Szombath D.–Tornóci L.: EKG workbook
Practical illustrations (P pages)

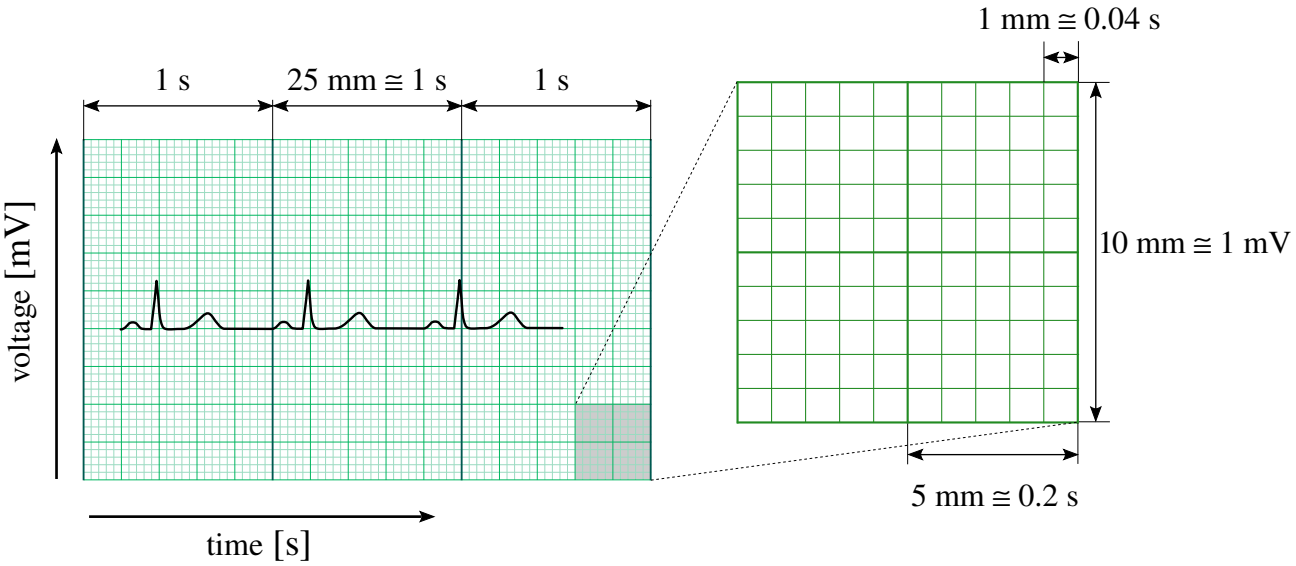
September 19, 2006.

This study aid has been prepared for classroom projection and not for printing. If you need a paper copy, you can by the one published by Semmelweis Kiadó. The quality of this is far superior than what you can get by printing it yourself.

Click on the selected item in the contents to get to the ECG you want.
You can get back to the contents page by clicking on the page number.

Contents

The ECG paper



Gain (standardization)

Usual setting: 10 mm/1 mV

One 1×1 mm small square ≅ 0.1 mV

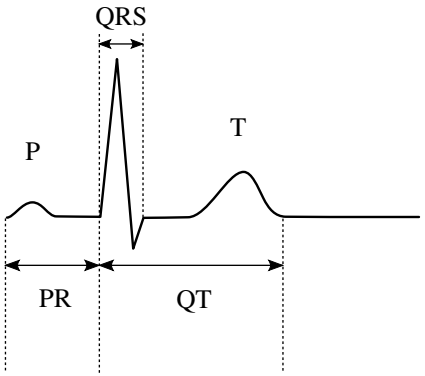
Chart speed

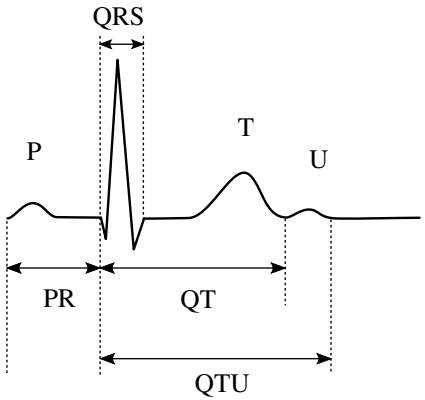
Usual setting: 25 mm/s

The thick vertical lines are 1 s apart.
One 1×1mm small square ≅ 0.04 s = 40 ms
One 5×5 mm large square ≅ 0.2 s = 200 ms

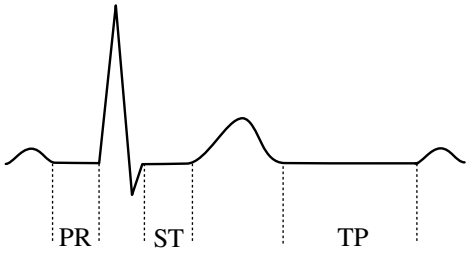
Other chart speeds: 50 mm/s (eg. in pediatric cardiology), sometimes 100 mm/s

