

## ELEKTROCARDIOGRAFI

Oleh : dr. Mustofa

### LEARNING OUTCOME

Mahasiswa mampu melakukan pemeriksaan EKG dan menganalisis hasil rekaman EKG:

1. Mahasiswa mampu memasang elektrode EKG
2. Mahasiswa mampu mengoperasikan EKG
3. Mahasiswa mampu menganalisis rekaman EKG

### TINJAUAN TEORI

Elek  
trok

ardiografi adalah representasi aktivitas listrik jantung yang direkam oleh elektrode pada permukaan tubuh.

#### BENTUK GELOMBANG EKG

##### 1. Gelombang EKG ( EKG wave) dan interval

- a. P wave/ gelombang P : Depolarisasi atrium kanan dan kiri
- b. QRS complex/ kompleks QRS : Depolarisasi ventrikel kanan dan kiri
- c. ST-T wave : Repolarisasi ventrikel
- d. U wave/ gelombang U : asal gelombang ini tidak jelas, tetapi mungkin representasi dari “afterdepolarizations” di ventrikel.
- e. PR interval/ Interval PR : interval waktu dari onset depolarisasi atrium sampai onset depolarisasi ventrikel.
- f. QRS duration/ durasi QRS: durasi depolarisasi otot ventrikel.
- g. QT interval/ interval QT : durasi dari depolarisasi dan repolarisasi ventrikel
- h. RR interval/ interval RR: durasi dari siklus ventrikel jantung( indicator kecepatan ventrikel)
- i. PP interval : durasi dari siklus atrial

##### 2. Orientasi spasial 12 lead EKG

Penting untuk di ingat bahwa EKG 12 lead menyediakan informasi spasial tentang aktivitas listrik jantung dalam sedikitnya 3 daerah ortogonal (RA = right arm; LA = left arm, LF = left foot).

Setiap lead standar representasi orientasi ruang, sebagai mana ditunjukkan di bawah ini:

- Bipolar limb leads (frontal plane):
  - Lead I: RA (-) to LA (+) (Right Left, or lateral)
  - Lead II: RA (-) to LF (+) (Superior Inferior)
  - Lead III: LA (-) to LF (+) (Superior Inferior)
- Augmented unipolar limb leads (frontal plane):
  - Lead aVR: RA (+) to [LA & LF] (-) (Rightward)
  - Lead aVL: LA (+) to [RA & LF] (-) (Leftward)
  - Lead aVF: LF (+) to [RA & LA] (-) (Inferior)
- Unipolar (+) chest leads (horizontal plane):
  - Leads V1, V2, V3: (Posterior Anterior)
  - Leads V4, V5, V6: (Right Left, or lateral)

### **Alat dan bahan**

1. Mesin EKG
2. Jelly
3. Tissue
4. Elektroda

### **PROSEDUR PEMERIKSAAN**

1. P  
ersia

pan alat

Siapkan alat di dekat tempat tidur penderita. hubungkan arder/ground ke lantai atau tempat arder. Nyalakan EKG, cek kaliberasi.

2. Persiapan penderita  
Berikan penjelasan kepada penderita tentang prosedur pemeriksaan. Baringkan penderita pada alas yang rata, tidak berhubungan langsung dengan tanah/ lantai tidak menyentuh logam, orang lain.
3. Pasang elektrode pada kulit penderita yang sebelumnya telah diberi jelly.

