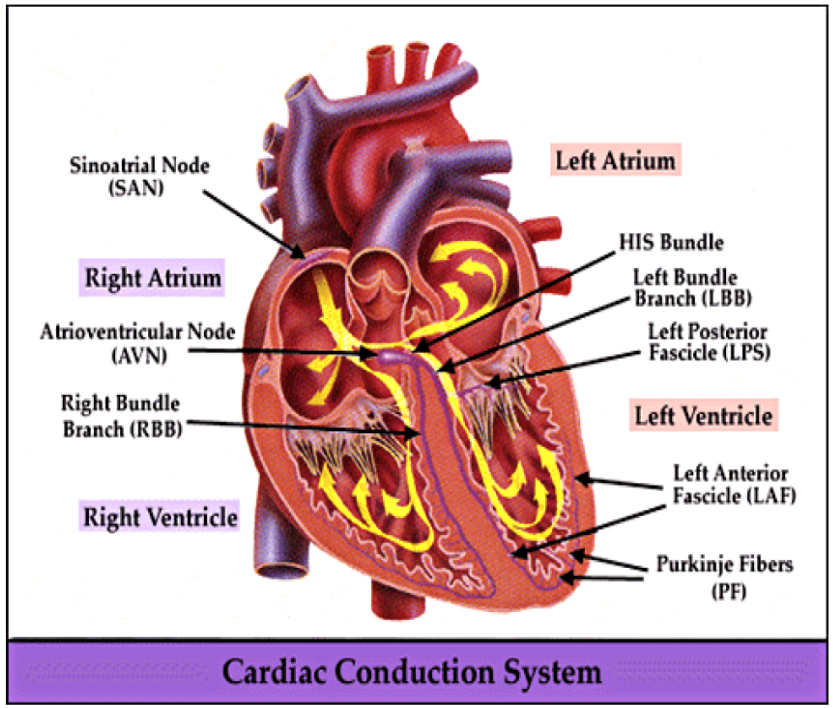
ElectroCardioGram

Voltage and Frequency Ranges for Some Important Parameters That Are Measured in the Human Body

Parameter sensor location	Voltage range	Frequency range (Hz)
Electrocardiography (ECG)	0.5–4 m V	0.01–250
Skin electrodes		
Electroencephalography (EEG)	5–200 μV	DC–150
Scalp electrodes		
Electrogastrography (EGG)		
Skin–surface electrodes	10–1000 μV	DC–1
Stomach–surface electrodes	0.5–80 mV	DC–1
Electromyography (EMG)	0.1–5 mV	DC–10,000
Needle electrodes		
Electrooculography (EOG)	50–3500 μV	DC–50
Contact electrodes		
Electroretinography (ERG)	0–900 μV	DC–50
Contact electrodes		
Nerve potentials	0.01–3 mV	DC–10,000
Surface or needle electrodes		

Cardiac Conduction System



http://library.med.utah.edu/kw/ecg

The Action potential that started from the SA(sinoatrial) node(동방결절) propagates down to atrium to reach the Atrioventricular node(심방결절).

The separation between the atrium and ventricle is called the Atirioventrical Ring (방실환) 뭉 acts as an insulation (with only 0.05 m/sec conduction velocity). This has a critical function of allowing a delay about 0.1 sec which is enough to finish atrial contraction before ventricular contraction starts.

(The conduction velocity is about 1m/sec within the atrium and ventricle)

The AP travels from the AV node through His' bunble at a speed of 4m/sec to arrive at the Purkinje network in the right and left branches of the central septum. Here the conduction is at 5m/sec and the entire ventricular muscle contracts almost simultaneously.

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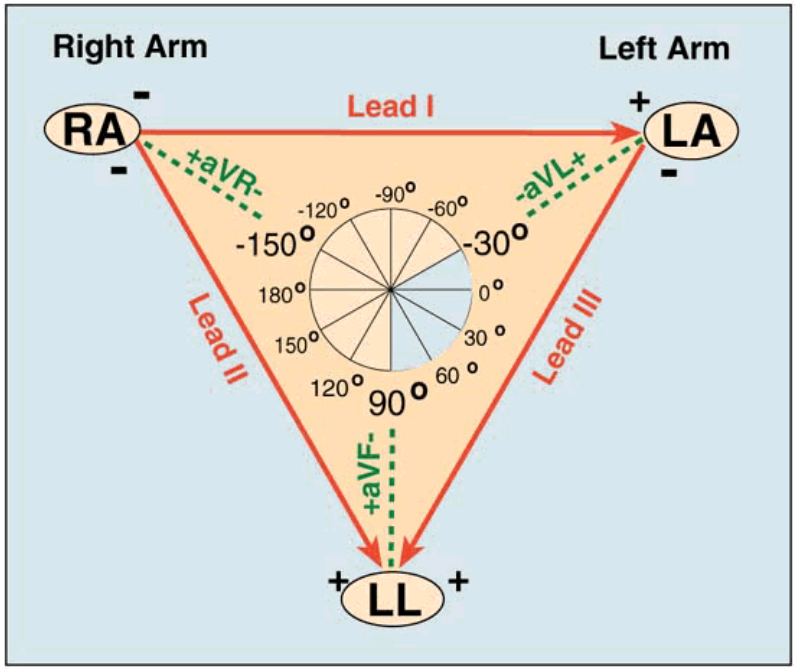
The Einthoven Triangle

Pacemaker voltage: The repetitive depolarization state in the SA node.