Important intervals





INTERVALS



SEGMENTS

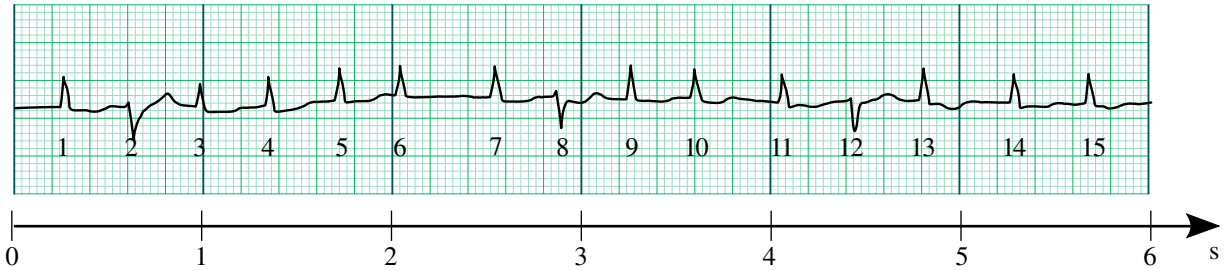
Interval	*Definition*	*Biological meaning*	*Normal value*
PR	from the beginning of the P wave to the beginning of Q (if missing, the R)	atrioventricular conduction time	0.12–0.20 s
QRS	from the beginning of the Q wave (if missing, the R) to the end of S (if missing, the R) wave	the duration of ventricular depolarization	< 0.11 s
QT	from the beginning of the Q wave (if missing, the R) to the end of T wave	the duration of electric activation of the ventricles “electric systole”	frequency dependent QTc < 0.44 s

corrected QT:
$QTc = QT / \sqrt{RR}$
(RR in s)

Determination of heart rate

1. Determination of mean frequency

Advantage: can be used when the heartbeat is irregular
Disadvantage: precise only if a long tracing is available



15 QRS : 6 s = x : 60 s

⇓

x = 150/min

2. Determination of constant frequency

Advantage: long tracing is not necessary
Disadvantage: can be used only if the heartbeat is regular

f = 60 / RR [s]

⇓

f = 300 / RR [□]

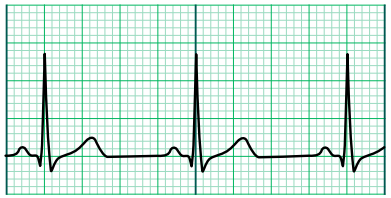
f = 1500 / RR [▫]