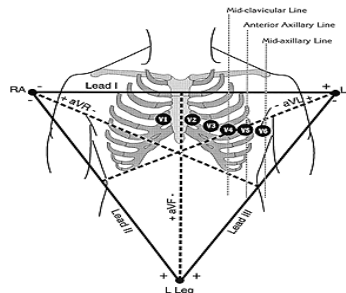
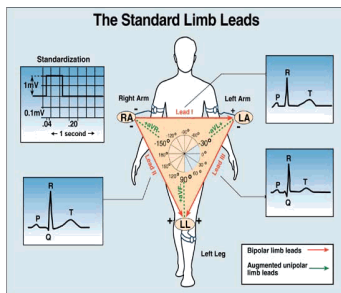
Kabel merah /R	: tangan kanan
Kabel kuning/L	: tangan kiri
Kabel hijau /F	: kaki kiri
Kabel hitam /N	: kaki kanan
Kabel merah /C1	: SIC IV linea sternalis dextra
Kabel kuning/C2	: SIC IV linea sternalis sinistra
Kabel hijau /C3	: SIC V linea mid axillaris sinistra
Kabel coklat /C4	: pertengahan elektrode C2 dan C3
Kabel hitam /C5	: setinggi C4, linea axillaris anterior sinistra
Kabel violet /C6	: setinggi C4, linea axillaris lateral sinistra

4. Lakukan pemeriksaan EKG  
Masing-masing lead minimal 3 gelombang, beri/ buat tanda pemisah masing-masing lead. Tuliskan identitas lengkap, tanggal, dan waktu pemeriksaan. Apabila diperlukan, lead II diperpanjang sampai 10 gelombang.
5. Lepaskan elektroda, rapikan peralatan.
6. Baca dan analisis hasil perekaman EKG

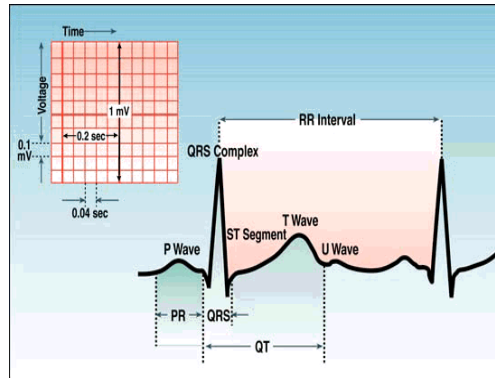
### METODA INTERPRETASI EKG

Metoda ini disarankan ketika membaca semua Lead EKG dari 12 lead standar. Seperti pemeriksaan fisik, sangat dianjurkan mengikuti urutan langkah-langkah untuk menghindari kelainan jantung yang terlewat ketika membaca EKG, yang mungkin mempunyai arti klinis penting. Enam bagian utama yang harus dipertimbangkan adalah:

1. Pengukuran
2. Analisis irama
3. Analisis konduksi jantung
4. Deskripsi bentuk gelombang
5. Interpretasi ekg
6. Perbandingan dengan hasil perekaman EKG terdahulu

