ECG interpretation fundamentals and arrhythmia recognition principles

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ECG fundamentals

Review

- Lead theory and wavefront activation
- Unipolar and bipolar leads
- Determination of frontal plane axis
- Determination of horizontal plane axis
- ECG recognition of electrolyte imbalance
- Systematic approach to arrhythmia recognition

ECG fundamentals

History

Augustus Waller (1856-1922)

- First ECG 1887
- Labelled V1 V2 then ABCD

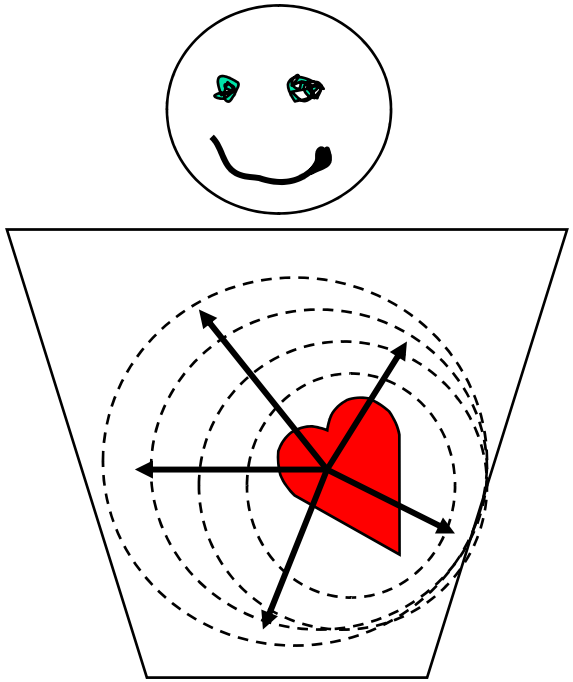
Willem Einthoven (1860-1927)

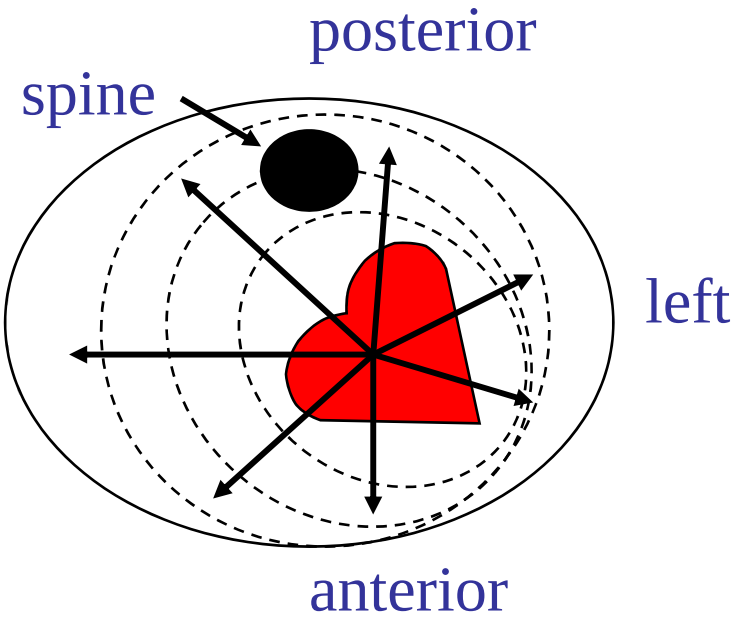
- PQRST
- Einthoven's triangle

Frank Wilson (1890-1952)

- Unipolar leads

ECG fundamentals





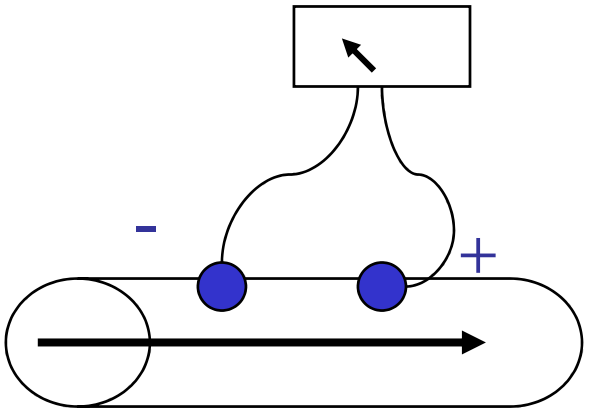
Electrical field passes through
lungs, muscle, blood, fat
Detected at skin
Spreads out from source (heart)

ECG fundamentals

- Skin resistance is critical to recording of electrical activity
- Resistance due to dry, dead, horny layer of epidermis
- MegaOhm resistance at surface (1 million Ohms)
- Simple abrading of skin reduces resistance to 5000 Ohms
- Good electrodes reduce to 100 Ohms

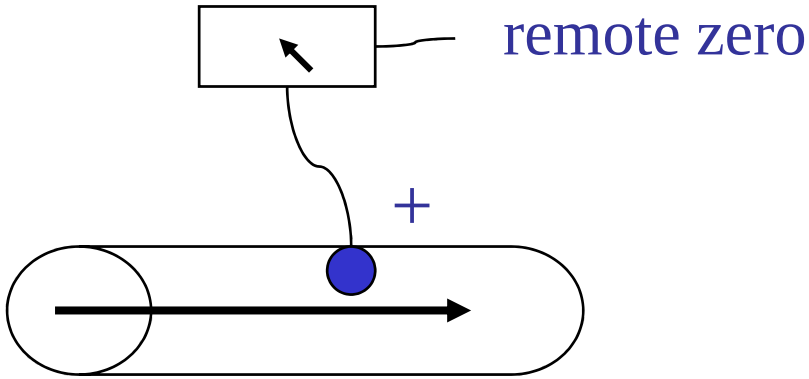
ECG fundamentals

Bipolar



Records difference between
-ve and +ve terminals
-ve is subtracted from +ve
Difference is recorded