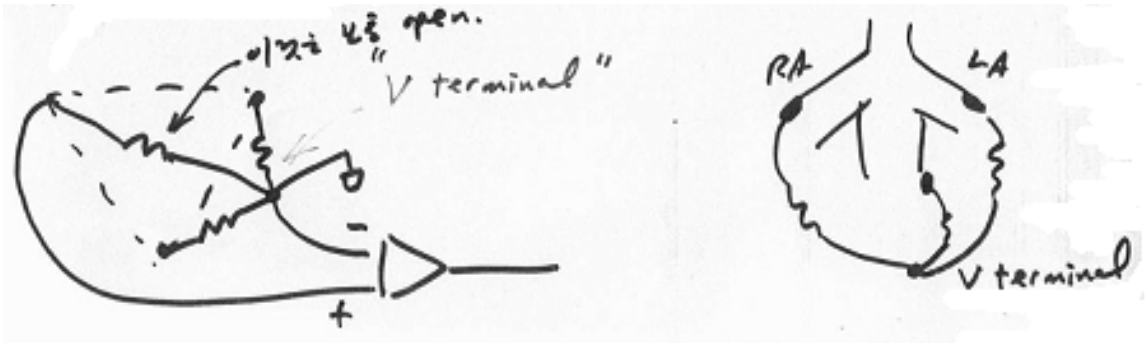
The propagation of the AP in the heart can be presented as a dipole vector that moves within the Einthoven Triangle drawn by him to record the ECG by the standard line lead method(사지 유도방식).



Lead Connections

Standard Line Lead: Biopolar measurement

Augmented Lead: Unipolar measurement



Heart as a Dipole Vector (at lead 2)

- (P)The AP that started from SA node propagates to the atrium then reaches to the AV node. The direction of the vector is bottom left.
- (QRS) The AP in the ventricle starts from the interventricular septum at the center and propagates to both left and right. The direction of vector is bottom right. (Q phase, phase 1)

  The depolarization continues to propagate from center to outside of the ventricle. Vector direction is to the bottom left. (R, phase 2)

  The last place to be excited is the top and posterior side of the septum. The vector points to top and right. (S, phase 3)
- (T) The repolarization in the ventricle propagates from the outer wall to the inner wall. This is opposite to the direction of R wave but considering the polarity of the dipole, the vector directs to bottom and left.

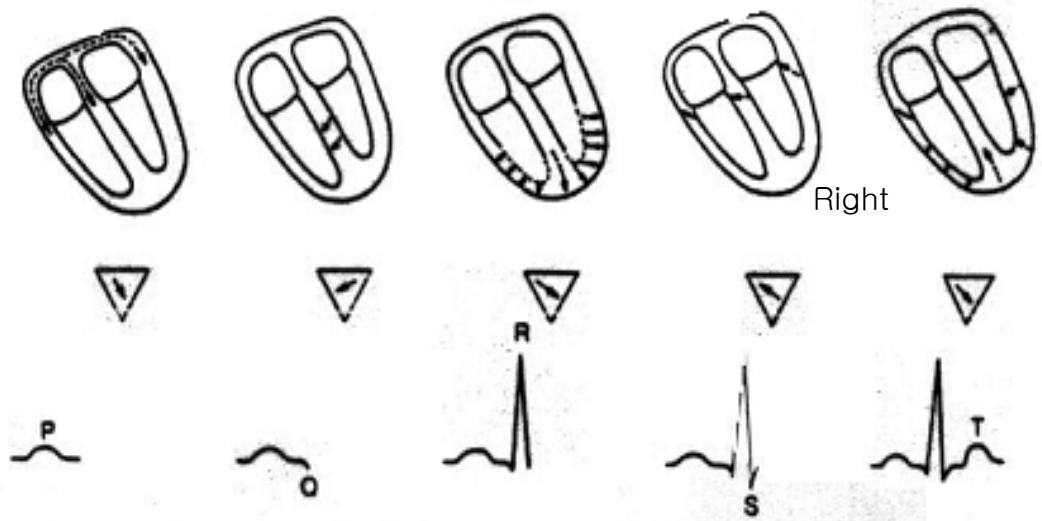


그림 5-19. 심장저분극과 재분극이 일어나는 순서. 그 결과 Einthoven 삼각형에 표시한 vector가 생기고, ECG 파형이 기록된다.