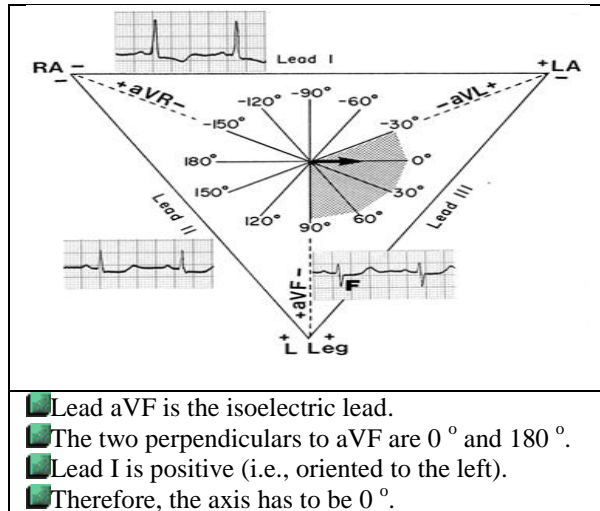


1. **Pengukuran**  
Biasanya dibuat pada Lead frontal



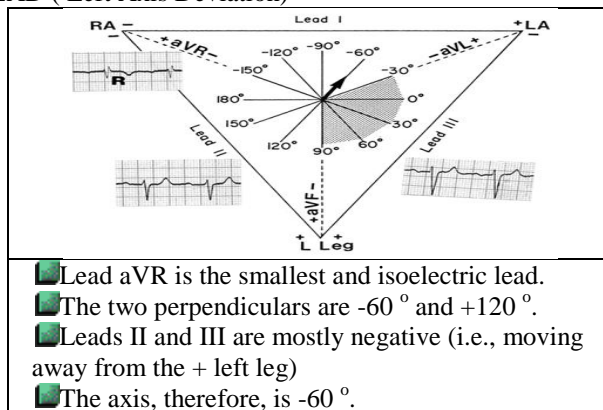
- Heart Rate (HR) : (nyatakan atrium dan ventrikel bila keduanya mempunyai frekuensi yang berbeda)
- Interval PR : dari awal gelombang P hingga awal kompleks QRS
- Durasi QRS kompleks : (width of most representative QRS)
- Interval QT : dari awal kompleks QRS hingga akhir gelombang T
- Aksis QRS kompleks pada Lead Frontal
  - 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  $30^{\circ}$  apart. Find the perpendiculars for each lead and chose an approximate QRS axis within the  $30^{\circ}$  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

**Contoh axis normal:**

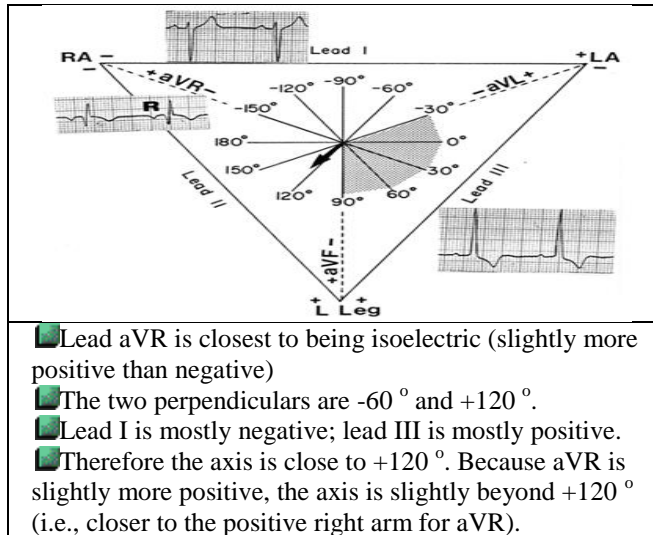


**Kelainan axis:**

1. LAD ( Left Axis Deviation)



2. RAD ( Right Axis Deviation)



## 2. Analisis irama

- Irama dasar (seperti: "normal sinus rhythm", "atrial fibrillation", dan lain-lain)
- Identifikasi irama tambahan bila ada (seperti: "PVC's", "PAC's", dan lain-lain)
- Pertimbangkan asal irama, dari atrium, AV junction, ventrikel.

## 3. Analisis konduksi

Konduksi normal berarti konduksi SA node, AV node, interventrikular.

- Identifikasi abnormalitas konduksi berikut ini:
  - SA block: 2nd degree (type I vs. type II)
  - AV block: 1st, 2nd (type I vs. type II), and 3rd degree
  - IV block: bundle branch, fascicular, and nonspecific blocks
  - Exit blocks: blocks just distal to ectopic pacemaker site