Unipolar

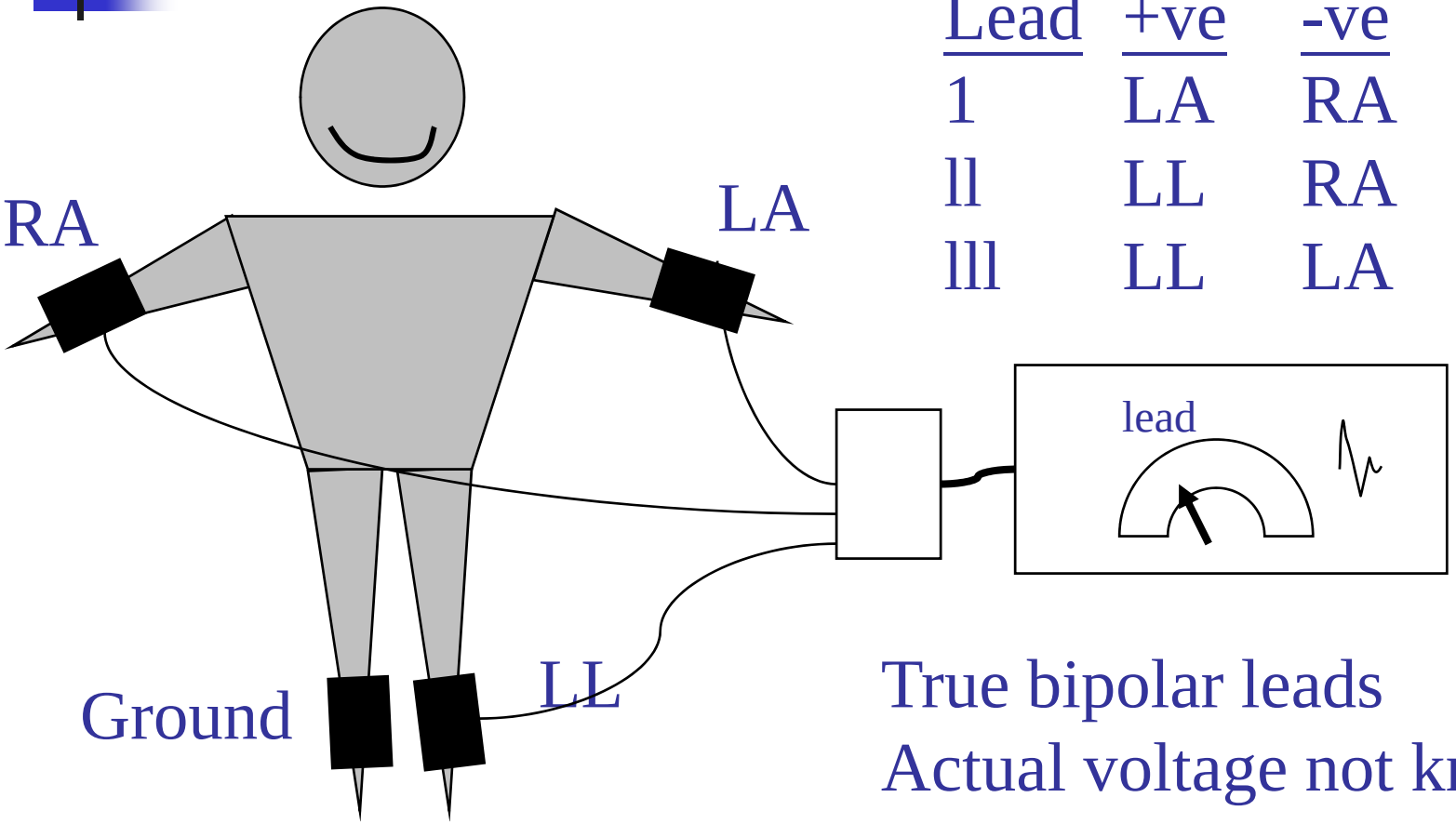


Records difference between
+ve electrode and remote zero

Impulse travelling towards
electrode causes a positive
deflection

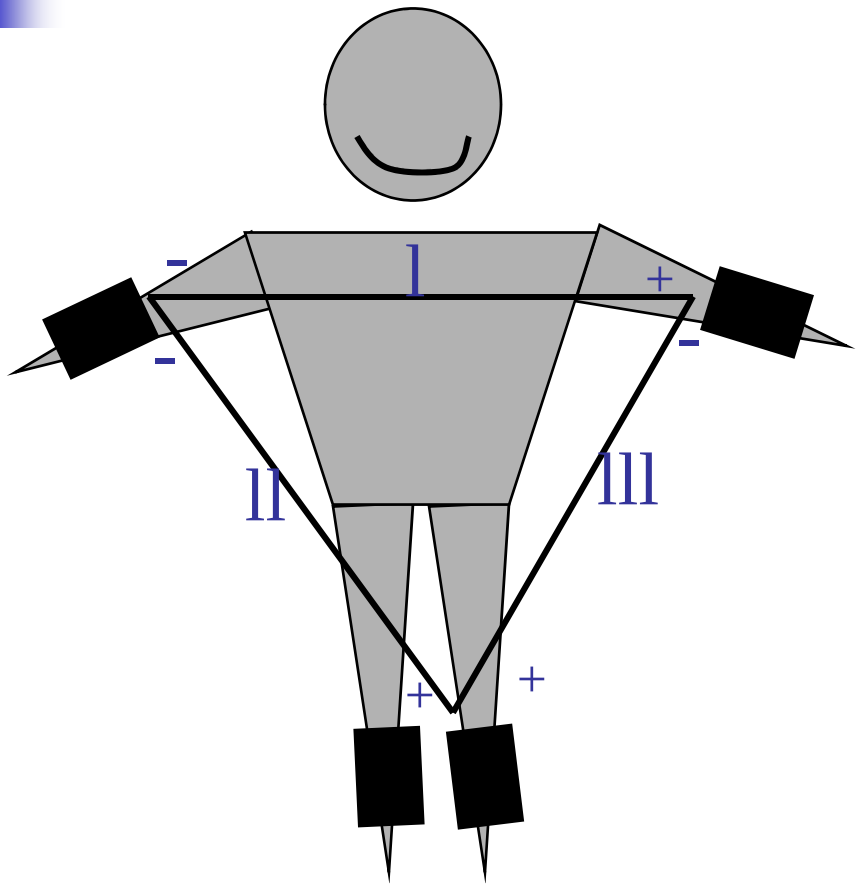
ECG fundamentals

Lead	+ve	-ve
1	LA	RA
ll	LL	RA
lll	LL	LA



True bipolar leads
Actual voltage not known

ECG fundamentals

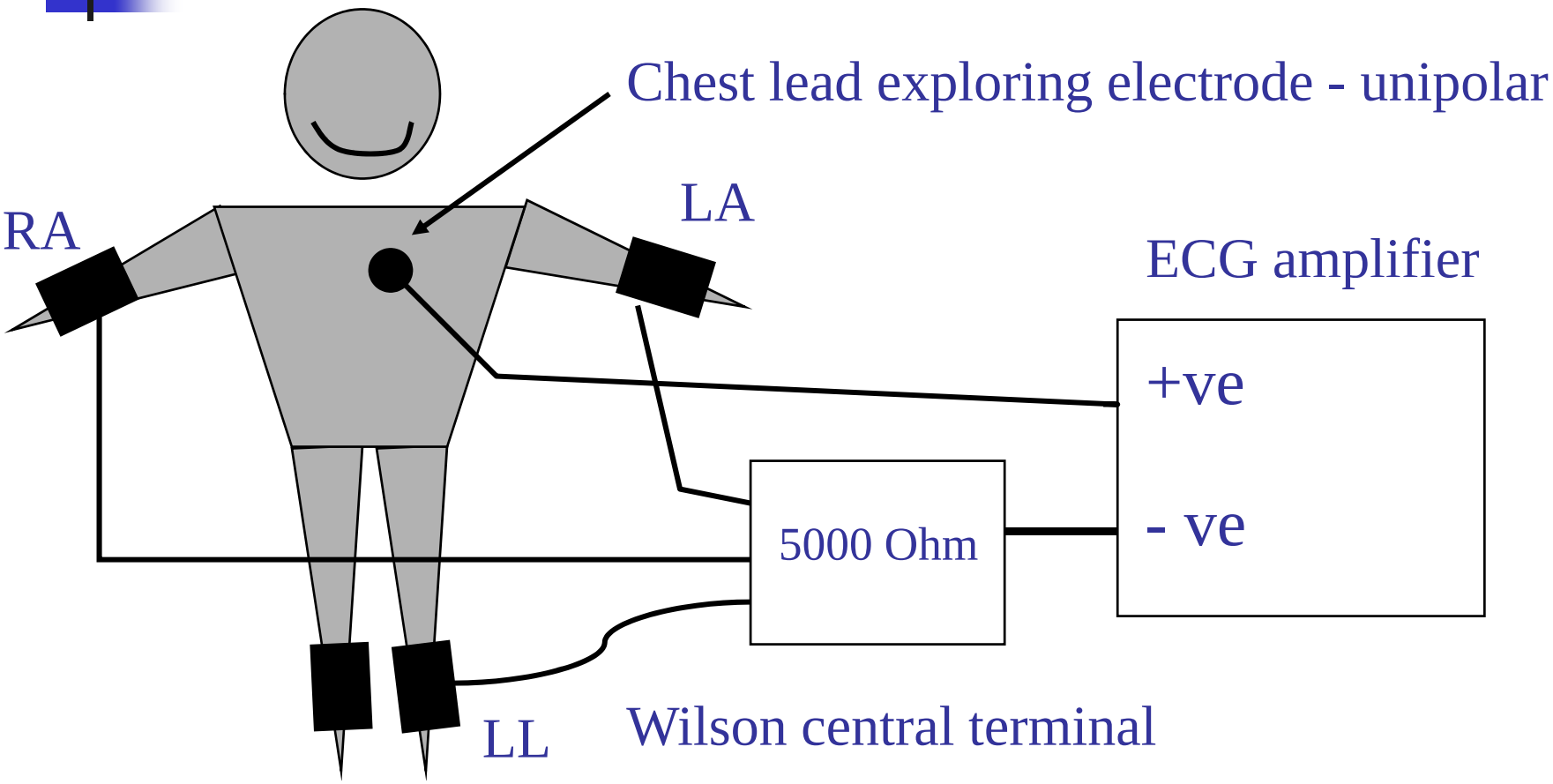


Einthoven's Law

l + lll = ll

Simple check for lead misplacement

ECG fundamentals



ECG fundamentals

Augmented limb leads

unipolar limb leads
compares one limb with the average of the other 2

<u>For example lead aVR</u>
unipolar RA is positive
average of LA and LL is negative
aVR equals the potential of right arm minus the mean of the potentials of left arm and left foot