calculation

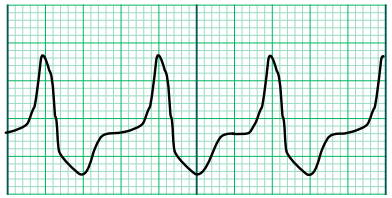
⇒

RR [□]	f
1	300
2	150
3	100
4	75
5	60
6	50

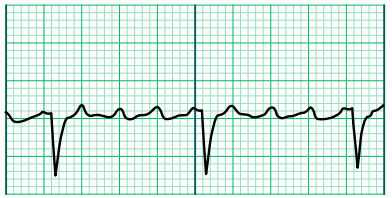
estimation



f = 75/min

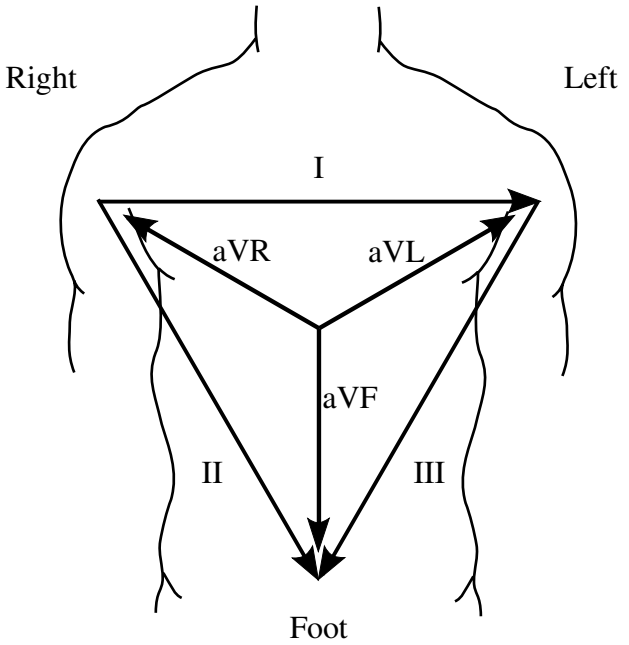


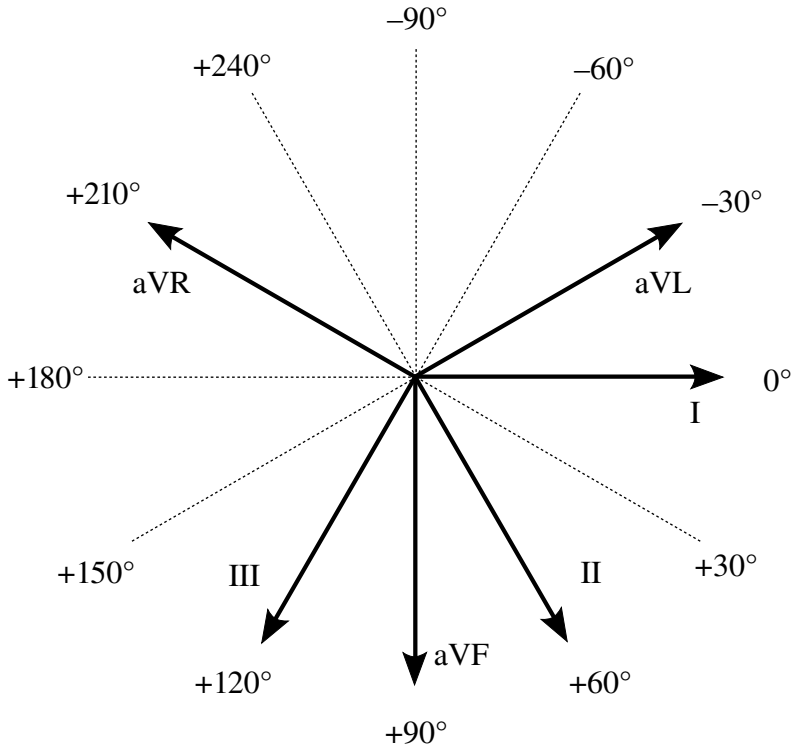
f = 100/min



atrial freq. = 300/min
ventricular freq. = 75/min

The hexaaxial reference system



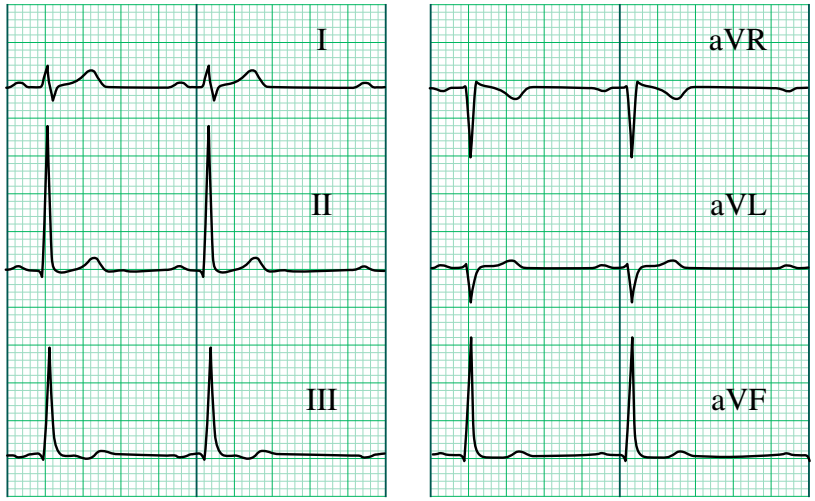


An axis can be assigned to every one of the frontal leads in a natural way

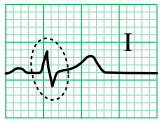
Drawing these axes from a single starting point creates the **hexaaxial reference system**

The mean QRS axis #1

ESTIMATION *(to be used if the QRS is narrow)*

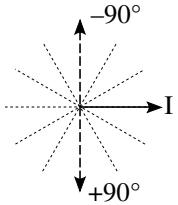


1. Let's select the equiphasic one from the 6 frontal leads:



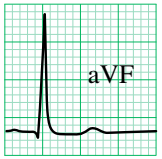
this time it is lead I

So the mean axis is perpendicular to the axis of lead I. There are two possible directions: +90° and –90°.