Source: Wikipedia

Precordial lead and Standard 12 lead

Precordial lead(orchest lead)
records the ECG by looking at the heart from the transverse plane and records the ECG with larger magnitude.

Including the standard line leads, augmented leads, and precordial leads, there are 12 leads total and the system is called the Standard 12 lead system.

For 12 lead ECG placement, see

http://www.youtube.com/watch?v=GUIKXnot-1k

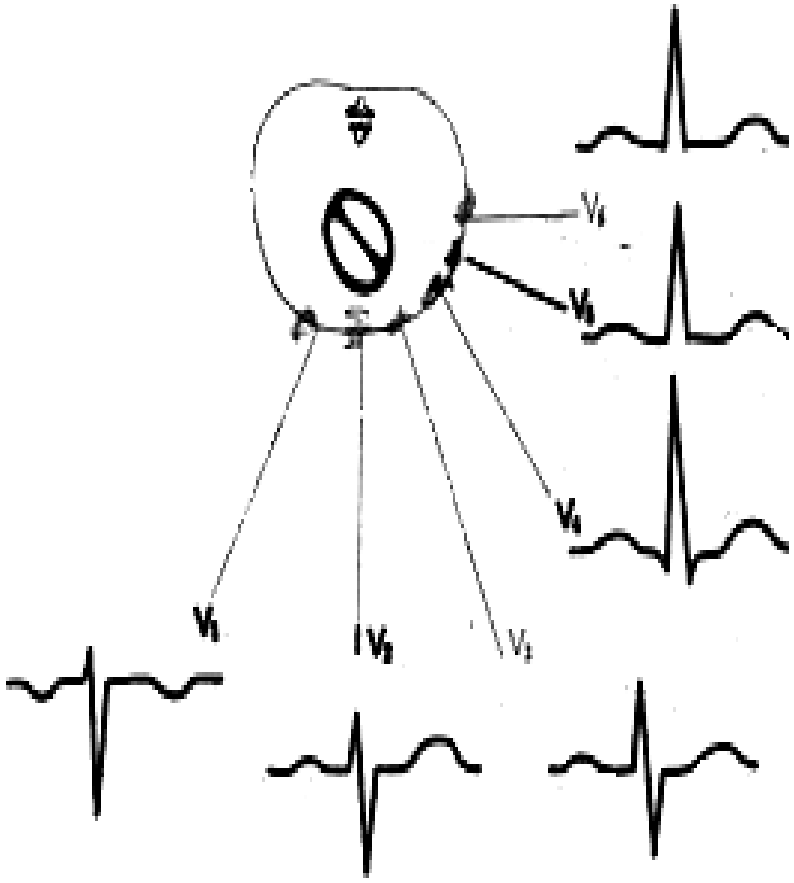


그림 5-21. Precordial lead로 기록된 심전도 모양. 이때는 심장을 수평면에서 본 것이다.

Normal variability in 12 lead ECG

Measurements

- Heart Rate: 60 - 90 bpm
- PR Interval: 0.12 - 0.20 sec
- QRS Duration: 0.06 - 0.10 sec
- QT Interval ($QT_c \leq 0.40$ sec)

ECG dependency on leads.

- lead II 는 대부분 주된 vector와 평행으로 바라보므로 P,R,T 파가 가장 크고 (+)로 기록되지만 (-)로 기록되는 Q, S 파는 거의 나타나지 않는다.
- Lead I과 aVF: 역시 모든 신호가 (+)로 기록된다. 그러나 주된 vector를 lead II와 같이 주 벡터에 평행한 방향으로 보지 않기 때문에 그 크기는 작다.
- Lead III는 주벡터를 정면으로 바라보기 때문에 QRS파의 크기가 작다. 한편 aVL은 주벡터가 멀어지는 방향이기 때문에 (-)방향의 QRS파가 기록된다.
- Lead III나 aVL에는 P파가 거의 기록되지 않고 T파도 아주 작은 (+)로서 기록된다.
- aVR 유도만이 주된 vector의 진행이 전극으로부터 멀어져가기 때문에 P파 및 T파는 대단히 작은 (-)파로 기록되고, QRS파는 (-)방향으로 대단히 크게 기록된다.
-

