Electrocardiography

Ewha Womans University School of Medicine
Department of Cardiology

Assistant professor, Junbeom Park, M.D.,PhD.
How to record EKG
Precordial Leads (1)

4th intercostal space, both sternal borders

5th intercostal space, mid-clavicular line

Midway between V2 & V4

Same level as V4, anterior axillary line

Same level as V4, mid-axillary line

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Precordial Leads (2)
Front & Horizontal planes

A

Superior

aVR + aVL +
-
-
-
-
-
+
+
+
+
+

Right

Left

Inferior

B

Posterior

Right

Left

Anterior

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EKG paper & waves

Speed = 25 mm/sec
Amplitude = 10 mm/mV

5 mm = 0.2 sec  1 mm = 0.04 sec  25 mm = 1 sec
How to read ECG?
Agenda

• ECG Basics
• How to read ECG
• Normal Sinus Rhythm
• Heart Arrhythmias
Conduction system
ECG wave
ECG wave

- P wave - Atrial depolarization
- QRS - Ventricular depolarization
- T wave – Ventricular repolarization

PR interval
QRS interval
ST segment
QT interval
Intrinsic pacemaker

- SA Node - Dominant pacemaker with an intrinsic rate of 60 - 100 beats/minute.

- AV Node - Back-up pacemaker with an intrinsic rate of 40 - 60 beats/minute.

- Ventricular cells - Back-up pacemaker with an intrinsic rate of 20 - 45 bpm.
ECG Paper

- Horizontally
  - One small box - 0.04 s
  - One large box - 0.20 s

- Vertically
  - One large box - 0.5 mV

ECG 1 장 = 10 sec (calculating the heart rate)
HOW TO READ ECG?
How to read ECG?
ECG analysis

- Calculate rate
- Regularity
- QRS axis
- Assess the P waves (morphology, PR interval)
- Assess the QRS wave (morphology, QRS duration)
- ST segment
- T wave and QT interval
Calculate heart rate

• Count the number of R waves in a 10sec x 6
  → 11~12x6=66~72/min

• 300,150,100,75,60,50...
Regularity

• RR interval (using caliper)
  – Occasionally irregular?
  – Regularly irregular?
  – Irregularly irregular?
QRS axis

Northwest axis deviation

Left axis deviation

Right axis deviation

Normal axis

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QRS axis (normal)
Axis deviation

Left axis deviation

Right axis deviation
P wave

- Are there P waves?
- Regular morphology?
- Regular rate?
- 1:1 of P wave before QRS?
- PR interval? 0.12-0.2 sec (120-200 ms, 3-5 boxes)
• Are there P waves?
• Regular morphology?
• Regular rate?
• QRS duration? 0.04-0.12sec (40-120ms, 1-3boxes)
Normal sinus rhythm

- The diagnosis of the normal ECG is made by excluding any recognized abnormality.
- Rate: 60 - 100 bpm (<10% variation)
- Regularity: regular
- Each P wave is followed by a QRS
- Normal P wave axis = 0° ~ 70°
- PR interval: 0.12 - 0.20 s
- QRS duration: 0.04 - 0.12 s
Normal sinus rhythm

- Normal P waves
  - Height < 2.5 mm in lead II
  - Width < 120 msec in lead II
  - Abnormal P waves: right / left atrial enlargement, atrial premature beat

- Normal PR interval
  - 120 to 200 msec (3~5 small squares)
  - Short PR segment: WPW syndrome
  - Long PR segment: first degree AV block
Normal sinus rhythm

• Normal QRS complex
  – < 120 msec duration (3 small squares)
  – No pathologic Q waves
  – No evidence of left or right ventricular hypertrophy

• Normal QT interval
  – QTc = (QT interval) / (square root of the preceding RR interval)
  – Normal QTc < 460 msec for men, < 480 msec for women
  – Long QT interval:
    – Electrolyte imbalance; hypoK, hypoMg, hypoCa
    – Bradyarrhythmia; sinus bradycardia, AV block
    – LV dysfunction, ventricular hypertrophy
    – Hypothyroidism, cerebrovascular disease
    – Drugs: sotalol, amiodarone, antidepressants, azoles
    – Congenital long QT syndrome
Normal sinus rhythm

- Normal ST segment
  - No elevation or depression
  - Elevation: acute MI, normal variants, acute pericarditis
  - Depression: myocardial ischemia, digoxin effect, ventricular hypertrophy, pulmonary embolism, LBBB
Normal sinus rhythm

• Normal T wave
  – Tall T waves: hyperkalemia, hyperacute MI
  – Inverted T waves: ischemia, age, race, hyperventilation, anxiety, drinking iced water, LVH, drugs (digoxin), pericarditis, pulmonary embolism, intraventricular conduction delay, electrolyte disturbance

• Normal U wave
  – Prominent U wave: Hypokalemia
How to read ECG?
ARRHYTHMIA (BEATS)
F/85 irregular beats
Conducted Premature Atrial Contraction (PAC)

<table>
<thead>
<tr>
<th>Heart Rate</th>
<th>Rhythm</th>
<th>P Wave</th>
<th>PR interval (s)</th>
<th>QRS (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Irregular</td>
<td>Premature &amp; abnormal or hidden</td>
<td>&lt; 0.20</td>
<td>&lt; 0.12</td>
</tr>
</tbody>
</table>

Heart Rate: N/A
Rhythm: Irregular
P Wave: Premature & abnormal or hidden
PR interval: < 0.20
QRS: < 0.12
Nonconducted Premature Atrial contraction (PAC)
Premature ventricular contraction (PVC)
## Premature Ventricular Contraction (PVC)

<table>
<thead>
<tr>
<th>Heart Rate</th>
<th>Rhythm</th>
<th>P Wave</th>
<th>PR interval (s)</th>
<th>QRS (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>irregular</td>
<td>Before each normal QRS, identical</td>
<td>&lt; 0.20</td>
<td>&lt; 0.12 normal beats; &gt; 0.12 on PVCs</td>
</tr>
</tbody>
</table>

### Compensatory pause

![ECG waveform with annotations](image)

- Before each normal QRS, the PVC is identical.
- PR interval < 0.20.
- QRS duration < 0.12 normal beats; > 0.12 on PVCs.