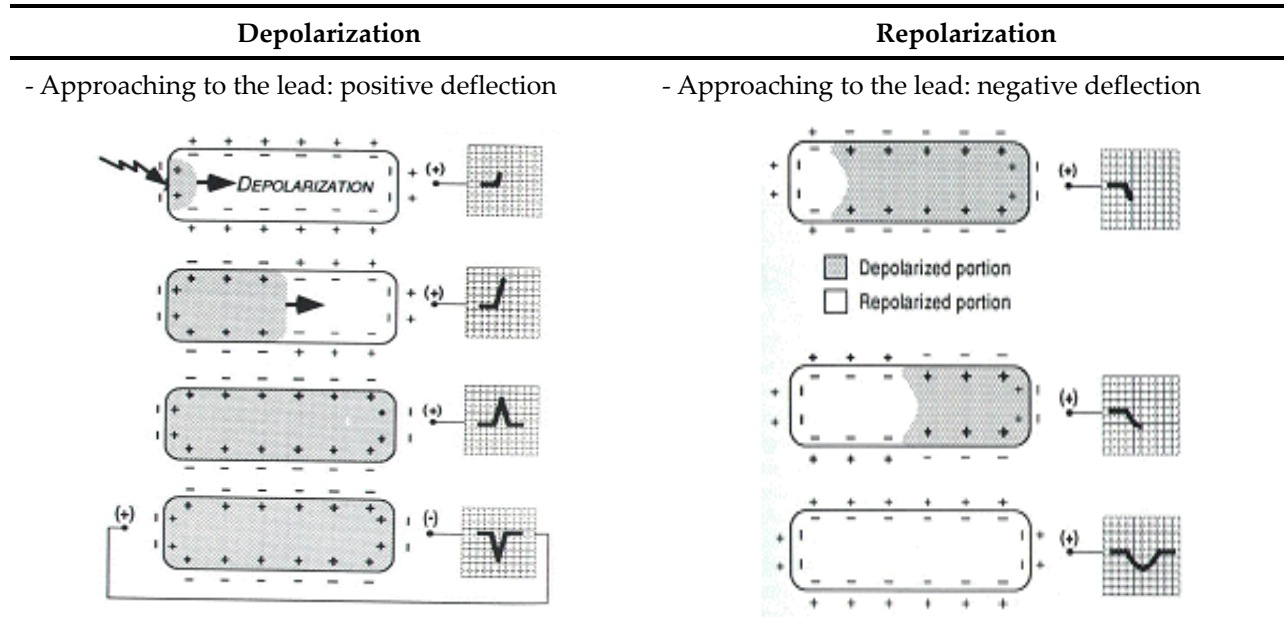


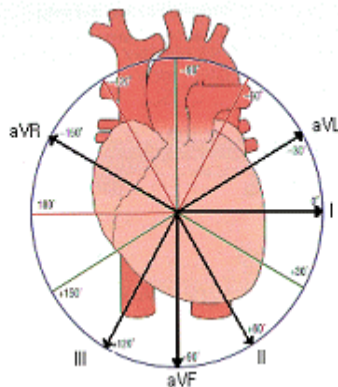
## 1. Electrophysiology



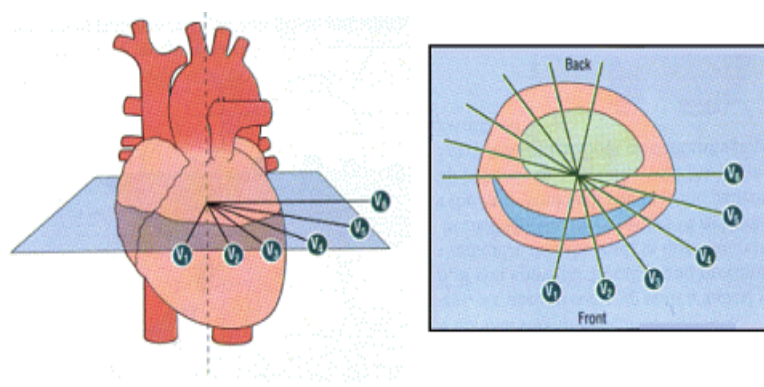
## 2. EKG Lead Reference System

Lead	Position
Limb leads(LA/RA/LL/RL)	In each extremity, at least 10cm from the heart
V1	4th intercostal space, just to the right of the sternum
V2	4th intercostal space, just to the left of the sternum
V3	Midway between V2 and V4
V4	Midclavicular line, 5th intercostal space
V5	Anterior axillary line, same level as V4
V6	Midaxillary line, same level as V4 and V5