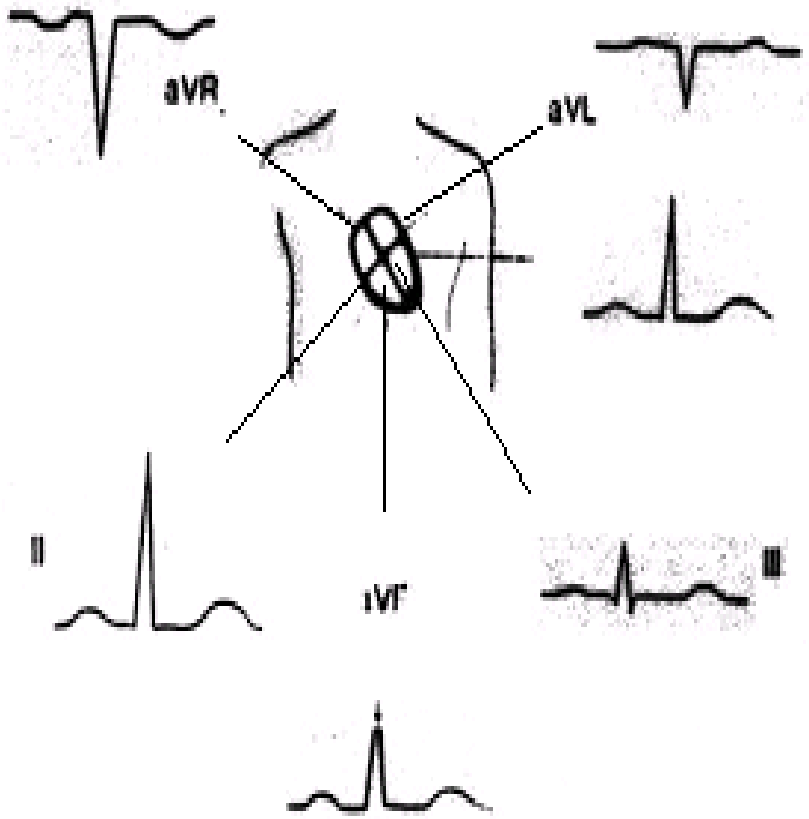
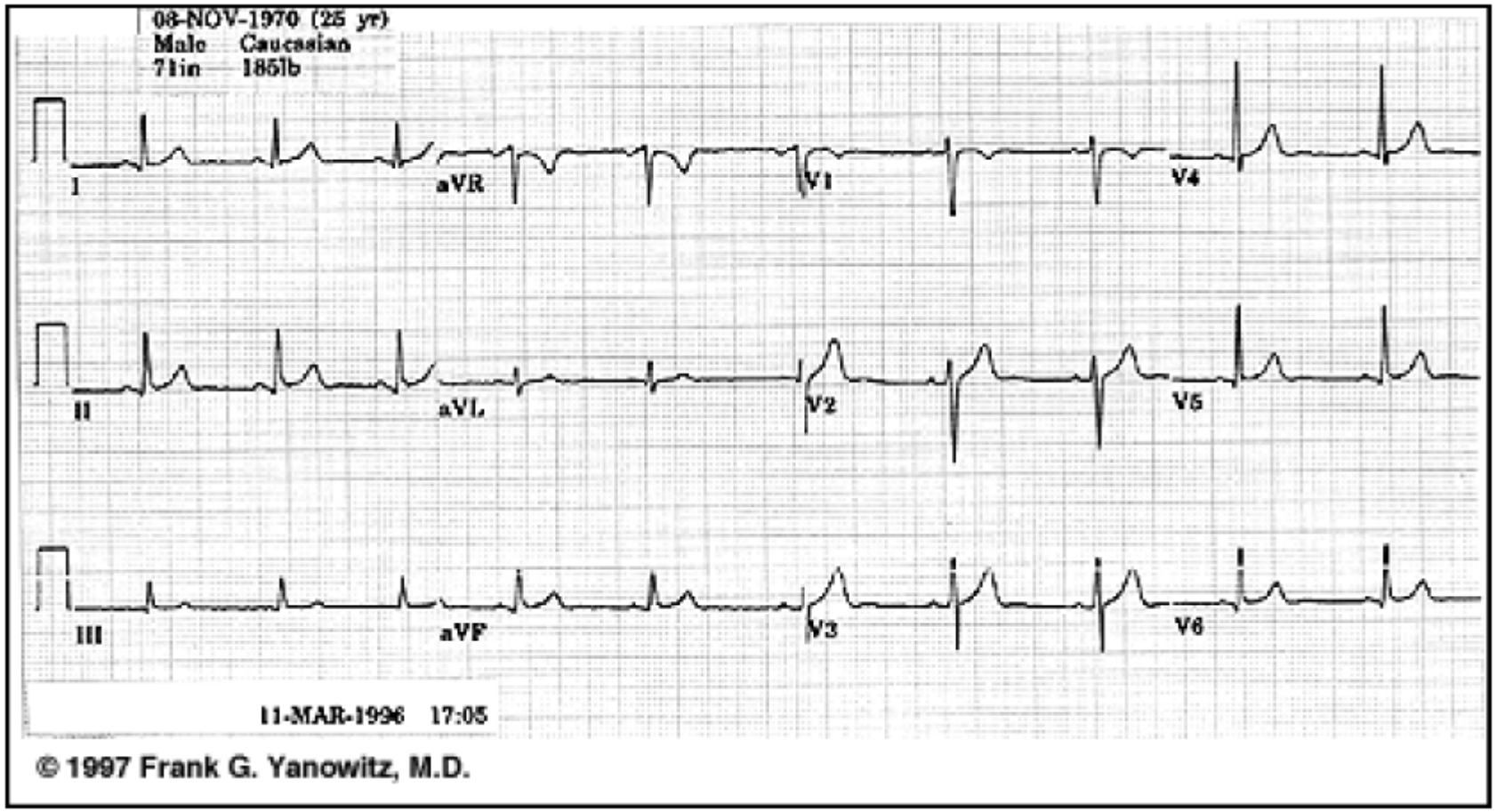
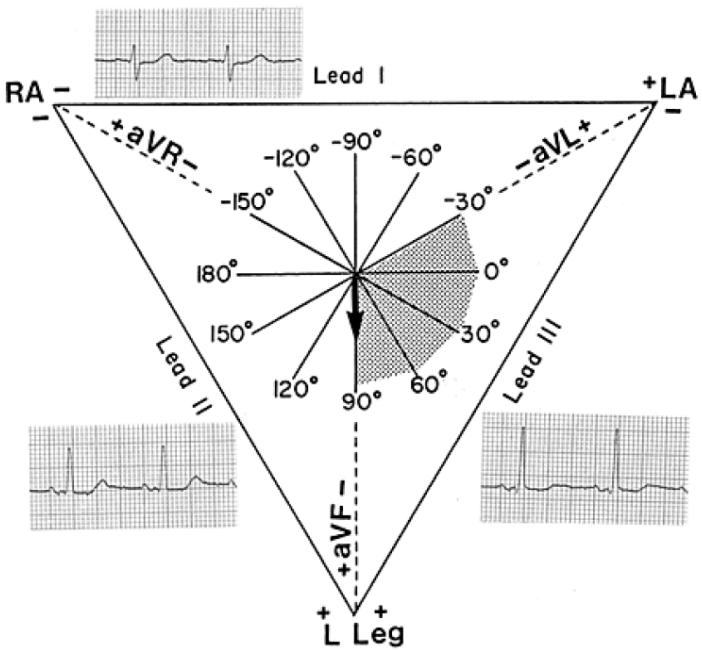


