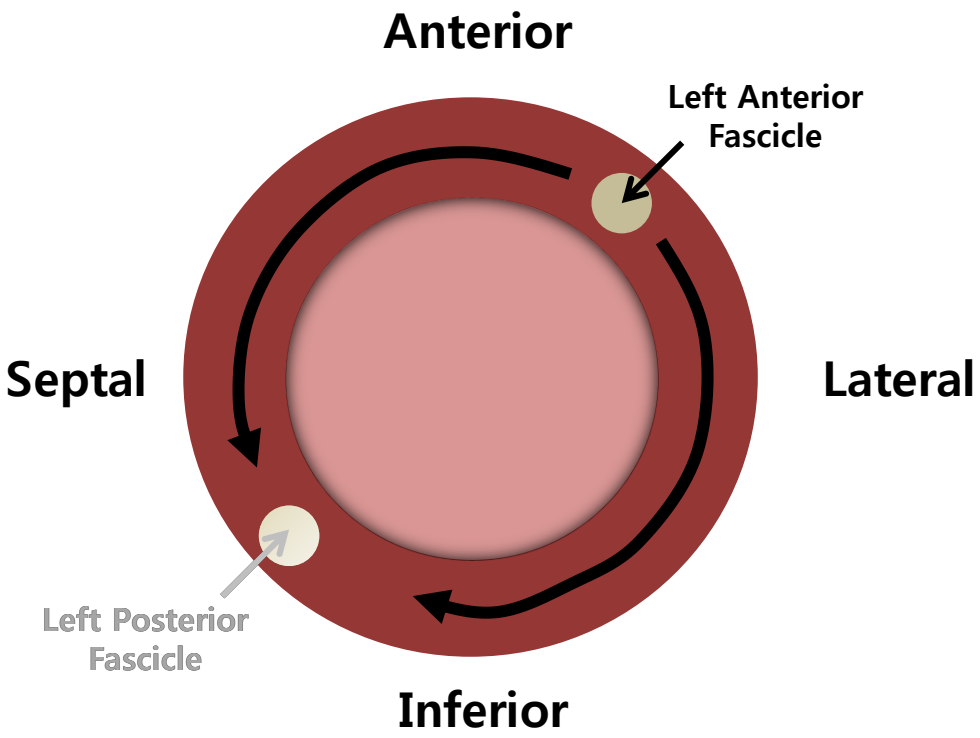

qR complexes in leads I and aVL, rS complexes in II, III and aVF


Prolonged R-wave peak time (= the time from onset of the QRS to the peak of the R wave) in aVL > 45 ms




1) Left anterior fascicular block
2) Left posterior fascicular block
3) Incomplete LBBB
4) Incomplete RBBB
5) WPW syndrome

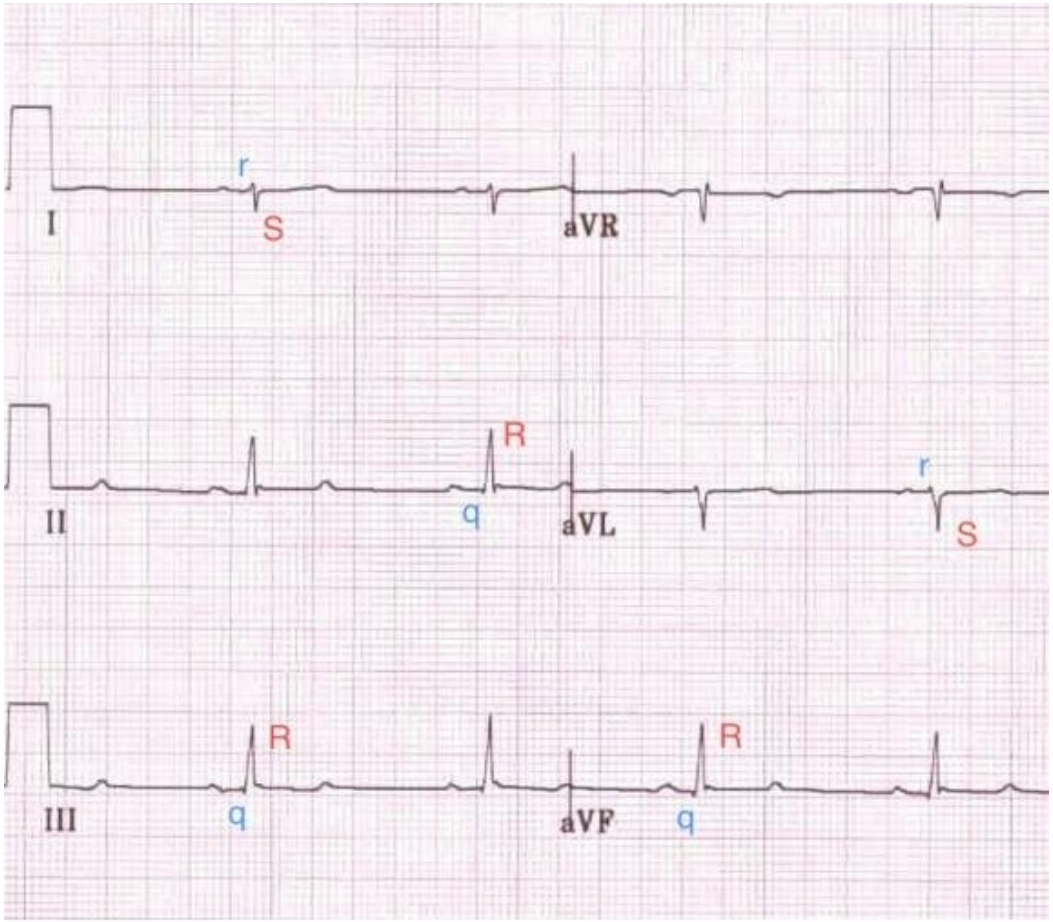
# Left Posterior Fascicular Block(LPFB)