ECG fundamentals

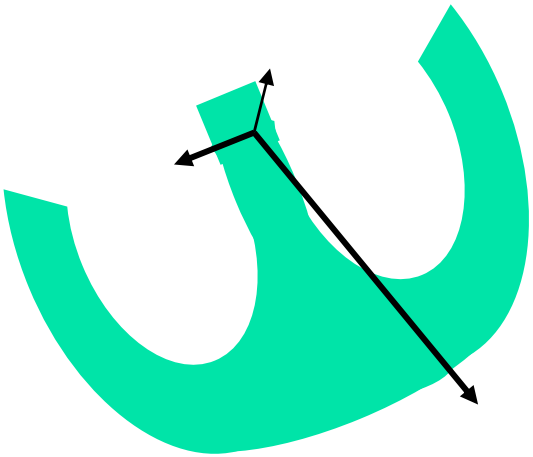
Lead theory

Vector: electrical forces have direction and magnitude

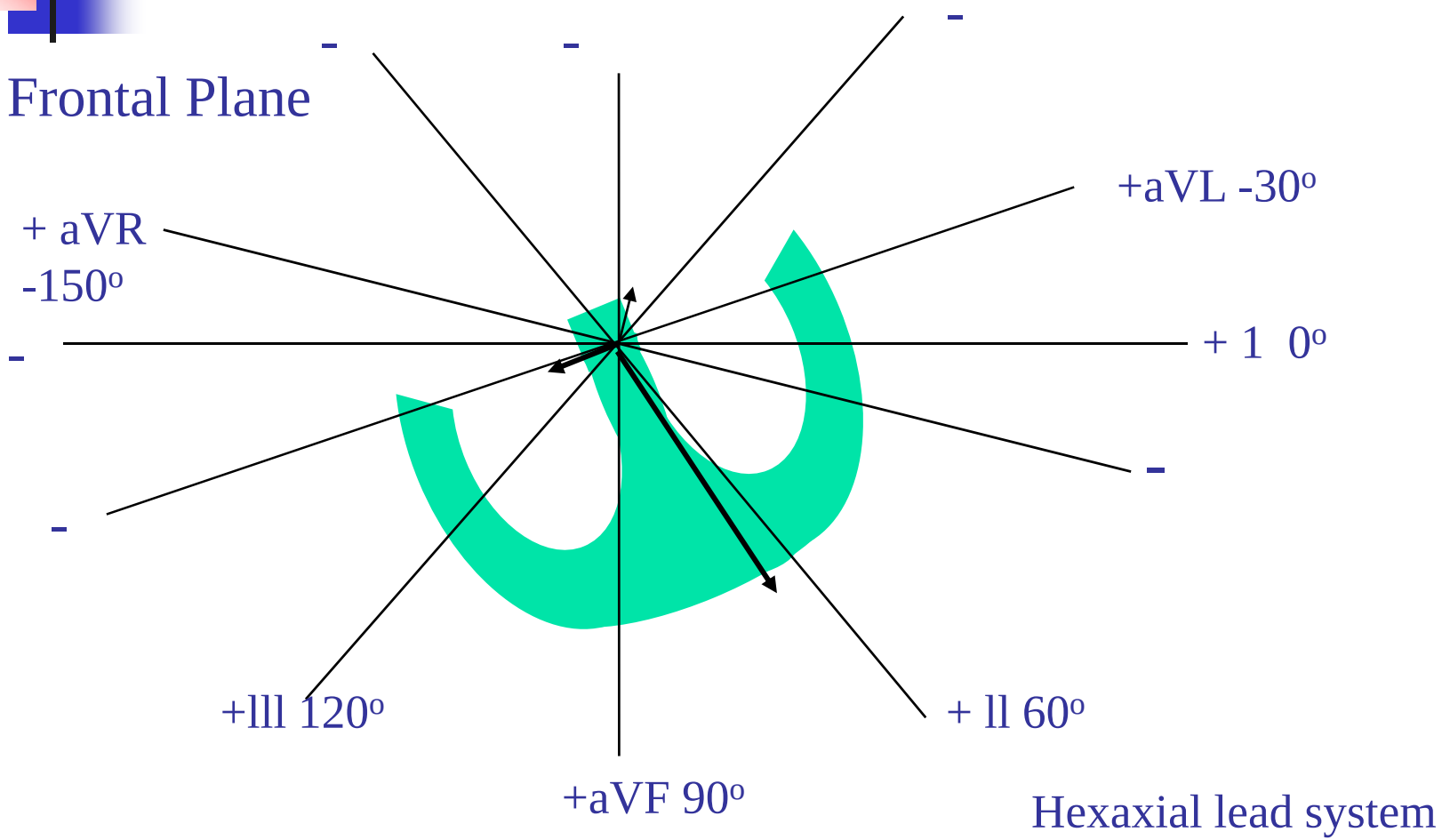
Heart vector - from activation and propagation

Lead vector - orientation of leads to heart vector

3 vector concept is an extreme simplification



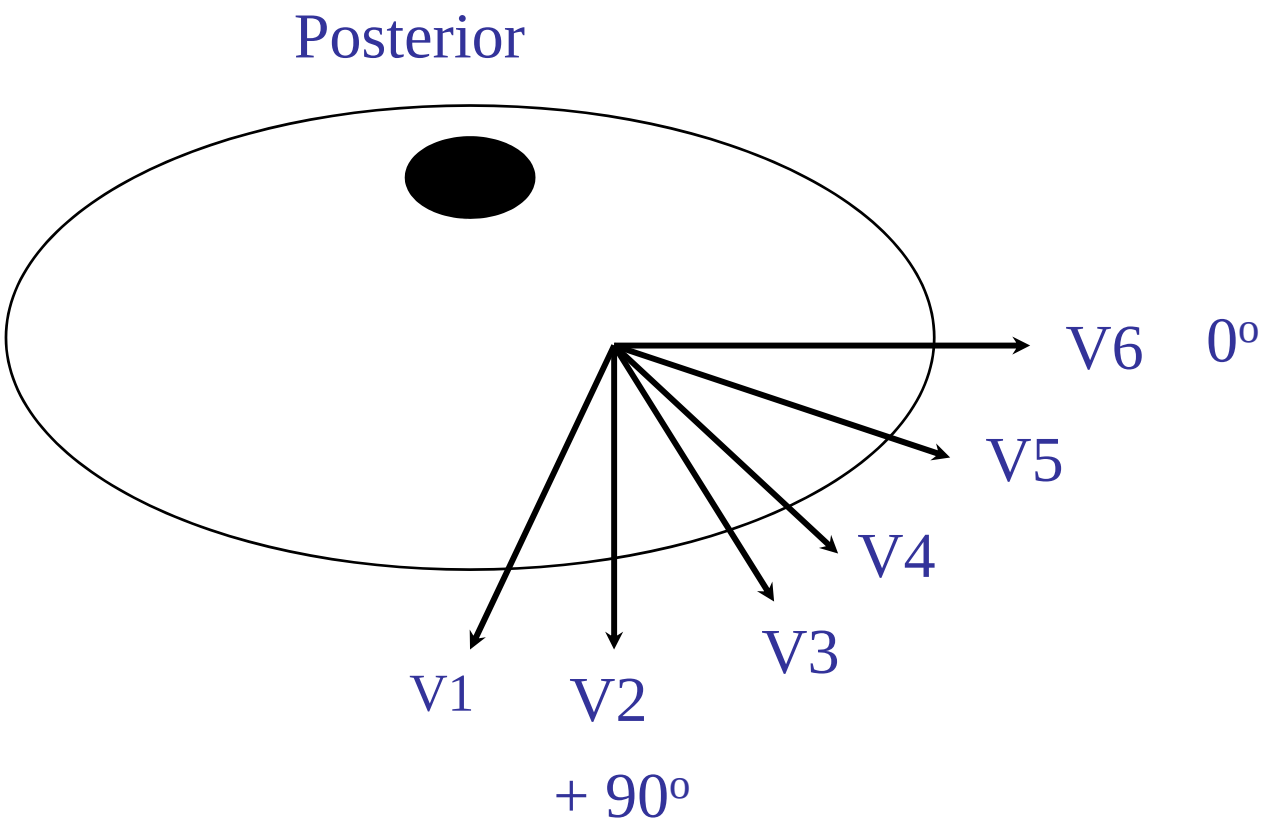
ECG fundamentals



Hexaxial lead system

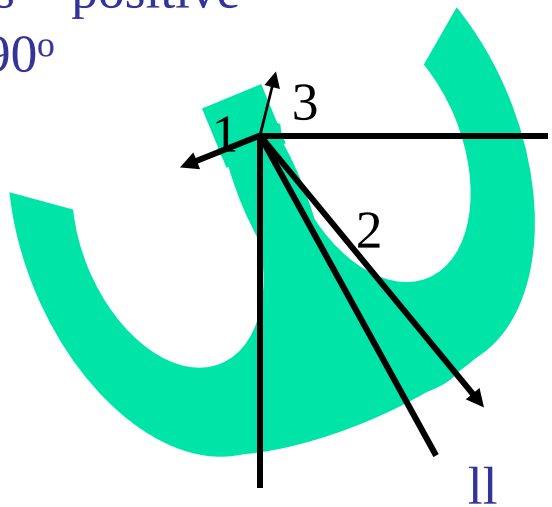
ECG fundamentals

Horizontal Plane Lead Vectors



ECG fundamentals

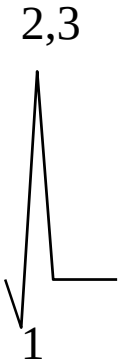
vector away = negative
vector towards = positive
equiphasic = 90°