그림 5-20. 표준사지유도와 augmented lead의. 사용된 심전도 부위. 화살표는 심장을 주위면에서 보았을때 나타나는 기동이다.

Normal ECG


08-NOV-1970 (25 yr)
Male Caucasian
71in 185lb
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
11-MAR-1996 17:05
© 1997 Frank G. Yanowitz, M.D.

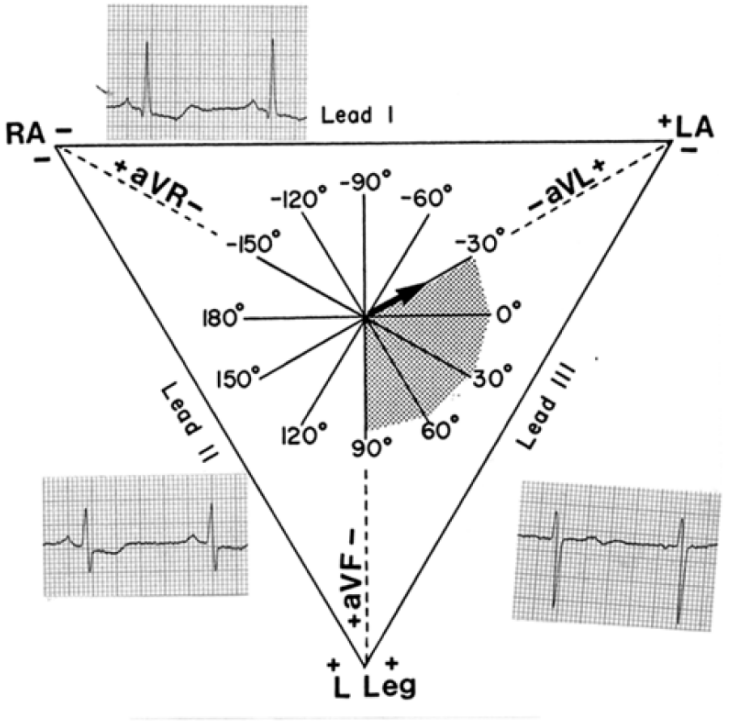
Frontal Plane QRS Axis



QRS Axis = +90 degrees-KH

Frank Yanowitz Copyright 1996

Lead I is isoelectric; II and III are positive; the axis is +90 degrees.