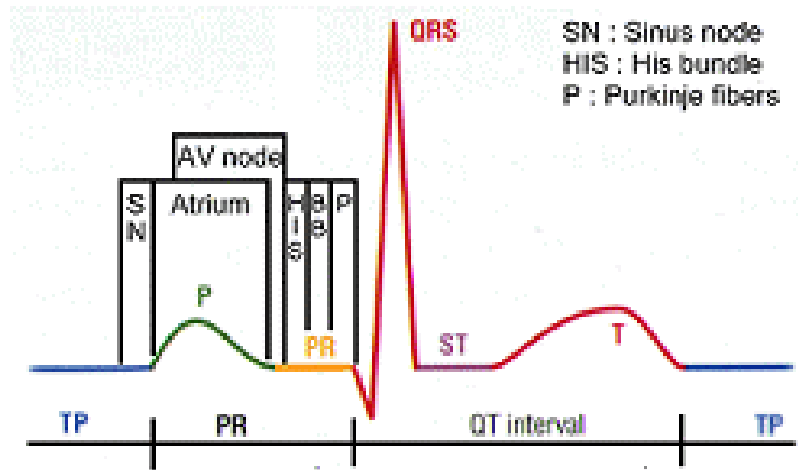
Hexaxial System



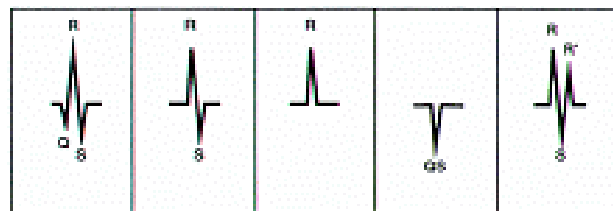
Precordial System



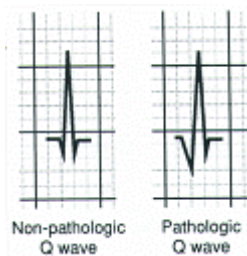
### 3. EKG Waveforms and Intervals

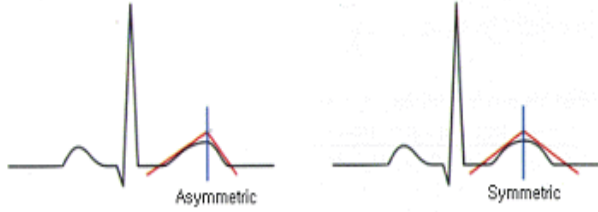


Waveforms / Intervals	Meaning	Normal Range
<b>P wave</b>	Depolarization of atria - Sinus P wave is upright in II and inverted in aVR.	0.08 – 0.11 sec
<b>PR segment</b>	Depolarization of AV node, His bundle, bundle branch, and the purkinje system	
<b>PR interval</b>	P wave + PR segment	0.08 – 0.20 sec
<b>QRS complex</b>	Depolarization of ventricles - Q wave : the first negative deflection after P wave - R wave : the first positive deflection after P wave - S wave : the first negative deflection after R wave	0.08 – 0.10 sec