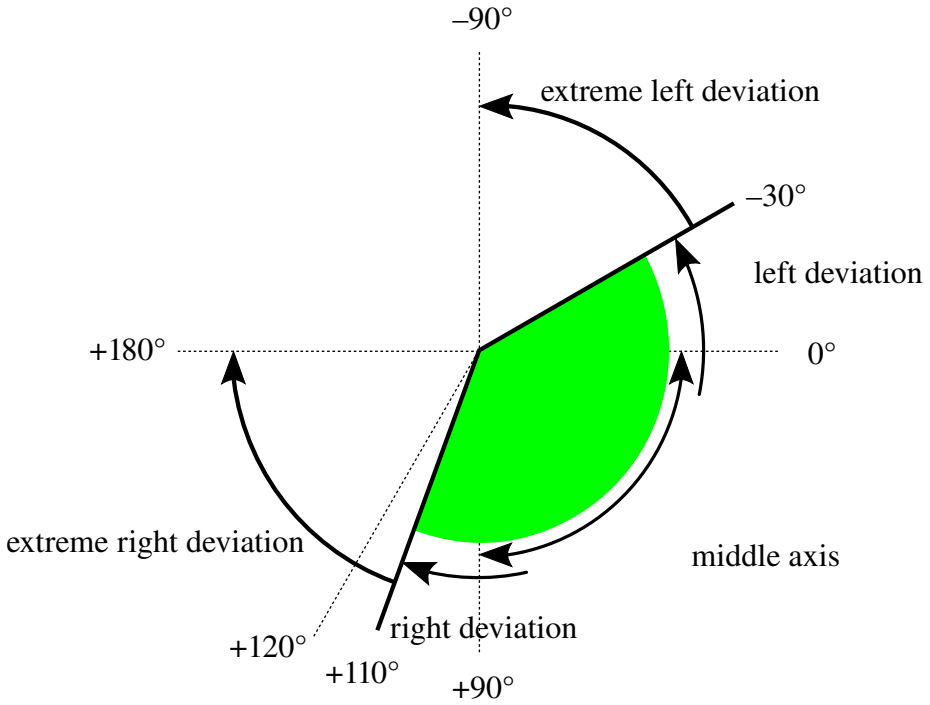


2. Let's select the real one from the two possibilities:

The axis of lead aVF lies parallell to the possible direction of the mean axis. Since QRS is strongly positive here, the –90° solution is not good, so the true axis is: +90°.



INTERPRETATION



Synonyms

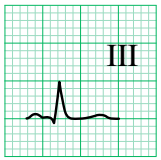
extreme deviation = pathological deviation
right deviation = vertical position
left deviation = horizontal position

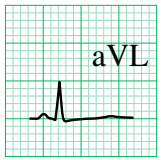
The mean QRS axis #2

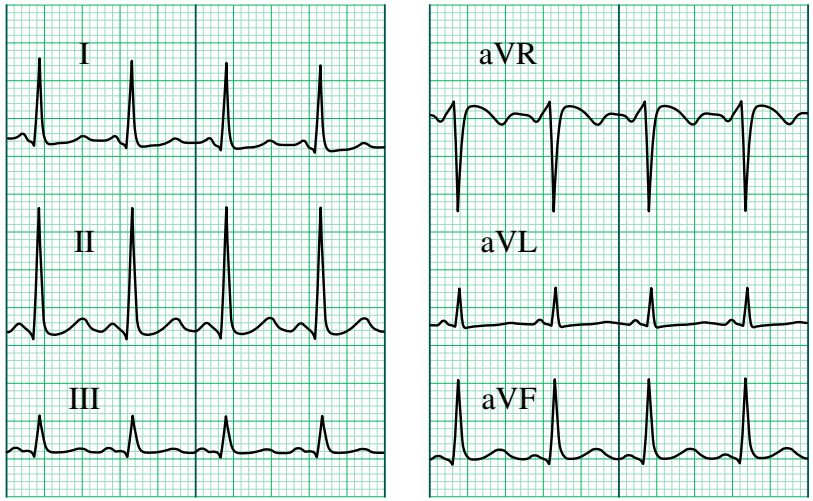
ESTIMATION, IF THERE IS NO EQUIPHASIC LEAD

1. Let us select the lead from the 6 frontal ones which differs the least from being equiphasic. This may be ambiguous.

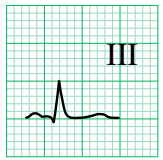
   In this case, for example we can choose two leads: III and aVL:

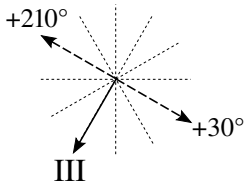
case A 

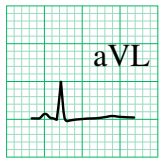
case B 

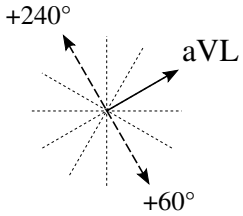


The two possible solutions:

case A 



case B 

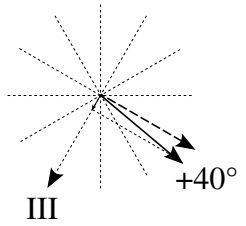


2. Let us choose the real solution from the two:

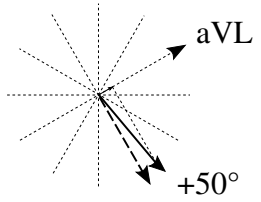
   +30º, because the QRS is positive in lead I

   +60º, because the QRS is positive in lead II

3. We need to modify the solution by cca. 10° in the proper direction, since the lead we originally selected is not really equiphasic.