## 4. Diskripsi bentuk gelombang

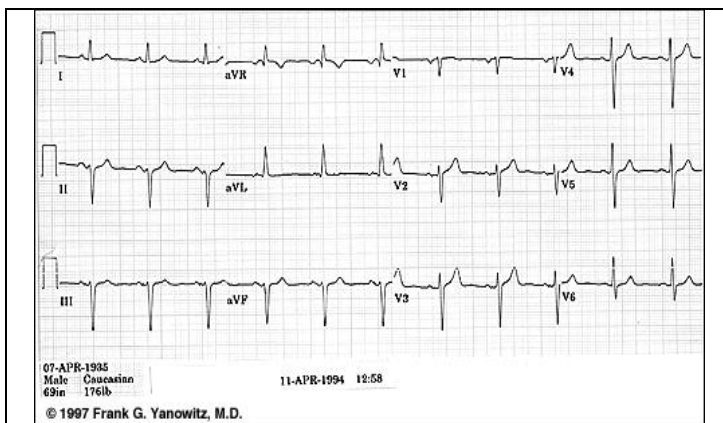
Analisis secara hati-hati kelainan bentuk gelombang EKG yang mungkin pada semua lead standar: gelombang P (P-wave), QRS complex, ST segment, T wave, U wave.

- P wave : apakah terlalu lebar, terlalu tinggi, bentuk yang aneh, ektopik, dan lain-lain.
- QRS complex : carilah gelombang Q patologis
- ST segment : carilah elevasi, depresi segmen ST abnormal
- T wave : carilah Inverted T wave abnormal
- U wave : carilah prominent atau inverted U waves

## 5. Interpretasi EKG

Ini merupakan kesimpulan dari analisis di atas. Interpretasikanlah sebagai "Normal", or "Abnormal". Biasanya istilah "borderline" digunakan bila ditemukan kelainan yang tidak signifikan. Cantumkan semua abnormalitas yang ditemukan, seperti:

- Miocard Infark (MI) inferior, kemungkinan akut
- Old anteroseptal MI
- Left anterior fascicular block (LAFB)
- Left ventricular hypertrophy (LVH)
- Nonspecific ST-T wave abnormalities
- Abnormalitas irama yang lain, seperti:



### Left Anterior Fascicular Block (LAFB)-KH

Frank G. Yanowitz, M.D.

HR=72bpm; PR=0.16s; QRS=0.09s; QT=0.36s; QRS axis =  $-70^{\circ}$  (left axis deviation). Normal sinus rhythm; normal SA and AV conduction; rS in leads II, III, aVF.

Interpretation: Abnormal ECG: 1) Left anterior fascicular block

## 6. Perbandingan dengan hasil perekaman EKG terdahulu

bila ada hasil rekaman EKG terdahulu penderita, EKG sekarang sebaiknya dibandingkan untuk melihat apakah ada perubahan yang signifikan. Perubahan ini mungkin mempunyai dampak penting dalam pengambilan keputusan klinis.

 **KARAKTERISTIK EKG NORMAL**

Penti  
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at bahwa ada variasi normal yang luas pada lead standar. Perlu pengalaman .  
Berikut karakteristik EKG normal, (meskipun tidak absolute):

Topiks :

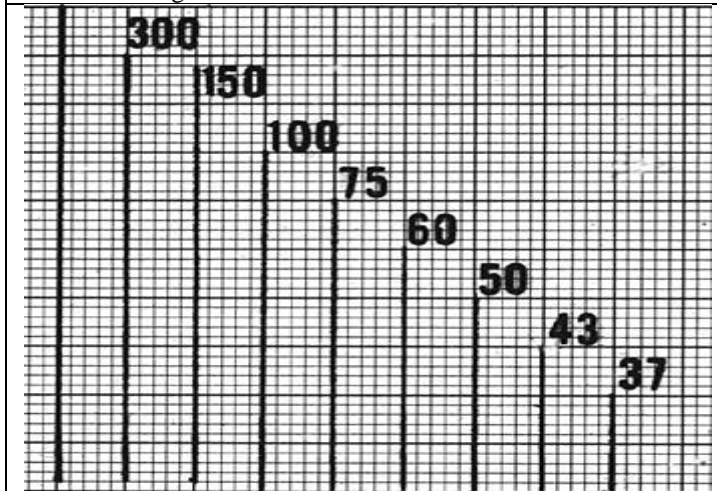
1. Pengukuran
2. Irama
3. Konduksi jantung
4. Deskripsi bentuk gelombang

**1. Pengukuran**

Heart Rate: 60 - 90 x per menit

Because ECG paper moves at a standardized 25mm/sec, the vertical lines can be used to measure time. There is a 0.20 sec between 2 of the large lines. Therefore, if you count the number of heart beats (QRS complexes) in between 30 large boxes (6 seconds) and multiply by 10, you have beats per minute. Conveniently, ECG paper usually has special markings every 3 seconds so you don't have to count 30 large boxes.