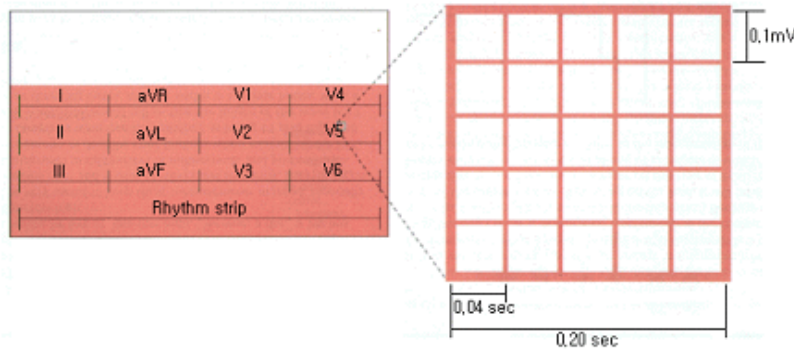


- Significant Q wave: either of the following criteria
  - (1) Q wave duration > 0.04 sec
  - (2) Q wave height > 1/4 of the total height of the QRS

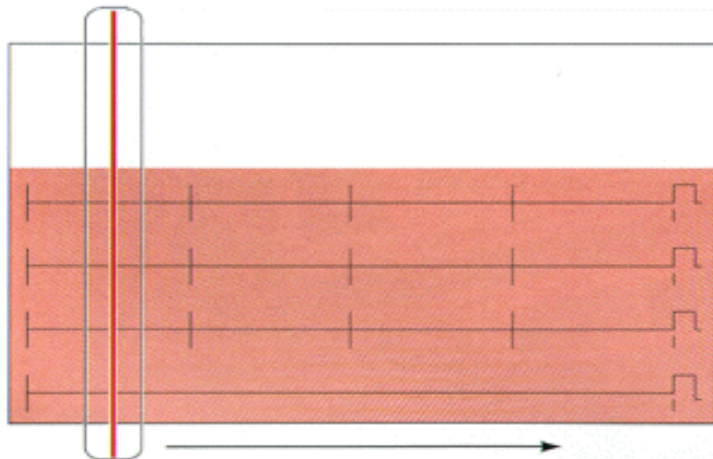


<b>ST segment</b>	Electrically neutral period between depolarization and repolarization of ventricles
<b>T wave</b>	Repolarization of ventricles - Normal T wave is asymmetric
	
<b>QT interval</b>	QRS complex + ST segment + T wave - Ventricular depolarization and repolarization - Corrected QT (QTc) (Normal QTc ≤ 0.44 seconds) = QT measured (sec) / Square root of R-R interval (sec)
<b>U wave</b>	- Drugs (Quinidine, Procainamide, Disopyramide) - Hypokalemia

**4. EKG Paper**



EKG paper speed = 25mm/sec

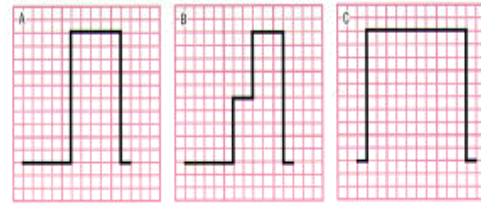


The red line represents time ; events that touch the red line occurred simultaneously.

## 5. Interpretation of EKG

### (1) Calibration

	One Small Vertical Box	One Small Horizontal Box
A. Standard	0.1 mV	0.04 sec (25 mm/sec)
B. Half-standard	0.2 mV	0.04 sec (25 mm/sec)
C. Double-speed	0.1 mV	0.02 sec (50 mm/sec)



### (2) Rate: Use one of the following three methods

- 1500/(number of mm between beats): only applicable to regular rhythm
- Count off method : 300-150-100-75-60-50: only applicable to regular rhythm
- Number of beats in 12-second strip (the entire EKG length) X 5: applicable to irregular rhythm

### (3) Rhythm: Sinus rhythm is present, if :

- (1) each P wave is followed by QRS
  - (2) each QRS is preceded by a P wave
  - (3) the P wave is upright in leads I, II, & III and inverted in lead aVR
  - (4) the PR interval is 0.12 – 0.20 sec (3 – 5 small boxes)
  - (5) If rate 60-100: normal sinus rhythm; If rate > 100: sinus tachycardia; If rate < 60: sinus bradycardia
- If these criteria are not met, determine the type of arrhythmia.