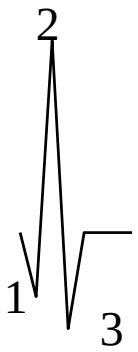


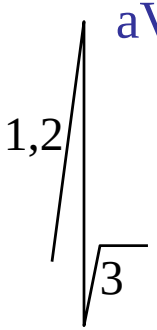
1

ll

aVF





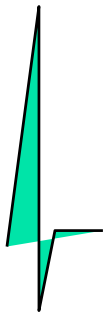


1 = septum
2 = dominant LV
3 = basal RV/LV

ECG fundamentals

QRS axis estimation

actually estimating a “mean” or average electrical forces
mean force estimated by area under QRS complex



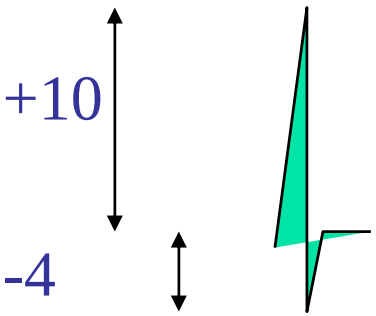
then these are plotted as vectors on the hexaxial graph

ECG fundamentals

QRS axis estimation

Thankfully, measuring the area is not necessary

The net amplitude of the QRS complexes can be used instead.



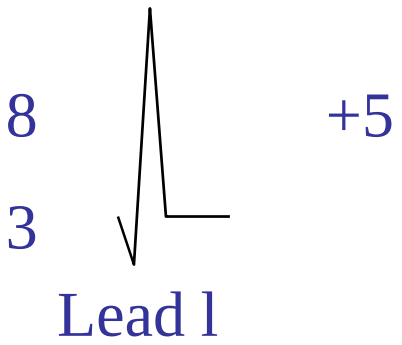
Resultant = (+10) + (- 4) = +6

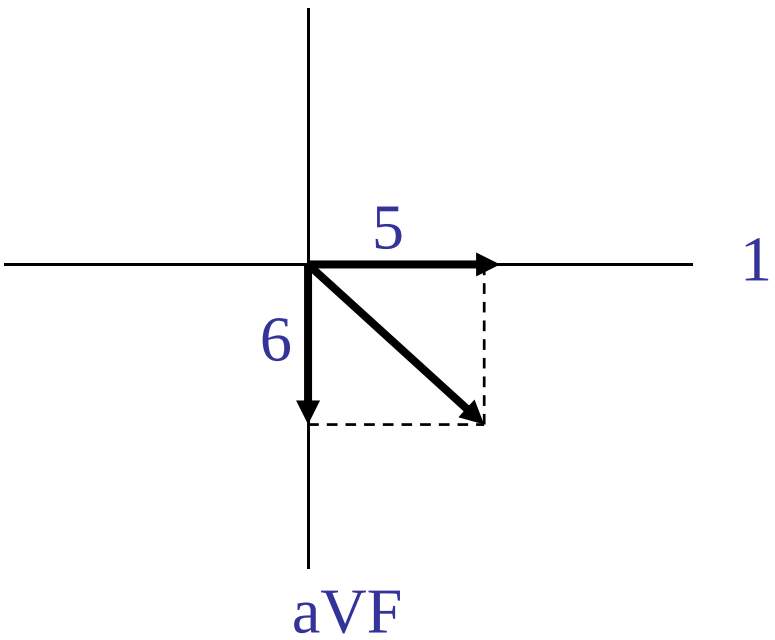
ECG fundamentals

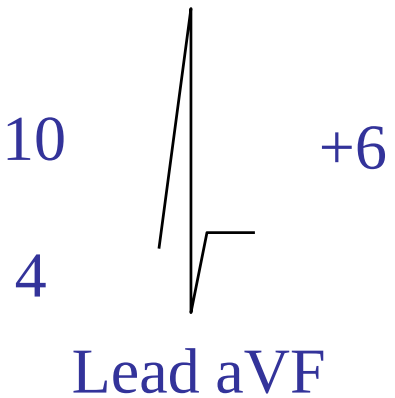
Different methods for frontal plane QRS axis

- Can take any 2 leads, or all six
- Leads 1, aVF commonly used
- Lead with smallest or equiphasic complex identified, and axis is approximately 90° to this lead