QRS Axis = -30 degrees-KH

Frank Yanowitz Copyright 1996

Lead II is isoelectric; I is positive; III is negative. The axis is -30 degrees.

Normal variability continued

P Wave

It is important to remember that the P wave represents the *sequential*activation of the right and left atria, and it is common to see notched or biphasic P waves of right and left atrial activation.

- P duration < 0.12 sec
- P amplitude < 2.5 mm
- Frontal plane P wave axis: 0º to +75º
- May see notched P waves in frontal plane

QRS Complex

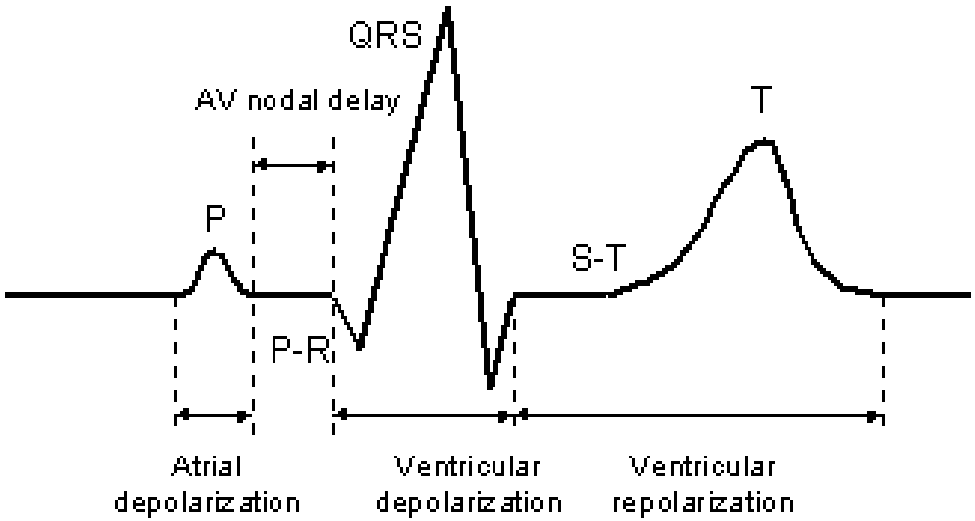
The QRS represents the *simultaneous*activation of the right and left ventricles, although most of the QRS waveform is derived from the larger left ventricular musculature.

- QRS duration ≤ 0.10 sec
- QRS amplitude is quite variable from lead to lead and from person to person. Two determinates of QRS voltages are:
  - Size of the ventricular chambers (i.e., the larger the chamber, the larger the voltage)
  - Proximity of chest electrodes to ventricular chamber (the closer, the larger the voltage)
- Frontal plane leads:
  - The normal QRS axis range (+90 ◦ to -30 ◦); this implies that the QRS be mostly positive (upright) in leads II and I.
  - Normal q-waves reflect normal septal activation (beginning on the LV septum); they are narrow (<0.04s duration) and small (<25% the amplitude of the R wave). They are often seen in leads I and aVL when the QRS axis is to the **left** of +60◦, and in leads II, III, aVF when the QRS axis is to the **right** of +60◦. Septal q waves should not be confused with the pathologic Q waves of myocardial infarction.

For more, see http://library.med.utah.edu/kw/ecg

Diagnosis

이들로부터 알고자 하는 parameter들은 heart output, output under stress, anatomy electrical conductivity, blood pressure, valve leakage 등이 있다.



예를 들어 QRS가 너무 길면 SA→AV bundle fiber의 Conduction에 문제 (bundle block)

Inverted T (repolorization의 문제;심실 첨부에서의 A.P.가 기저부 A.P. 보다 짧음.)

For more Diagnosis of cardiac diseases, see http://library.med.utah.edu/kw/ecg

Fibrillation and Defibrillation

세동(Fibrillation): 정상적으로는 A.P.가 refractory period 내에 돌아와서 또 다른 A.P.를 자극하지 않는데 치사적 부정맥(Arrhythmia)인 경우 심장박동이 증가하면서 refractory period 감소와 전도속도 감소 등으로 심장의 여러부분이 동시에 작동한다. 이를 세동이라 하고 특히 심실세동(Ventricle Fibrillation)은 심장마비(Cardioplegia)를 통한 돌연사(sudden death)를 일으키기 쉽다. 이때 소생술(Resuscitation)은 제세동기(Defibrillator)을 이용하게 된다. Cardiac Arrest (심장마비) (Do not get confused with Heart Attack (심장발작, 경색).)