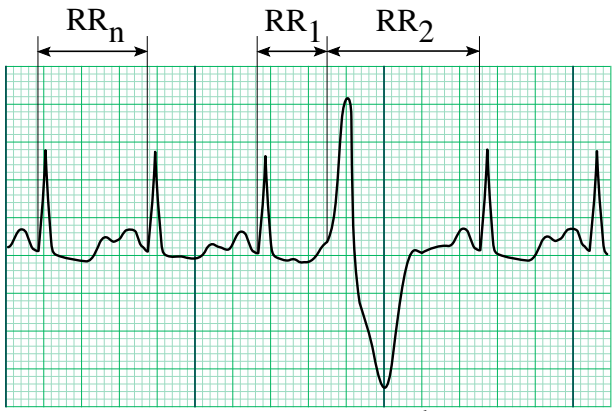


the final estimation is +40º instead of +30º, so the projection onto lead III becomes positive



the final estimation is +50º instead of +60º, so the projection onto aVL becomes positive

Time relations of premature contractions



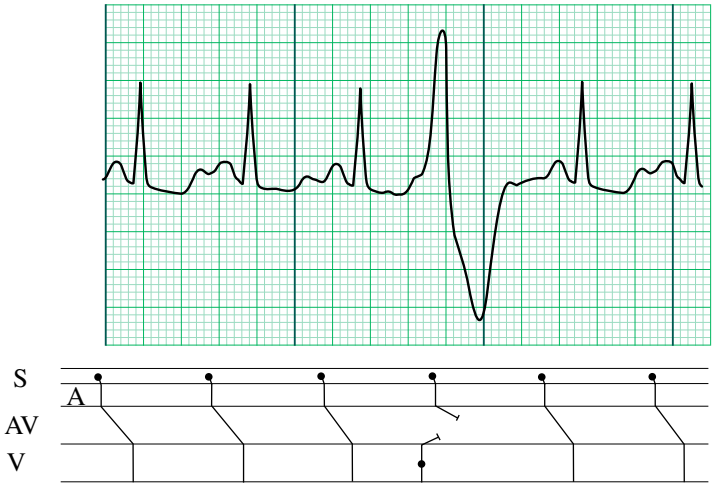
extrasystole

RR$_n$: normal time period

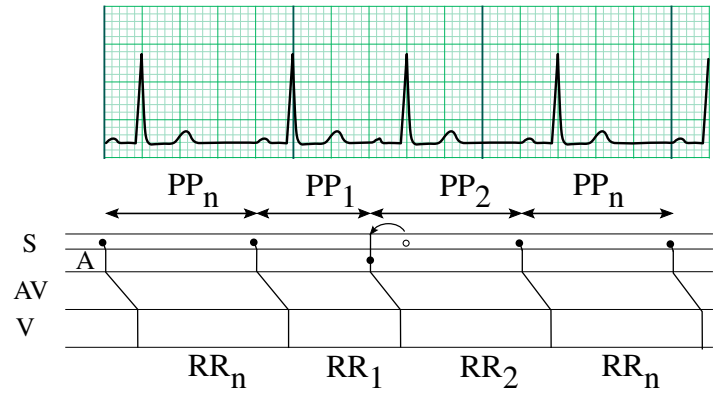
RR$_1$: coupling time

RR$_2$: compensatory pause

If:	then the extrasystole is:
RR$_1$ + RR$_2$ < 2RR$_n$	undercompensated
RR$_1$ + RR$_2$ = 2RR$_n$	compensated (totally compensated)
RR$_1$ + RR$_2$ > 2RR$_n$	overcompensated
RR$_1$ + RR$_2$ = RR$_n$	interpolated



Ventricular premature contractions are usually compensated.



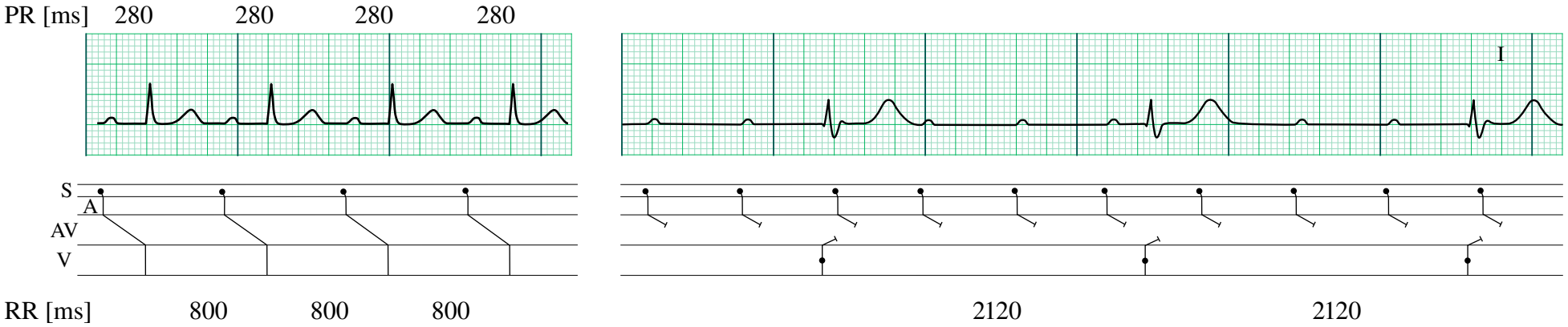
PP$_1$ < PP$_n$, PP$_2$ ≈ PP$_n$, RR$_1$ + RR$_2$ = PP$_1$ + PP$_2$

Supraventricular premature contractions are usually undercompensated.