**LPFB → Right axis deviation**

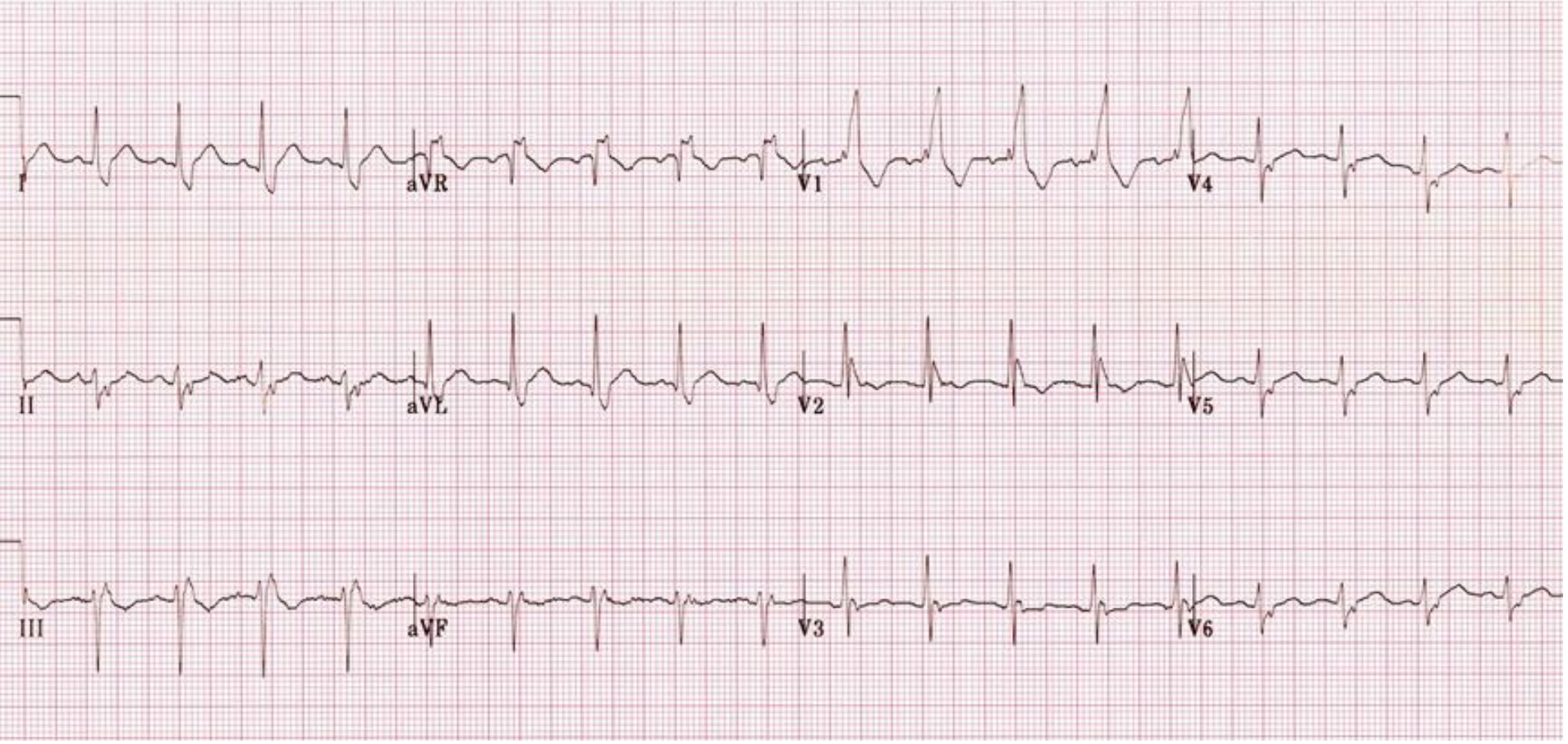
**Left Ventricle – Short Axis View**

# Left Posterior Fascicular Block(LPFB) -Criteria

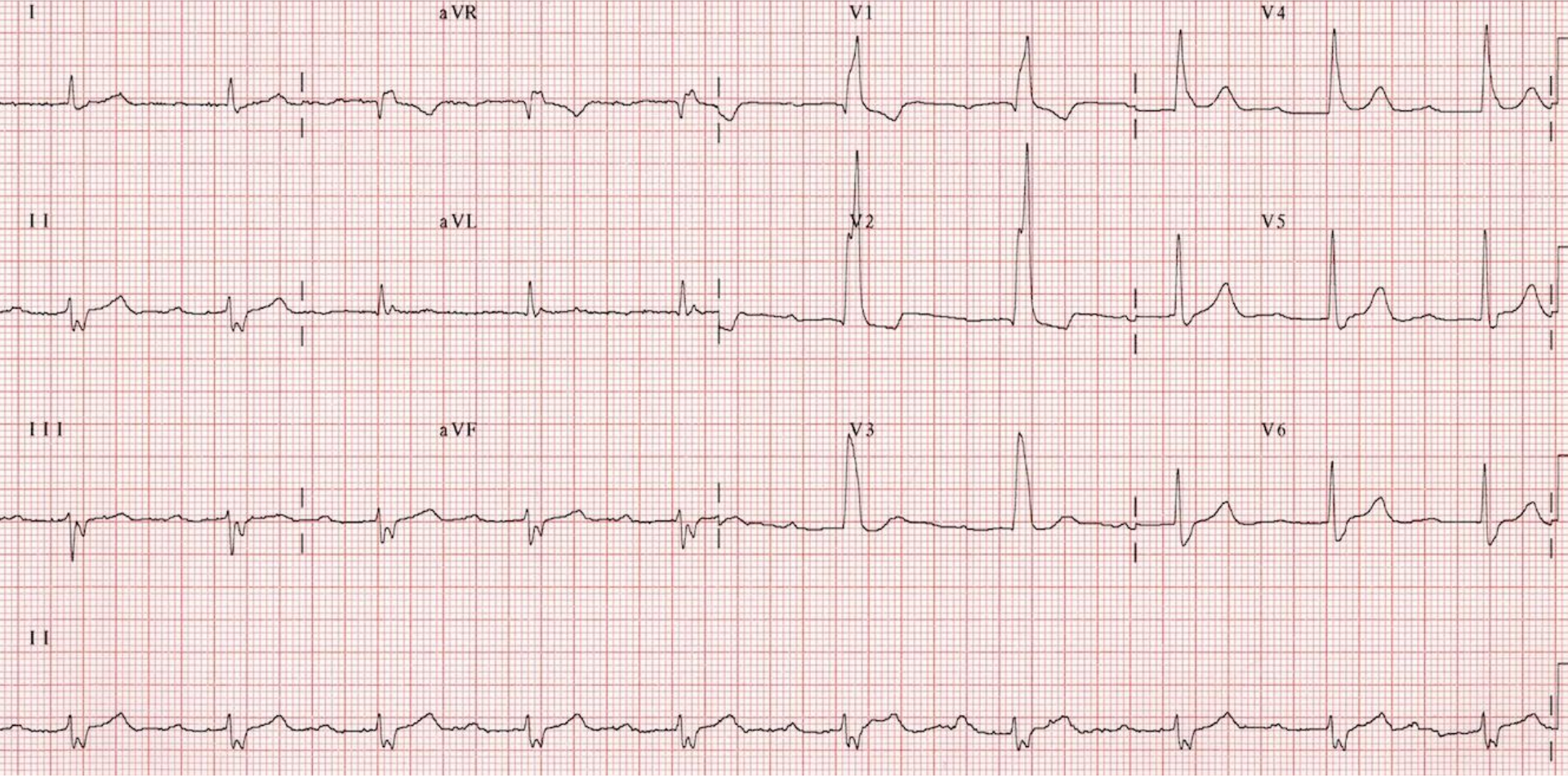



rS complexes in leads I and aVL, qR complexes in II, III and aVF

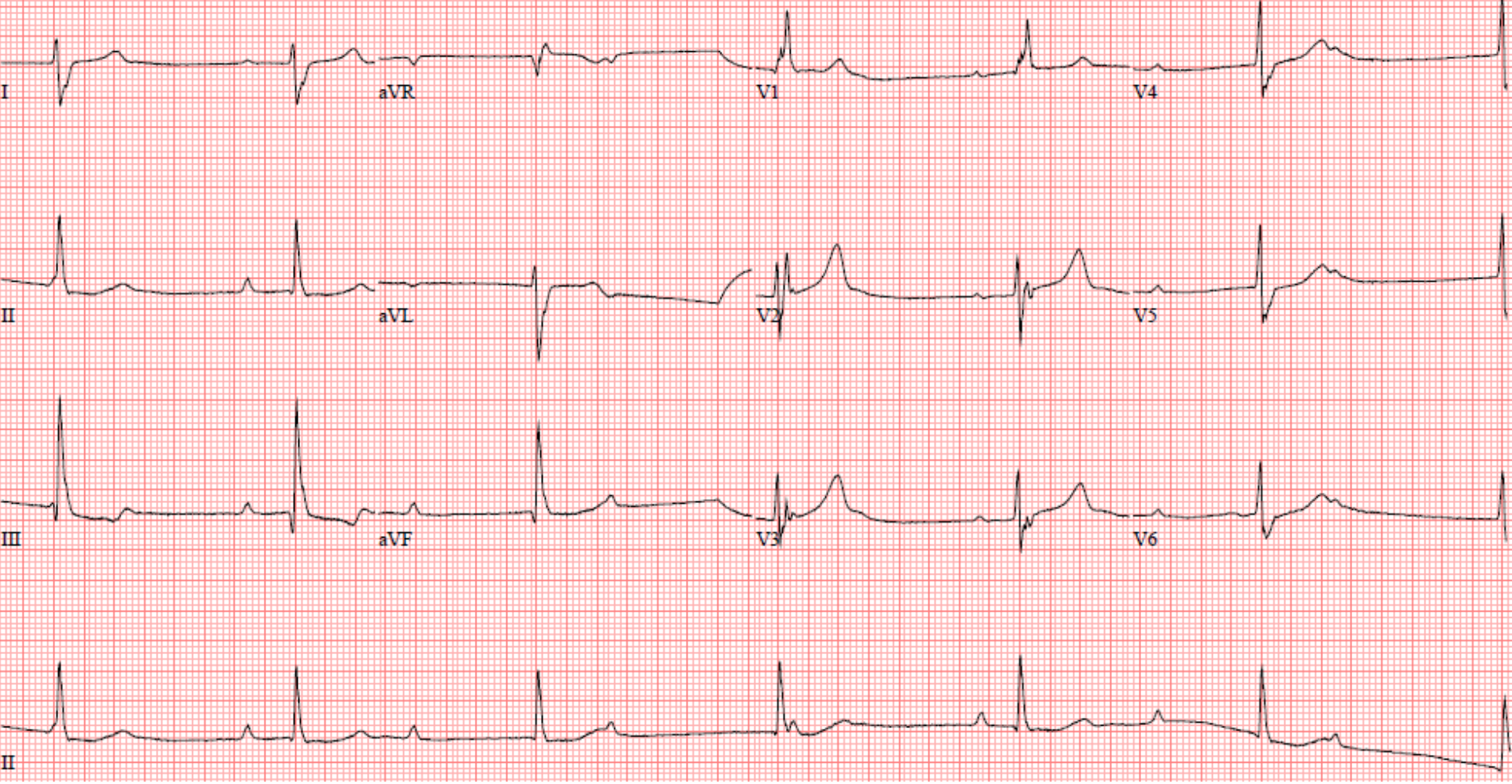

Prolonged R-wave peak time (= the time from onset of the QRS to the peak of the R wave) in aVF > 45 ms




1) RBBB + LAFB(Bifascicular block)
2) RBBB + LPFB(Bifascicular block)
3) LBBB
4) RBBB
5) WPW syndrome




1) RBBB + LAFB
2) RBBB + LPFB
3) RBBB + LPFB + 1st degree AV block
4) RBBB + LAFB + 1st degree AV block
5) WPW syndrome




1) RBBB + LAFB + 3rd degree AV block
2) RBBB + LPFB + 3rd degree AV block
3) RBBB + LPFB + 2nd degree AV block
4) RBBB + LAFB + 2nd degree AV block
5) WPW syndrome

# Trifascicular Block

- Incomplete trifascicular block

  Bifascicular block + 1st degree AV block

  Bifascicular block + 2nd degree AV block

  RBBB + alternating LAFB / LPFB

- Complete trifascicular block

  Bifascicular block + 3rd degree AV block

# 경청해 주셔서 감사합니다.