There is, however, an easier and quicker way to estimate the heart rate. As seen in the diagram below, when QRS complexes are 1 box apart the rate is 300 bpm. 2 boxes apart...150 bpm, etc. So if you memorize these simple numbers you can estimate the heart rate at a glance!



PR Interval : 0.12 - 0.20 sec  
QRS Duration : 0.06 - 0.10 sec  
QT Interval (QTc < 0.40 sec)



- Bazett's Formula :  $QTc = (QT) / \sqrt{RR}$  (in seconds)
- Poor Man's Guide to upper limits of QT: For HR = 70 bpm, QT < 0.40 sec; for every 10 bpm increase above 70 subtract 0.02 sec, and for every 10 bpm decrease below 70 add 0.02 sec. For example:

QT < 0.38 @ 80 bpm

QT < 0.42 @ 60 bpm

Frontal Plane QRS Axis: +90° to -30° (in the adult)

## 2. Rhythm/ Irama:

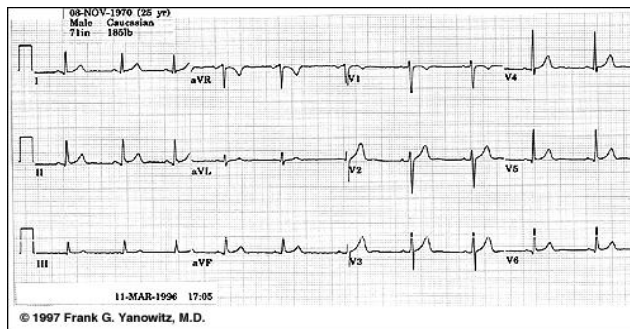
Normal sinus rhythm, Gelombang P di lead I dan II harus *upright* (*positive*), jika irama berasal dari *sinus node*.

## 3. Konduksi:

Normal Sino-atrial (SA), Atrio-ventricular (AV), and Intraventricular (IV. *Conduction*, bila kedua PR interval dan QRS *duration* berada dalam range di atas.

## 4. Diskripsi bentuk gelombang:

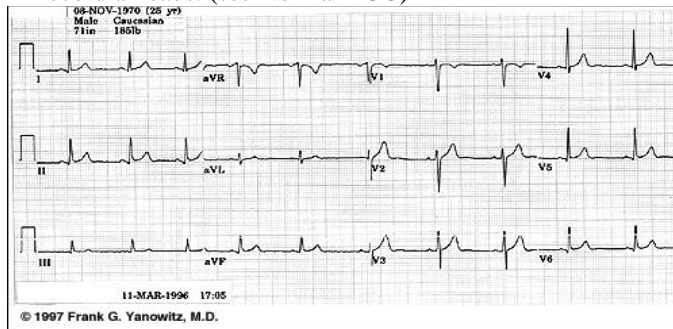
EKG normal ditunjukkan di bawah ini, bandingkan dengan diskripsi selanjutnya.



- P Wave
  - Penting diingat bahwa P wave merupakan representasi aktifitas atrium dekstra dan sinistra, dan sering terlihat *notch* atau *biphasic P waves*
    - P duration < 0.12 sec
    - P amplitude < 2.5 mm
    - Frontal plane P wave axis: 0° to +75°
    - May see notched P waves in frontal plane
- QRS Complex

Merupakan representasi aktivitas depolarisasi ventrikel dekstra dan sinistra.