Classification of AV blocks

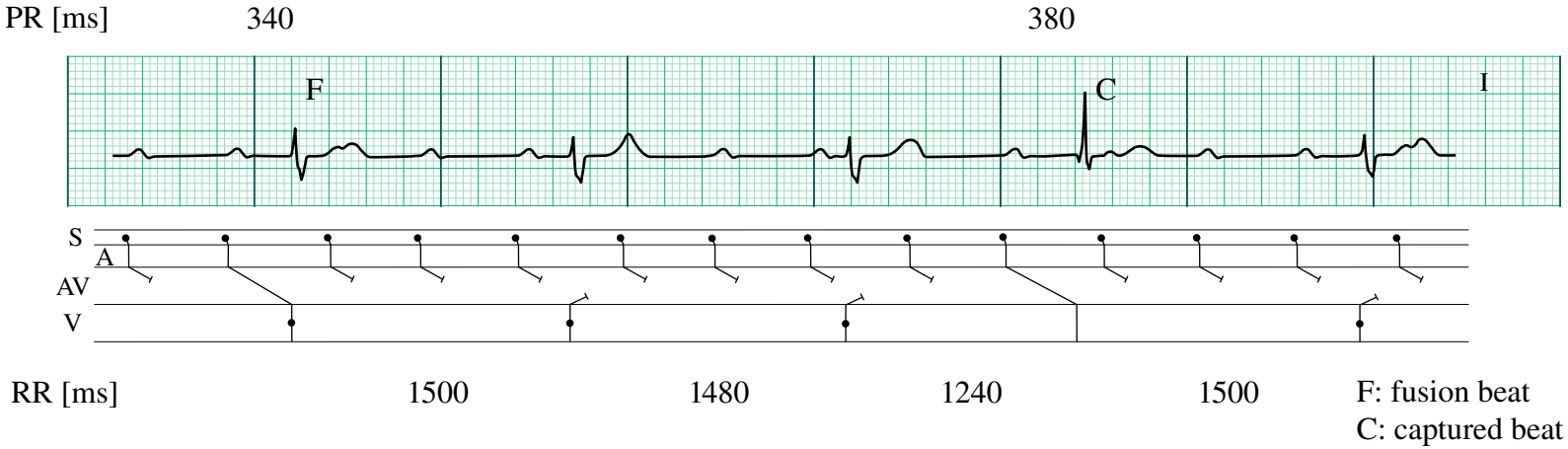
Severity		*Definition*	*Note*	*Pacemaker needed*
First degree		every P wave gets conducted, but slowly (PR interval is prolonged)	RR = PP, the heart rate does not change	no
Second degree		certain P waves get blocked, but the subsequent one always gets conducted	frequently occurs in cycles	no
	Mobitz I	PR intervals progressively lengthen within the cycles	it is usually temporary and proximal so it has good prognosis	no
	2:1 block	only every other P wave gets conducted	needs to be determined if it is proximal or distal	yes/no
	Mobitz II	PR intervals are constant within the cycles	usually it gets worse/is distal so it has bad prognosis	yes
High grade		consecutive P waves get blocked, but conduction still occurs sometimes	it can be differentiated from a total block by identifying captures and fusion beats	yes
Third degree (total)		none of the P waves gets conducted	can be survived only if an escape rhythm starts; the atria and the ventricles function independently in this case	yes