### (4) Interval

Interval	Normal	Decreased in	Increased in
PR	0.12 - 0.20 sec (3 – 5 small boxes)	Pre-excitation syndrome Junctional rhythm	First-degree AV block
QRS	≤ 0.10 sec (≤2.5 small boxes)		Bundle branch blocks Ventricular ectopic beat Toxic drug effect (e.g., quinidine) Severe hyperkalemia
QT	QTc ≤ 0.44 sec	Hypercalcemia Tachycardia	Hypocalcemia Hypokalemia(due to ↑ U wave) Hypomagnesemia Myocardial ischemia Congenital prolongation of QT Toxic drug effect (e.g., quinidine)

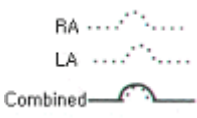

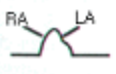
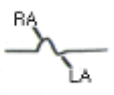
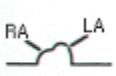
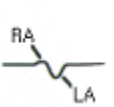
**(5) Mean QRS Axis**

- Normal QRS axis: - 30 degrees to 90 degrees
- If QRS is positive in leads I and II, normal QRS axis
- If not, (1) find the isoelectric lead; (2) examine the perpendicular lead to the isoelectric lead.

Left axis deviation	Right axis deviation
	Normal variant(in children and young adults)
	RVH
LVH(sometimes)	Acute or chronic RV overload
Left anterior fascicular block	(e.g. massive pulmonary embolism)
Inferior wall MI	Left posterior fascicular block
Normal variant	Lateral wall MI
	Dextrocardia
	Left pneumothorax

**(6) P wave**

- Look for atrial enlargement

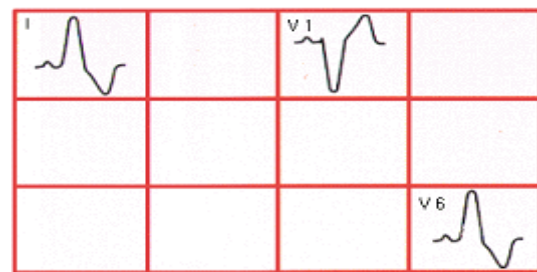
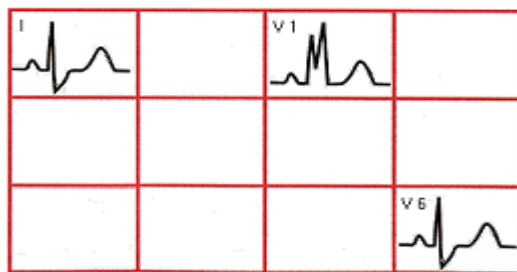
		Lead II	V1
Normal	Note slightly biphasic P in V1		
Right atrial abnormality (RAA)	"P-pulmonale" P in lead II $\geq 2.5$ mm		
Left atrial abnormality (LAA)	"P-mitrale" Biphasic P in V1 Broad, often notched P in lead II		

**(7) QRS Complex**

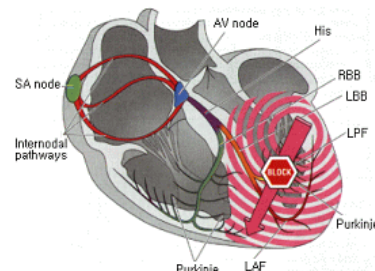
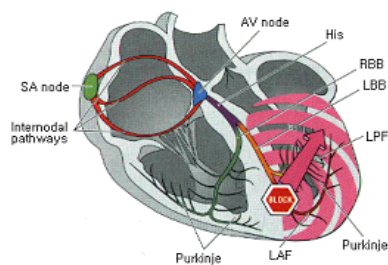
- Look for ventricular hypertrophy
- Look for bundle branch block and fascicular block
- Look for infarction
- Look for poor R wave progression