For BiVentricular Degibrillator Implantation

see from 10 minute point of or-live.com video:

http://www.youtube.com/watch?v=fE13wVvt8Gg

Implantable cardioverter-defibrillator (ICD)

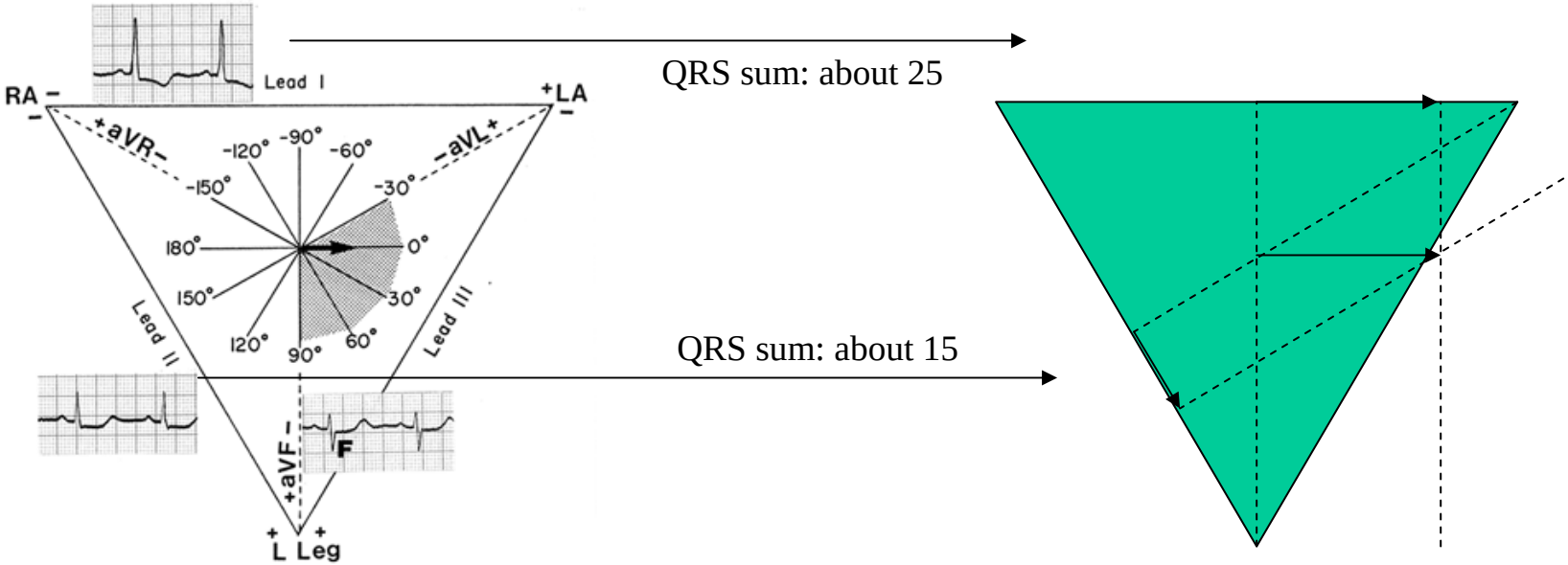
A small battery-powered electrical impulse generator

implanted in patients who are at risk of sudden cardiac death due to ventricular fibrillation.

The device is programmed to detect cardiac arrhythmia and correct it by delivering a jolt of electricity

Defibrillator

- First find the *isoelectric* lead if there is one; i.e., the lead with equal forces in the positive and negative direction. Often this is the lead with the smallest QRS.
- The QRS axis is *perpendicular* to that lead's orientation (see above diagram).
- Since there are two perpendiculars to each isoelectric lead, chose the perpendicular that best fits the direction of the other ECG leads.
- If there is no isoelectric lead, there are usually *two* leads that are nearly isoelectric, and these are always 30◦ apart. Find the perpendiculars for each lead and chose an approximate QRS axis within the 30◦ range.
- Occasionally each of the 6 frontal plane leads is small and/or isoelectric. The axis cannot be determined and is called *indeterminate*. This is a normal variant.



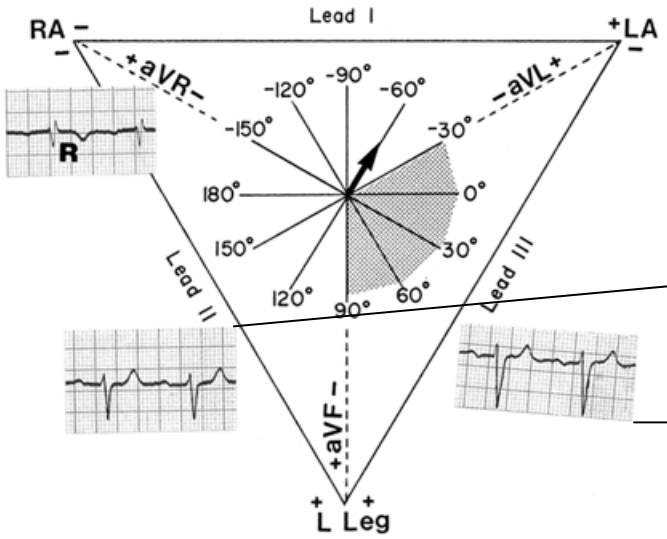
Lead aVF is the isoelectric lead.