First degree, high grade and total AV blocks



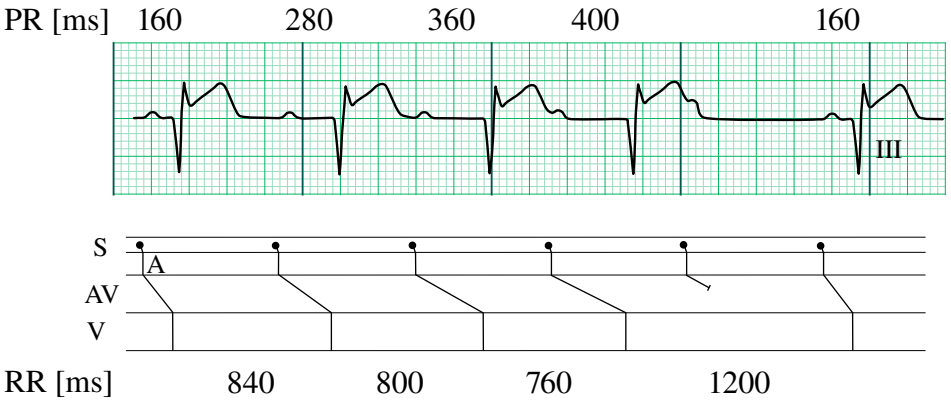
FIRST DEGREE BLOCK

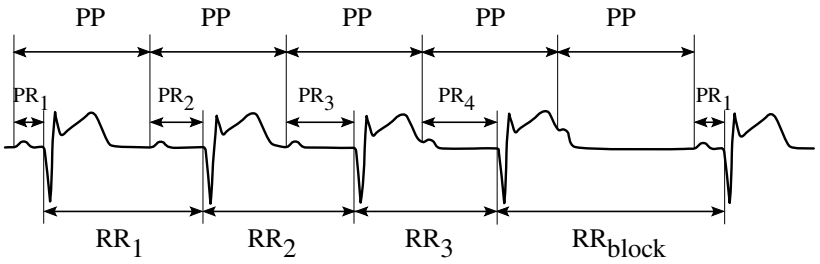
TOTAL (THIRD DEGREE) BLOCK



HIGH GRADE BLOCK

Second degree AV block, Wenckebach (Mobitz I) type





1. The AV conduction time (PR interval) gets progressively longer, then one P wave does not get conducted. This phenomenon is repeated in cycles. This ECG strip shows one cycle with a 5:4 conduction ratio, and the first member of the next cycle.

2. The RR intervals progressively shorten within the cycles in a typical case.

3. The RR interval between cycles (containing the blocked P wave) is longer than the PP, but shorter then 2PP (or twice any of the RRs within the cycle).

Requirements: PP constant, $PR_1 < PR_2 < PR_3 < PR_4$

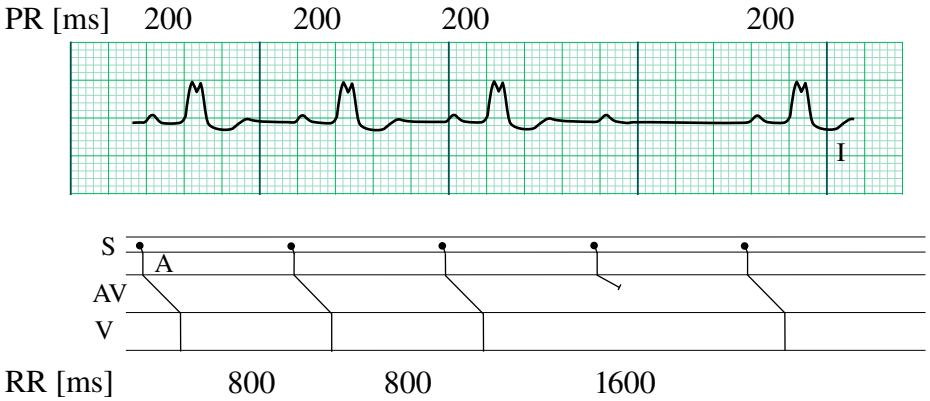
$RR_1 = PP + PR_2 - PR_1$
$RR_2 = PP + PR_3 - PR_2$
$RR_3 = PP + PR_4 - PR_3$

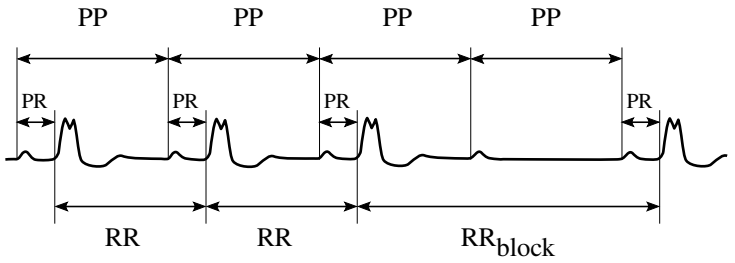
The increment of consecutive PR intervals is decreasing in a typical case:
$PR_2–PR_1 > PR_3–PR_2 > PR_4–PR_3$

So: $RR_1 > RR_2 > RR_3$

$RR_{block} > PP + PR_1 > PP$
$RR_{block} = 2PP + PR_1 - PR_4 < 2PP$

Second degree AV block, Mobitz II type





1. The AV conduction time (PR interval) is constant (it may be normal or prolonged), but one of the P waves does not get conducted. This may be repeated in cycles. The ECG strip shows a cycle with a 4:3 conduction ratio and the first member of the next cycle.

Requirements: constant PP and PR

2. The RR intervals within the cycles are constant (unless there is sinus arrhythmia).

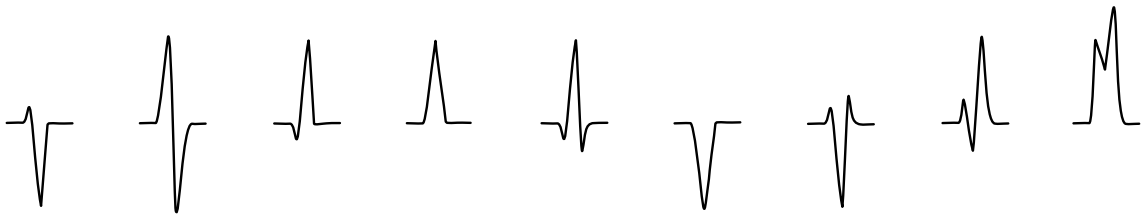
RR = PP

3. The RR interval between cycles (containing the blocked P wave) is twice the length of the PP and the other RR intervals.