ECG fundamentals



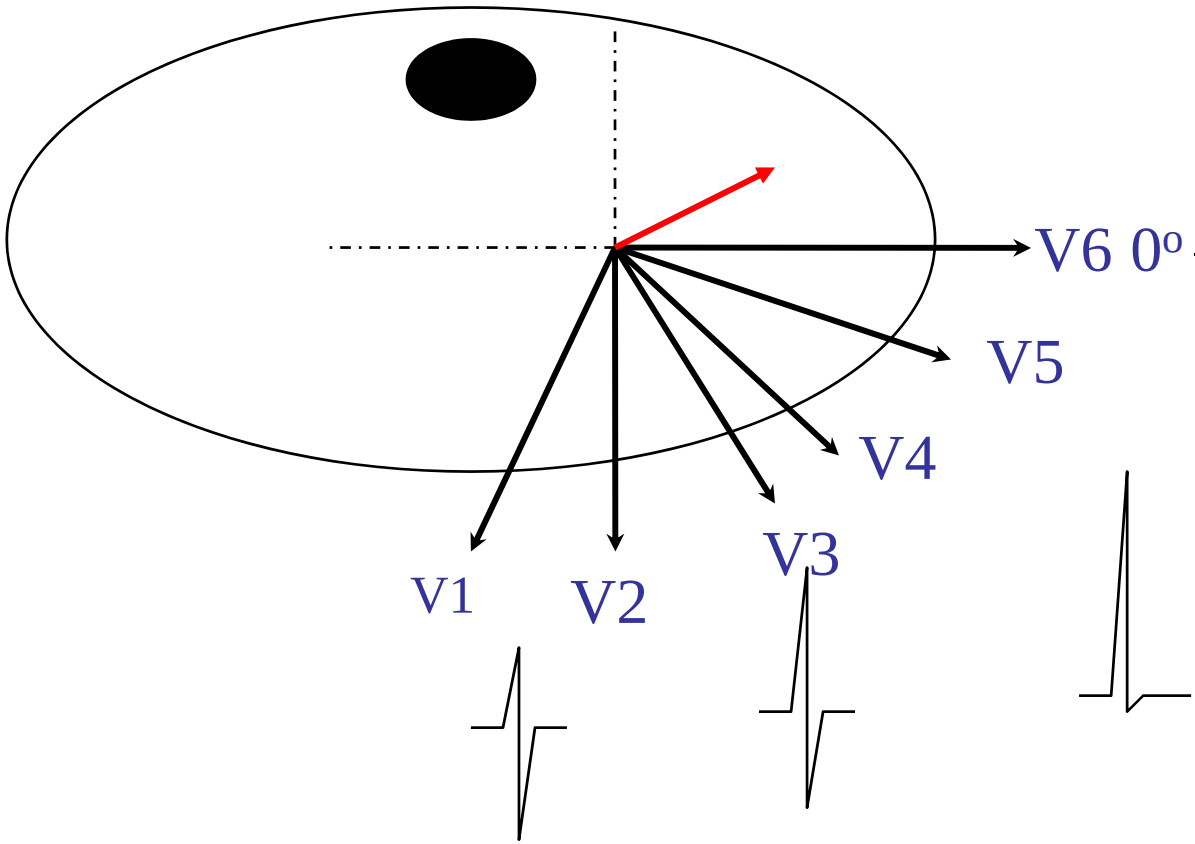


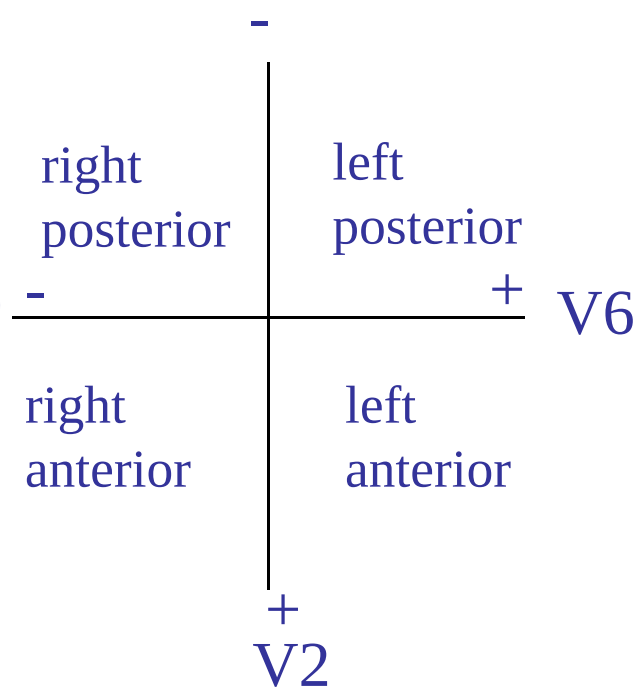


Not perfect, but good enough

ECG fundamentals

Horizontal Plane





ECG fundamentals

QRS axis

- affected by anatomic position of the heart
- properties of the cardiac conduction system
- developmental changes in RV/LV mass relationships
- conduction system most influential in mature heart

ECG fundamentals

Electrolyte abnormalities

Hypokalaemia

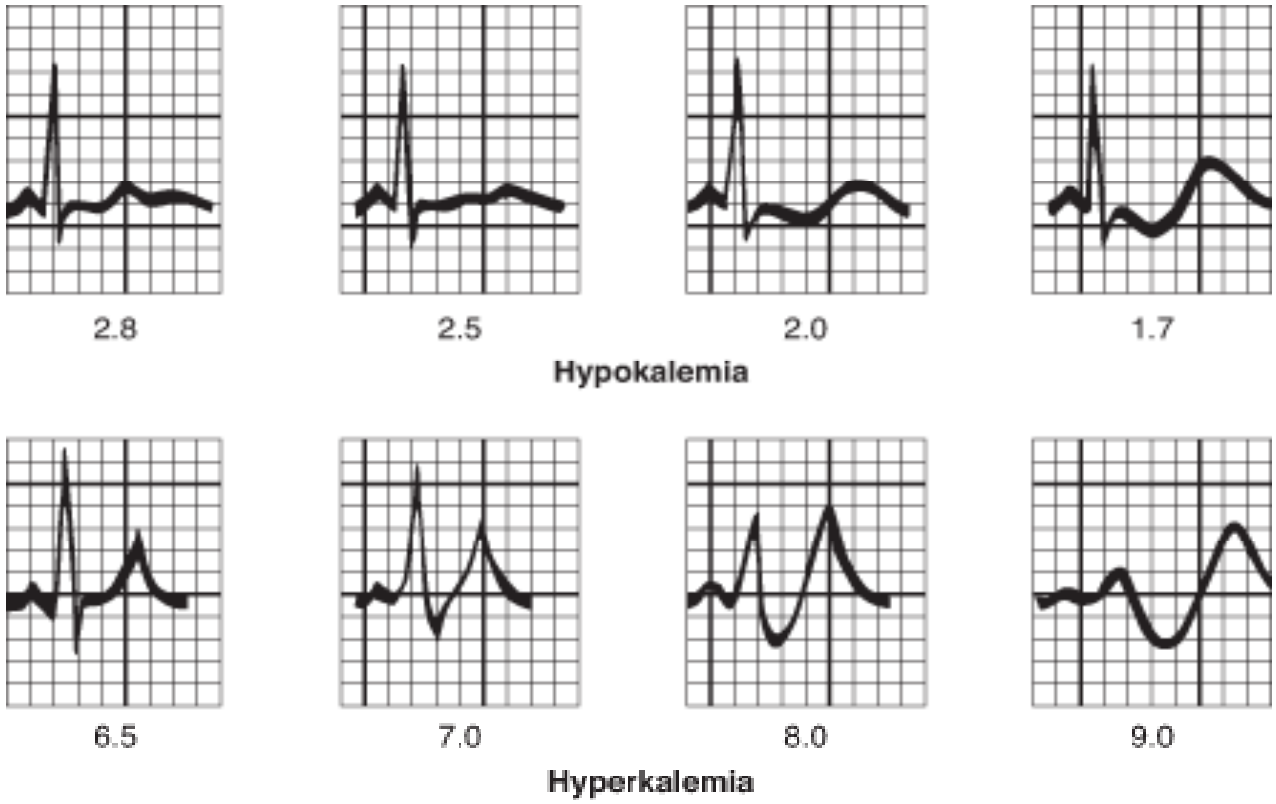
- ST depression
- lowering of T wave
- increase in U wave height
- U > T suggests K < 2.7 mEq/l

Hyperkalemia

- Tall thin T waves
- PR prolonged
- QRS widens
- P waves disappear

ECG fundamentals

Electrolyte abnormalities



ECG fundamentals

Electrolyte abnormalities

Hypocalcaemia

Prolongs QT interval (ST segment)

Hypercalcaemia

Shortening of QT interval (QTa – apex of T)