	V1	Main QRS vector	V6
<b>Right ventricular hypertrophy</b> $R \geq S$ in V1 Right axis deviation			
<b>Left ventricular hypertrophy</b> $S$ in V1 + $R$ in V5 or V6 $\geq 35$ mm $R$ in V5 or V6 $\geq 25$ mm $R$ in I $\geq 15$ mm $R$ in aVL $\geq 11-13$ mm $R$ in aVF $\geq 20$ mm $R$ in I + S in III $\geq 25$ mm			

Right bundle branch block	Left bundle branch block
1. QRS $\geq 0.12$ sec 2. Deep, slurred S wave in I and V6 3. RSR' pattern in V1	1. QRS $\geq 0.12$ sec 2. Broad, monomorphic R in I/V6, with no Q waves 3. Broad, monomorphic S in V1

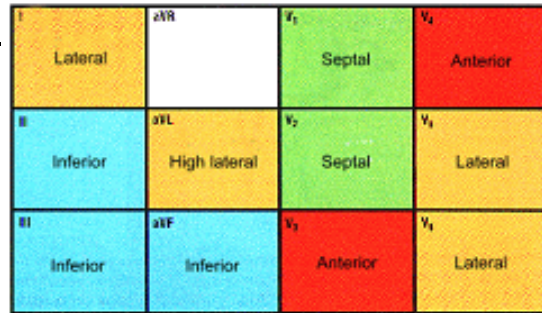


Left anterior fascicular block	Left posterior fascicular block
1. LAD with the axis at -30 to -90 2. qR complex in I, aVL 3. rS complex in II, III, aVF	1. RAD with the axis at 90 to 180 2. rS complex in I, aVL 3. qR complex in II, III, aVF 4. Exclusion of RAE and/or RVH

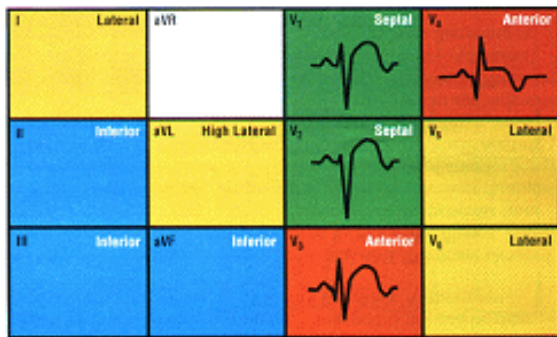


Summary of EKG Interpretation by DH Kim

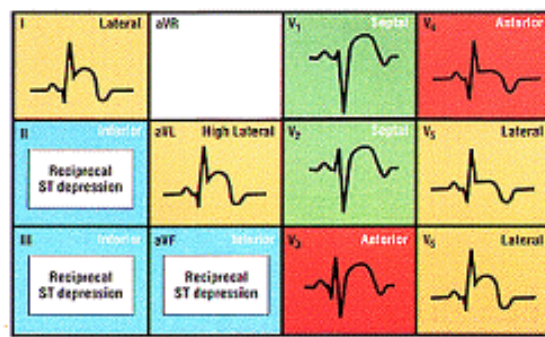
Anatomic Site	Changes on EKG	Coronary Artery
Inferior	II, III, aVF	RCA or LCx
Anteroseptal	V1, V2	LAD
Anteroapical	V3, V4	LAD(distal)
Anterolateral	V5, V6, I, aVL	LCx
Posterior	tall R in V1, V2	RCA or LCx



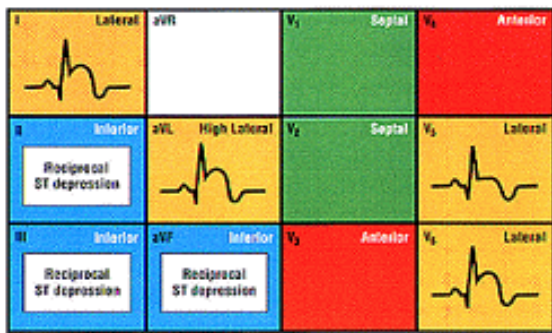
**Anteroseptal MI**



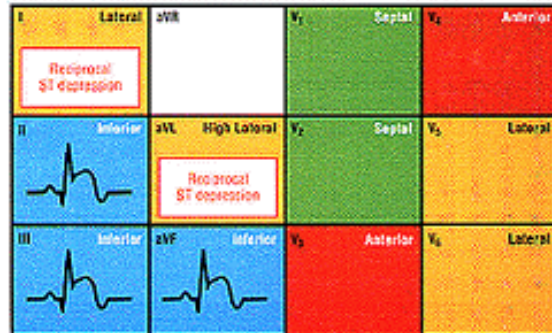
**Anteroseptal MI with Lateral Extension**