$RR_{block} = 2PP$

Description of the QRS complex. The intrinsicoid deflection (ID)

The QRS COMPLEX



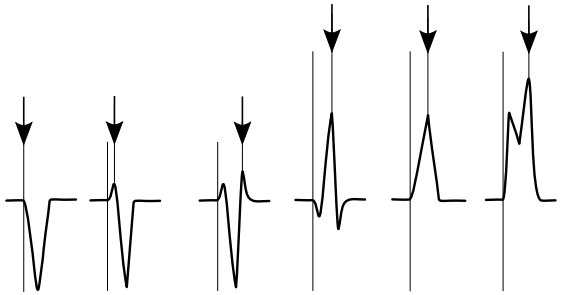
rS RS qR R qRs QS rSr' rsR' RR'

slurred R wave notched R wave

The rSr', rsR' RR' etc. forms are also called an M complex. (Pronounciation of rSr': r S r prime.)

The INTRINSICOID DEFLECTION (ID)

The ID can be defined only in the chest leads!
The ID point is the point where the QRS turns downwards the last time (shown with arrows).
The ID time is the time interval between the beginning of the QRS and the ID point.



The ID time measures the time it takes for the ventricular depolarization to reach the area of the heart under the particular chest lead electrode. Determination of the ID time is useful to diagnose a bundle branch block or ventricular hypertrophy.

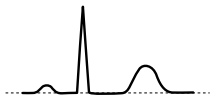
Normally:

right side leads (V_1 , V_2) ID < 40 ms

left side leads (V_5 , V_6) ID < 60 ms

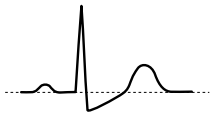
Description of repolarization abnormalitites

ST SEGMENT

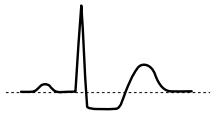


Normally, the ST segment is isoelecric.

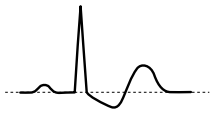
ST depression (depressed ST)



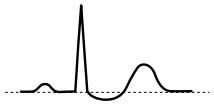
ascending



horizontal

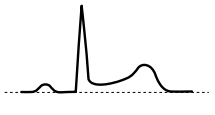


descending

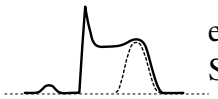


scooped

ST elevation (elevated ST)



ST elevation

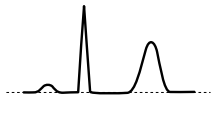


"T en dome" type of ST elevation (significant ST elevation merged with a tall T wave)

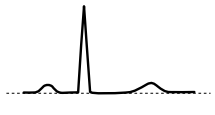
T WAVE

Usually the T wave is positive and not symmetrical.

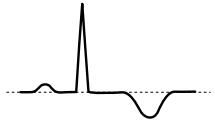
T wave abnormalities



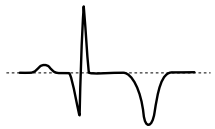
tall, peaked



flat

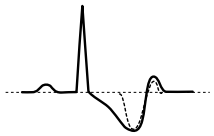


negative

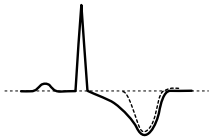


coronary T (symmetrical, deep, peaked, negative)

Combined ST-T changes



ventricular "strain" (descending ST depression, which is convex from above, followed by a biphasic or negative T wave)



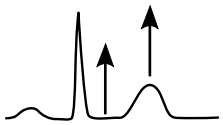
ST elevation, followed by a biphasic T wave (in acute stage of infarcts)

Localization and staging of infarction

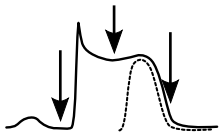
Localization	*Leads, in which signs of the infarct are present*
extensive anterior (anterolateral)	I, aVL, V_1 , V_2 , V_3 , V_4 , V_5 , V_6
anteroseptal	V_1 , V_2 , V_3 , V_4
lateral	I, aVL, V_5 , V_6
high lateral	I, aVL
inferior	II, III, aVF
posterior	reciprocal signs: (V_1), V_2 , V_3 direct signs: V_7 , V_8 , V_9

The evolution of ECG abnormalities following infarction is very variable. The typical course of an ST-elevation infarct is illustrated here.

onset of pain

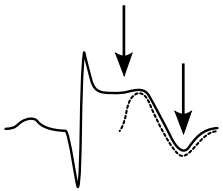


hyperacute stage



"T en dome" type ST elevation (ST elevation, merged with a tall peaked T wave)

acute stage

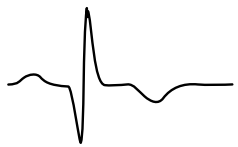


pathological Q wave and/or R reduction, ST elevation, negative T wave (the T wave is really biphasic, but the positive phase merges with the ST elevation)

subacute stage

pathological Q wave and/or R reduction, coronary T wave (symmetric, deep, peaked, negative T wave)

definitive stage (old infarct)



the pathological Q wave usually remains life-long; the repolarization abnormalities may be normalized