Systematic approach to arrhythmia recognition

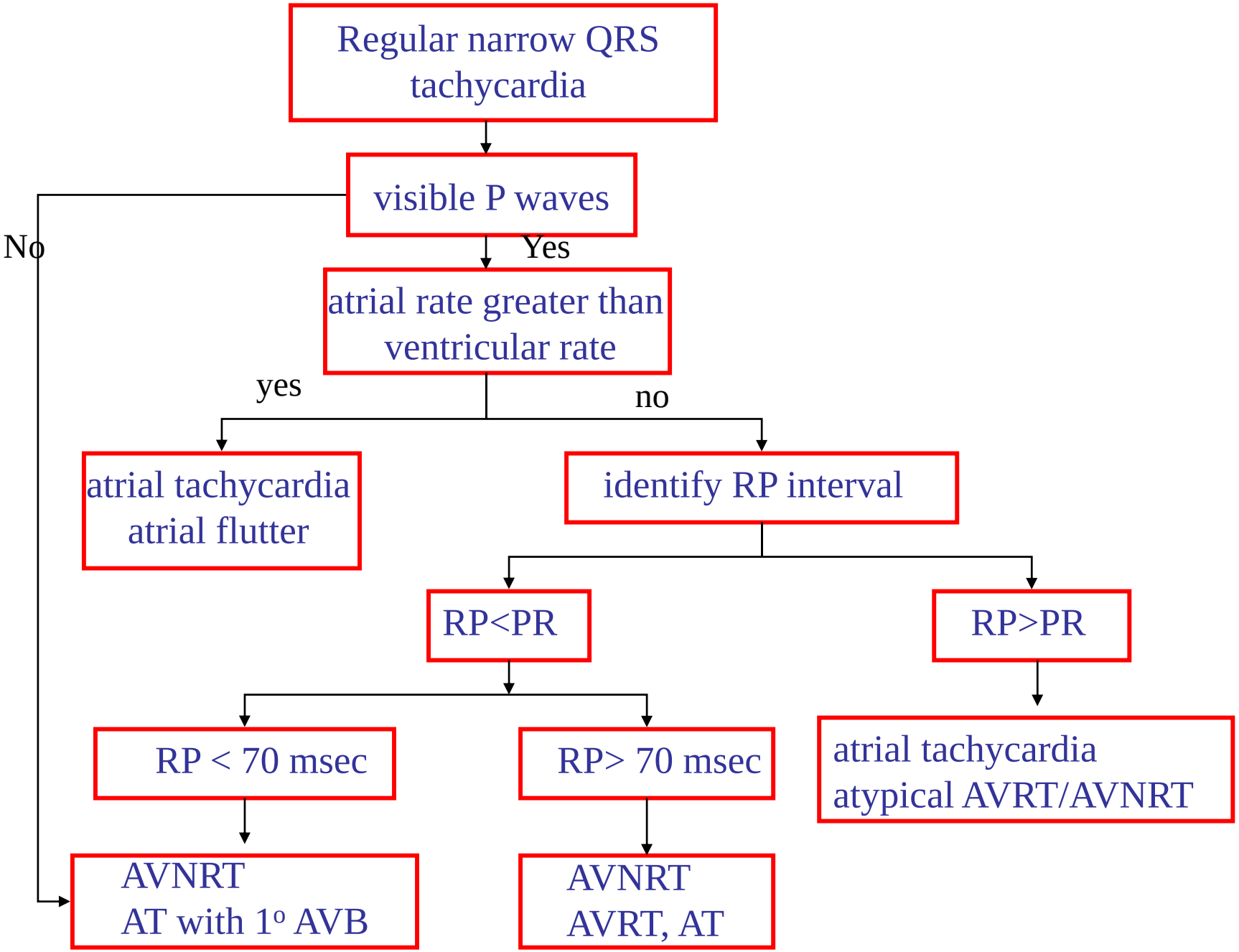
Tachyarrhythmias

- Supraventricular
- Ventricular

- Narrow complex
- Wide complex

Regular, narrow complex/supraventricular

principles behind the components of the algorithm


Regular narrow QRS tachycardia
visible P waves
No
Yes
atrial rate greater than ventricular rate
yes
no
atrial tachycardia
atrial flutter
identify RP interval
RP<PR
RP>PR
RP < 70 msec
RP> 70 msec
atrial tachycardia
atypical AVRT/AVNRT
AVNRT
AT with 1º AVB
AVNRT
AVRT, AT

Systematic approach to arrhythmia recognition

Narrow complex/supraventricular (normal QRS duration, appearance)
QRS normal for age <120 msec (adults)

- Classification schemes
  - Mechanistic
    - automaticity/ectopic
    - reentry
    - triggered
  - Anatomical
    - atrial, junctional, accessory pathway
  - AV relationship
    - independent, dependent

Systematic approach to arrhythmia recognition

Narrow complex/supraventricular

Combined anatomical/AV relationship

Dependent

the arrhythmia requires both atrium and ventricle to continue

Independent

the arrhythmia continues regardless of the involvement of the other chamber

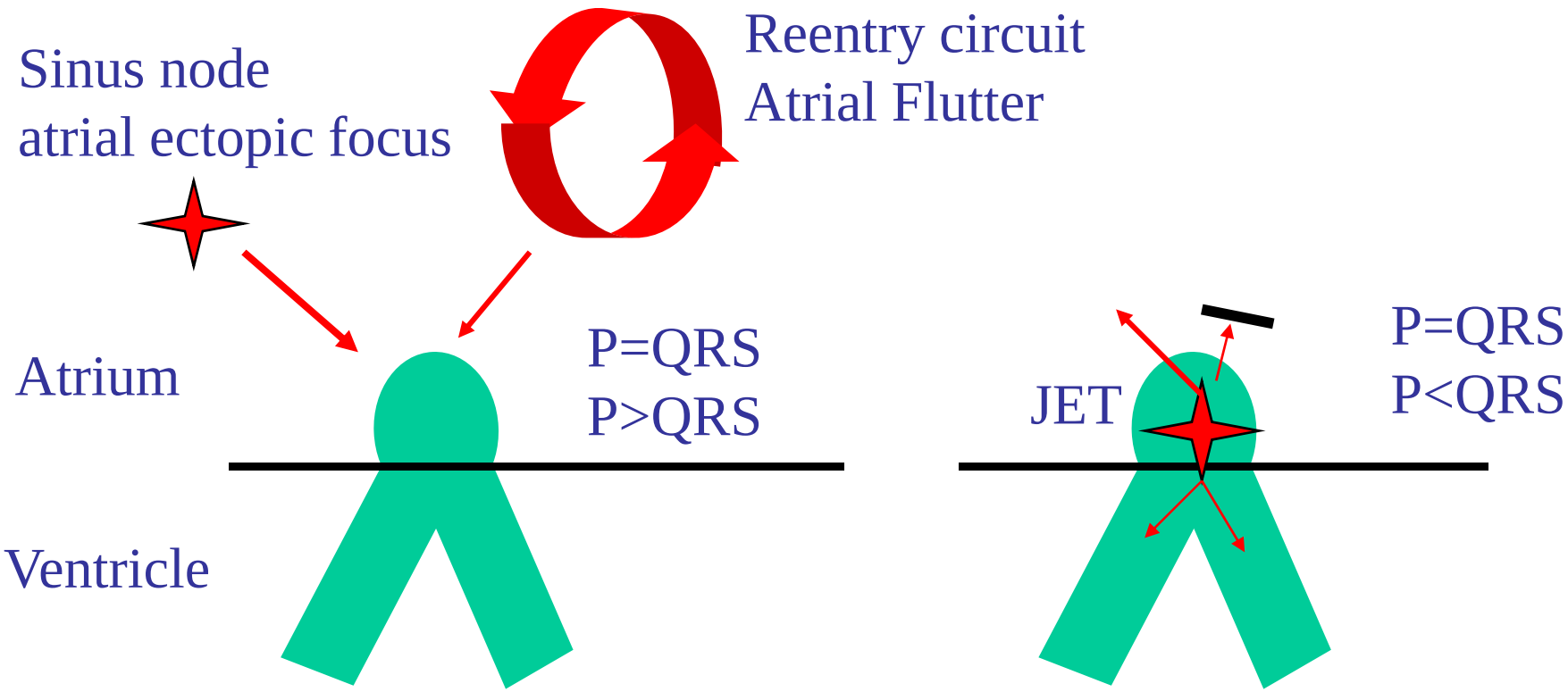
Systematic approach to arrhythmia recognition

Narrow complex/supraventricular

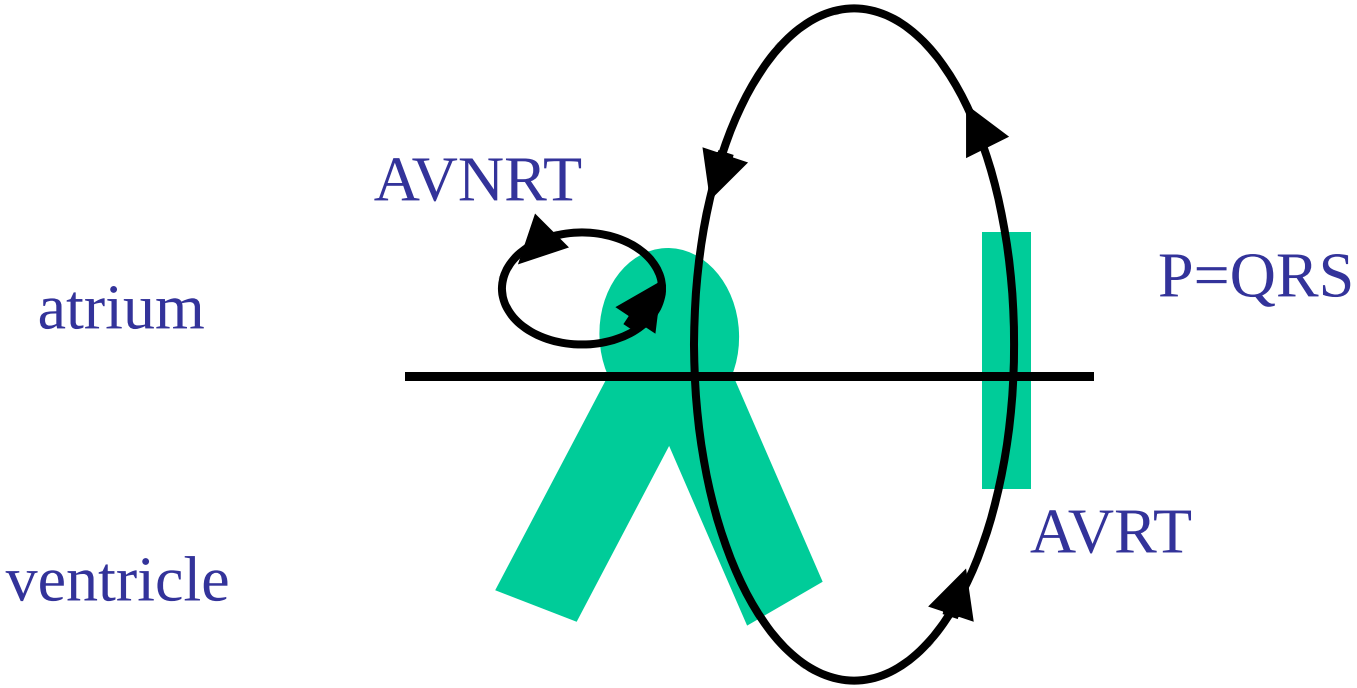
Direction of activation

arrhythmia arises in the atrium
the atrial activity drives the ventricle

the atrium is activated by impulses that arise lower down (AV node, ventricle)