The two perpendiculars to aVF are 0 o and 180 o.

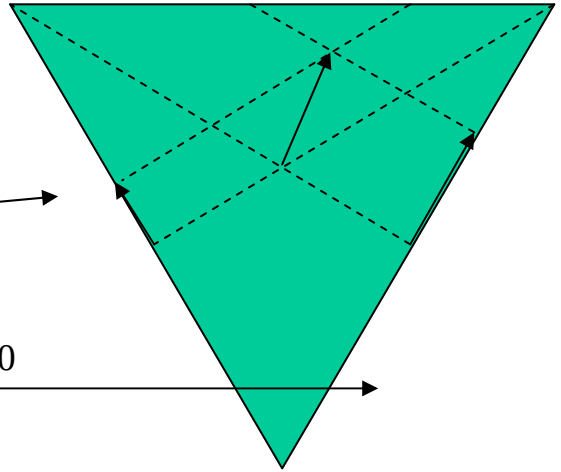
Lead I is positive (i.e., oriented to the left).

Therefore, the axis has to be 0 o.

http://library.med.utah.edu/kw/ecg/ecg_outline/Lesson2/QRS_axis.html

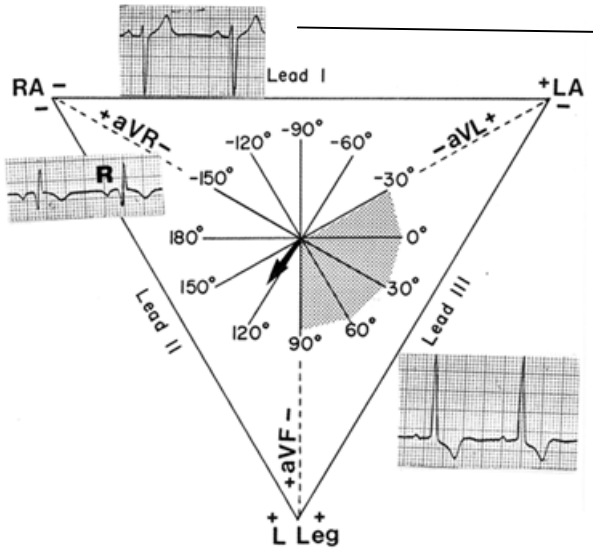


QRS sum: about -10

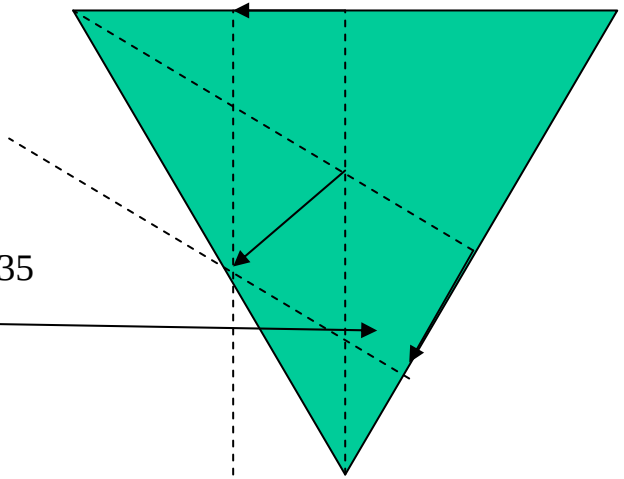


QRS sum: about -20

QRS sum: about -30



QRS sum: about 35



I. Axis Determination: Method 1

A. Check lead I (0 degrees)
   1. QRS positive (predominately up)
      a. Vector points to patient's Left
      b. Correlates with right half of axis circle
   2. QRS negative (predominately down)
      a. Vector points to patient's Right
      b. Correlates with left half of axis circle

B. Check lead aVF (90 degrees)
   1. QRS positive (predominately up)
      a. Vector points to bottom half of axis circle
   2. QRS negative (predominately down)
      a. Vector points to upper half of axis circle

II. Axis Determination: Method 2

A. Select Isoelectric lead from limb and augmented leads
   1. Isoelectric lead averages to baseline
   2. Positive deflection equals negative deflection

B. Identify isoelectric lead on axis circle
C. Choose lead that is perpendicular to isoelectric lead
D. Use Lead I and aVF to determine quadrant
E. Read perpendicular lead's degrees off axis circle