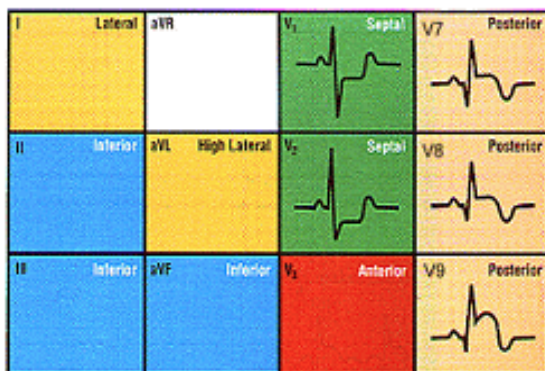
**Lateral MI**



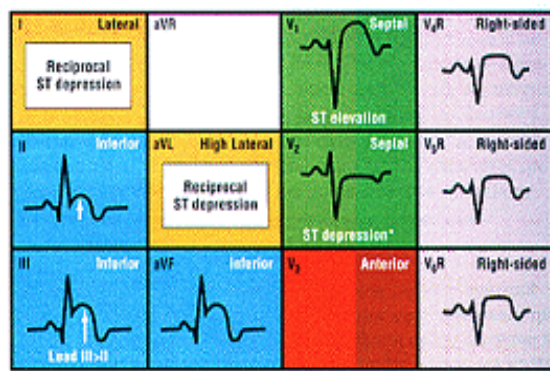
**Inferior MI**



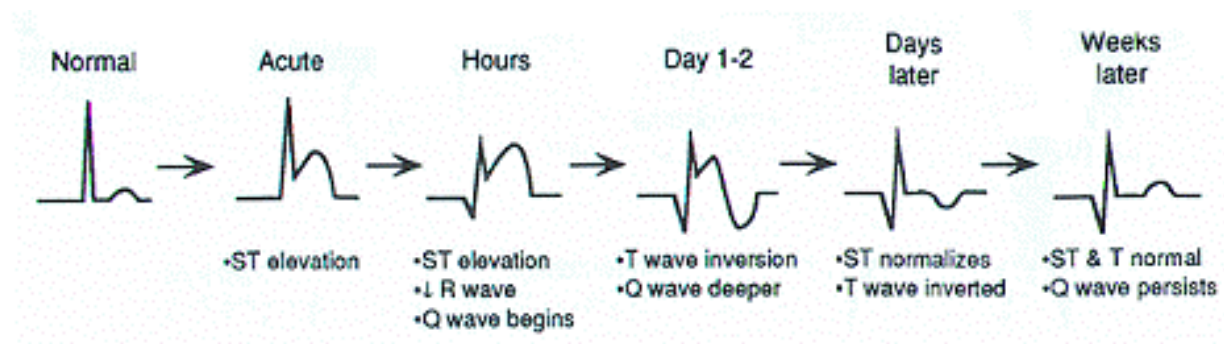
**Posterior MI**



**RV + Inferior MI**



EKG Progression in MI

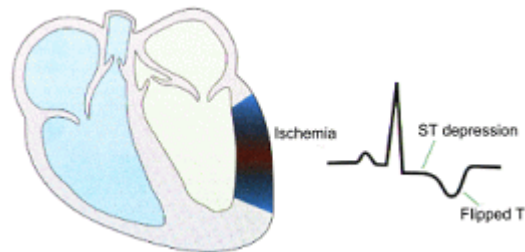
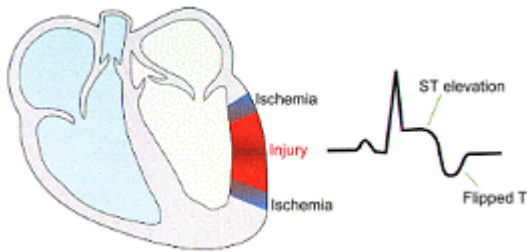