Independent arrhythmias
Can have different rates in 2 chambers
Atrium may be faster in one, may be slower in other
More (or less) P waves than QRS complexes on ECG



arrhythmia dependent on both chambers
expect a 1:1 relationship
one P for each QRS on ECG

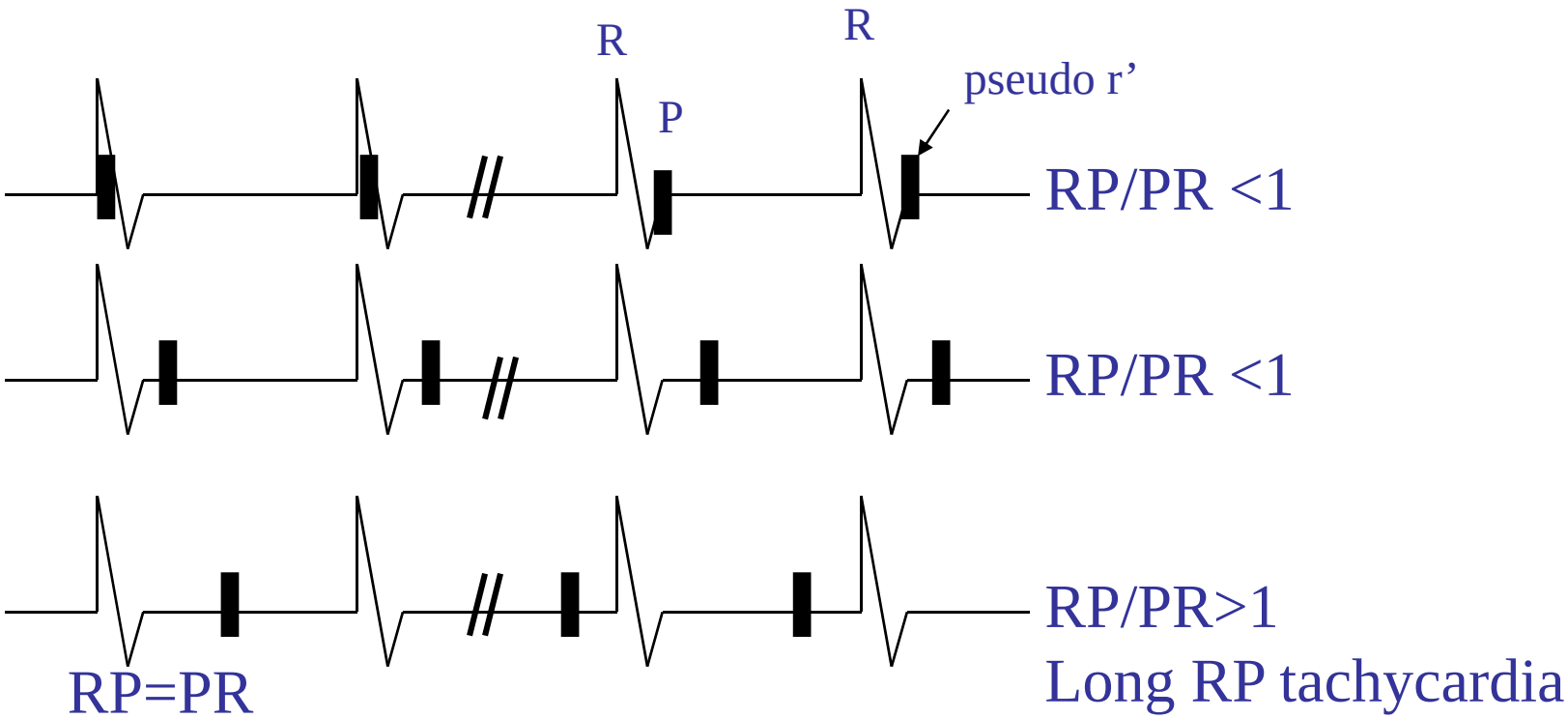
Systematic approach to arrhythmia recognition

Narrow complex/supraventricular

	Anatomical	Indep/dependent
SNRT	atrium	independent
Atrial tach	atrium	independent
Atrial flutter	atrium	independent
Atrial fib	atrium	independent
AVNRT	Atr/AV node	dependent
AVRT	Atr/Cond/vent	dependent
JET	AV node	independent

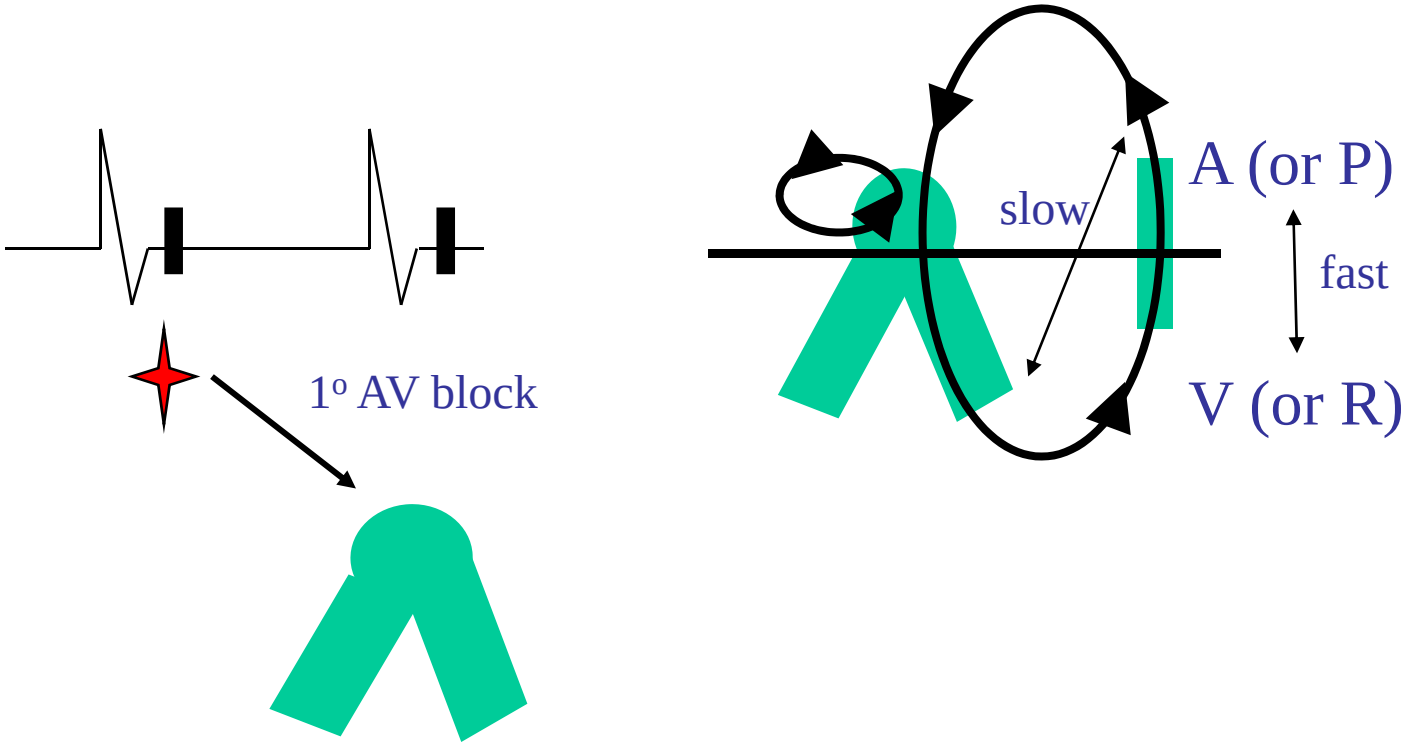
Systematic approach to arrhythmia recognition