- QRS duration  $< 0.10$  sec
- QRS *amplitude* berbeda pada tiap lead, pada tiap individu. Dua *determinan* dari tegangan QRS adalah:
  - Ukuran ventrikel, semakin besar ventrikel, semakin besar tegangan.
  - Jarak electrode dari ventrikel, semakin dekat, semakin besar tegangan.
- Frontal plane leads:
  - Range *QRS axis* normal ( $+90^{\circ}$  to  $-30^{\circ}$ ); ini berarti QRS kompleks *positive (upright)* di leads II dan 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  $+60^{\circ}$ , and in leads II, III, aVF when the QRS axis is to the right of  $+60^{\circ}$ . Septal q waves should not be confused with the pathologic Q waves of myocardial infarction.*
- Precordial leads: (see Normal ECG)



### Normal ECG

Frank G. Yanowitz, M.D., copyright 1997

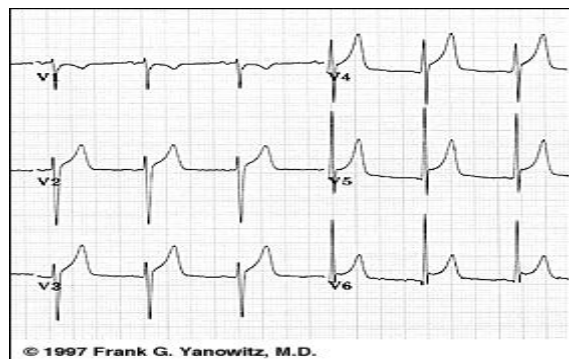
- Small r-waves begin in V1 or V2 and progress in size to V5. The R-V6 is usually smaller than R-V5.
- In reverse, the s-waves begin in V6 or V5 and progress in size to V2. S-V1 is usually smaller than S-V2.
- The usual transition from  $S > R$  in the right precordial leads to  $R > S$  in the left precordial leads is V3 or V4.
- Small "septal" q-waves may be seen in leads V5 and V6.

- ST Segment dan T wave

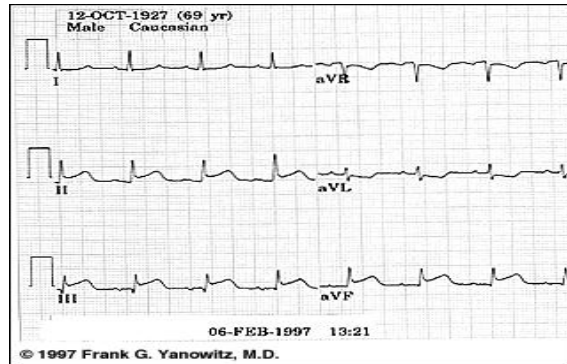
*In a sense, the term "ST segment" is a misnomer, because a discrete ST segment distinct from the T wave is usually absent. More often the ST-T wave is a smooth, continuous waveform beginning with the J-point (end of QRS), slowly rising to the peak of the T and followed by a rapid descent to the isoelectric baseline or the onset of the U wave. This gives rise to an asymmetrical T wave. In some normal individuals, particularly women, the T wave is symmetrical and a distinct, horizontal ST segment is present.*

*The normal T wave is usually in the same direction as the QRS except in the right precordial leads. In the normal ECG the T wave is always upright in leads I, II, V3-6, and always inverted in lead aVR.*

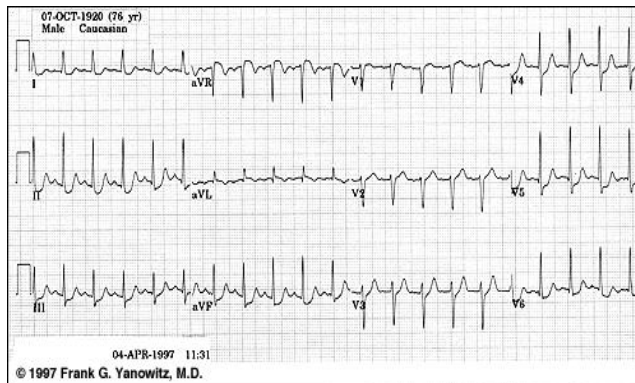
- *Normal ST segment elevation: this occurs in leads with large S waves (e.g., V1-3), and the normal configuration is concave upward. ST segment elevation with concave upward appearance may also be seen in other leads; this is often called early repolarization, although it's a term with little physiologic meaning (see example of "early repolarization" in leads V4-6):*