(8) ST and T changes

- Baseline: TP segment

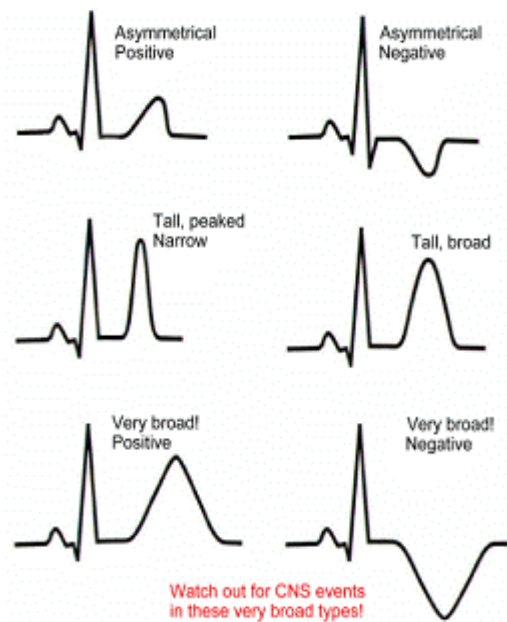
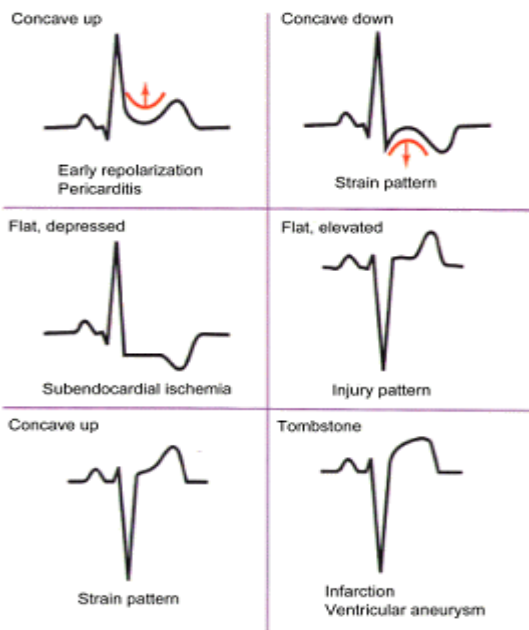
ST elevation: Injury and ischemia

ST depression: Ischemia

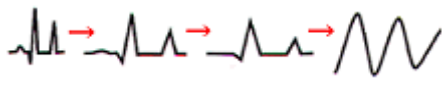



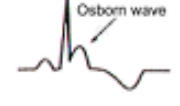

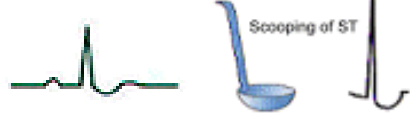


Examples of ST changes

Examples of T changes





Conditions	EKG change	Features
Hyperkalemia		Tall, peaked and narrow T wave Widening of intervals Loss of P wave Sine wave pattern
Hypokalemia		Prominent U wave Mild ST depression Flattened T wave
Hypercalcemia		Shortening of ST → ↓QTc
Hypocalcemia		Prolongation of ST → ↑QTc
Hypothermia		Osborn wave : a distinctive convex elevation of J point
Intracranial bleeds (SAH)		Marked QT prolongation Deep, wide T inversions
Digoxin		Shortened QT interval "Scooping" of the ST-T wave
Drugs(increase the duration of the action potential): Type IA antiarrhythmics (quinidine, disopyramide, procainamide), TCAs, phenothiazines, type III antiarrhythmics (amiodarone, sotalol)		Prolongation of QT

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