Locate P wave
Calculate RP and PR intervals



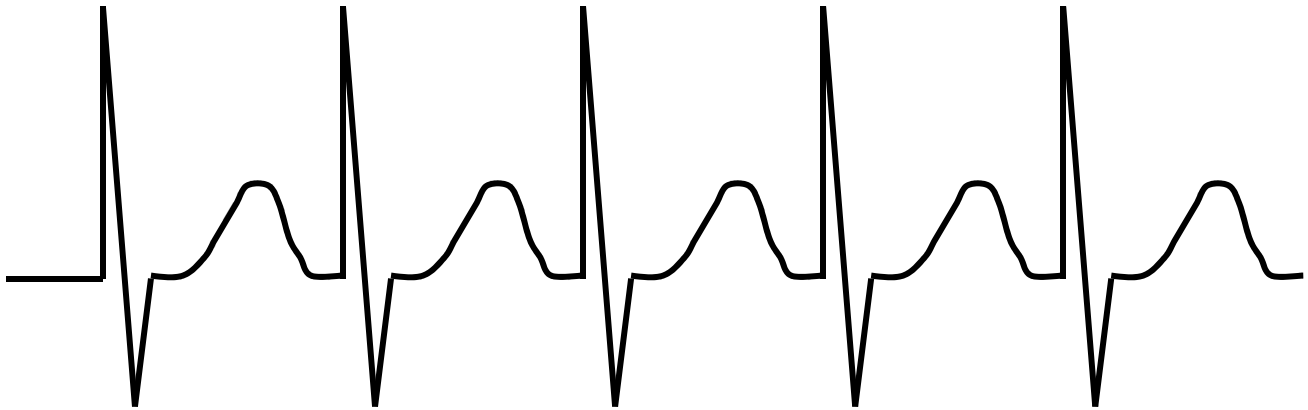
Systematic approach to arrhythmia recognition

2 explanations for same ECG



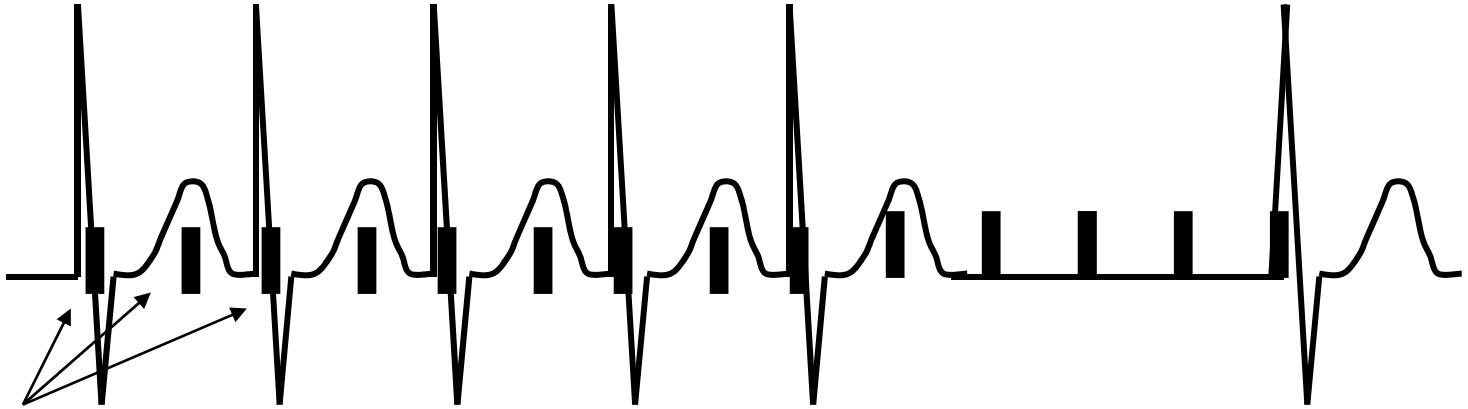
Systematic approach to arrhythmia recognition

Regular, narrow complex tachycardia with no visible P waves



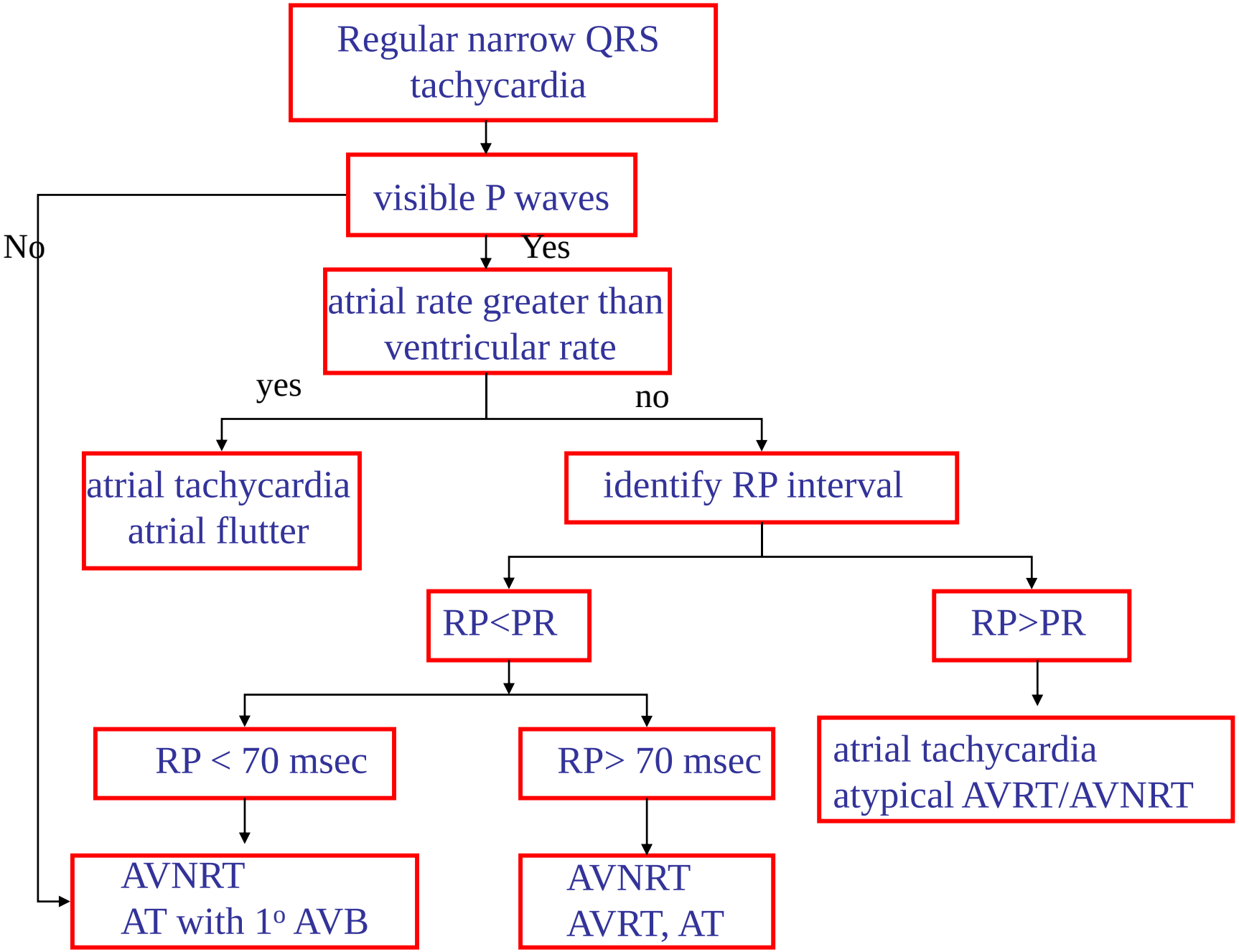
Could be simple, uncomplicated AVNRT

Systematic approach to arrhythmia recognition



Concealed atrial activity

adenosine
carotid sinus massage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atrial tachycardia
atypical AVRT/AVNRT
AVNRT
AT with 1º AVB
AVNRT
AVRT, AT

Systematic approach to arrhythmia recognition

In general the common forms of SVT are short RP tachycardias (RP/PR<1), because the atrial activation is from rapid retrograde conduction to, and then activation of, the atrium

Long RP tachycardias (those with a normal looking PR interval) are either tachycardias arising in the atrium, or unusual forms of SVT.

Sometimes it may be difficult to differentiate whether the atrium has been activated from the top or retrograde.

Systematic approach to arrhythmia recognition

The analysis of the electrocardiogram in narrow complex SVT requires an understanding of the possible mechanisms, anatomical substrates and atrioventricular dependence.

Being aware of all these features will usually enable an accurate diagnosis to be made on the electrocardiogram.