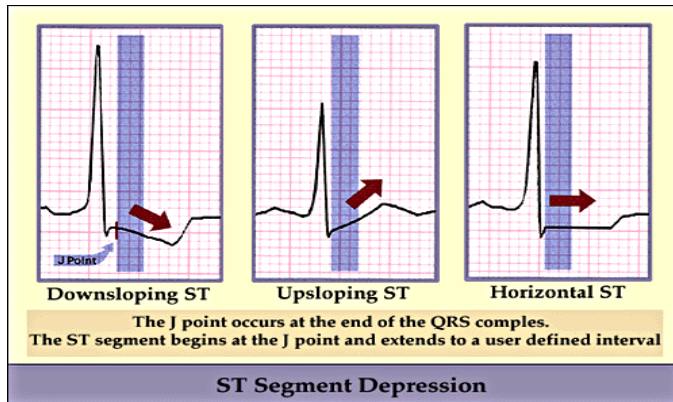
- *Convex or straight upward ST segment elevation (e.g., leads II, III, aVF) is abnormal and suggests transmural injury or infarction:*



- *ST segment depression is always an abnormal finding, although often nonspecific (see ECG below):*



- *ST segment depression is often characterized as "upsloping", "horizontal", or "downsloping".*



- The normal U Wave: (the most neglected of the ECG waveforms)
  - U wave amplitude is usually  $< 1/3$  T wave amplitude in same lead
  - U wave direction is the same as T wave direction in that lead
  - U waves are more prominent at slow heart rates and usually best seen in the right precordial leads.
  - Origin of the U wave is thought to be related to afterdepolarizations which interrupt or follow repolarization.

### Laporan Hasil Rekaman pengukuran

Heart Rate (HR) 60 - 90 x per : Kali per menit  
 menit

Interval PR 0.12 - 0.20 sec : Detik

Durasi QRS kompleks 0.06 - 0.10 : Detik  
 sec

Interval QT (QTc  $< 0.40$  sec) : Detik

Aksis QRS kompleks : °

P wave

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

ST segment

Isoelektrik  
 Elevasi  
 Depresi  
*"upsloping",*

*"horizontal",  
"downsloping"*

T wave

U wave

**Irama:**

- Irama dasar :
- Irama tambahan bila :
- Asal irama :

**Abnormalitas konduksi :**

Interpretasi :

### PENILAIAN MONITORING EKG

Nama :  
 Nim :

NO	KETERANGAN	SCORE		
		0	1	2
1	Persiapan alat			
2	Cek kaliberasi			
3	Persiapan penderita			
4	Oleskan jelly pada tempat pemasangan elektroda			
5	Pasang elektrode pada kulit extremitas			
6	Pasang elektrode precordial*			
7	Melakukan perekaman lead I, II, III, aVR, aVL, aVF			
8	Melakukan perekaman lead V1, V2, V3, V4, V5, V6			
9	Menulis identitas penderita, waktu perekaman pada elektrokardiogram			
10	Memberikan tanda pemisah pada tiap lead			
11	Lepaskan eletroda, rapikan peralatan.			
12	Baca dan analisis hasil perekaman EKG			
	<b>TOTAL</b>			

**KETERANGAN**

Score 0 : bila tidak dikerjakan

Score1 : bila dikerjakan, tetapi tidak sempurna

Score 2 : bila dikerjakan dengan sempurna

Nilai = skor total/24 X 100%

Purwokerto,  
 Penguji,

2005

(.....)