

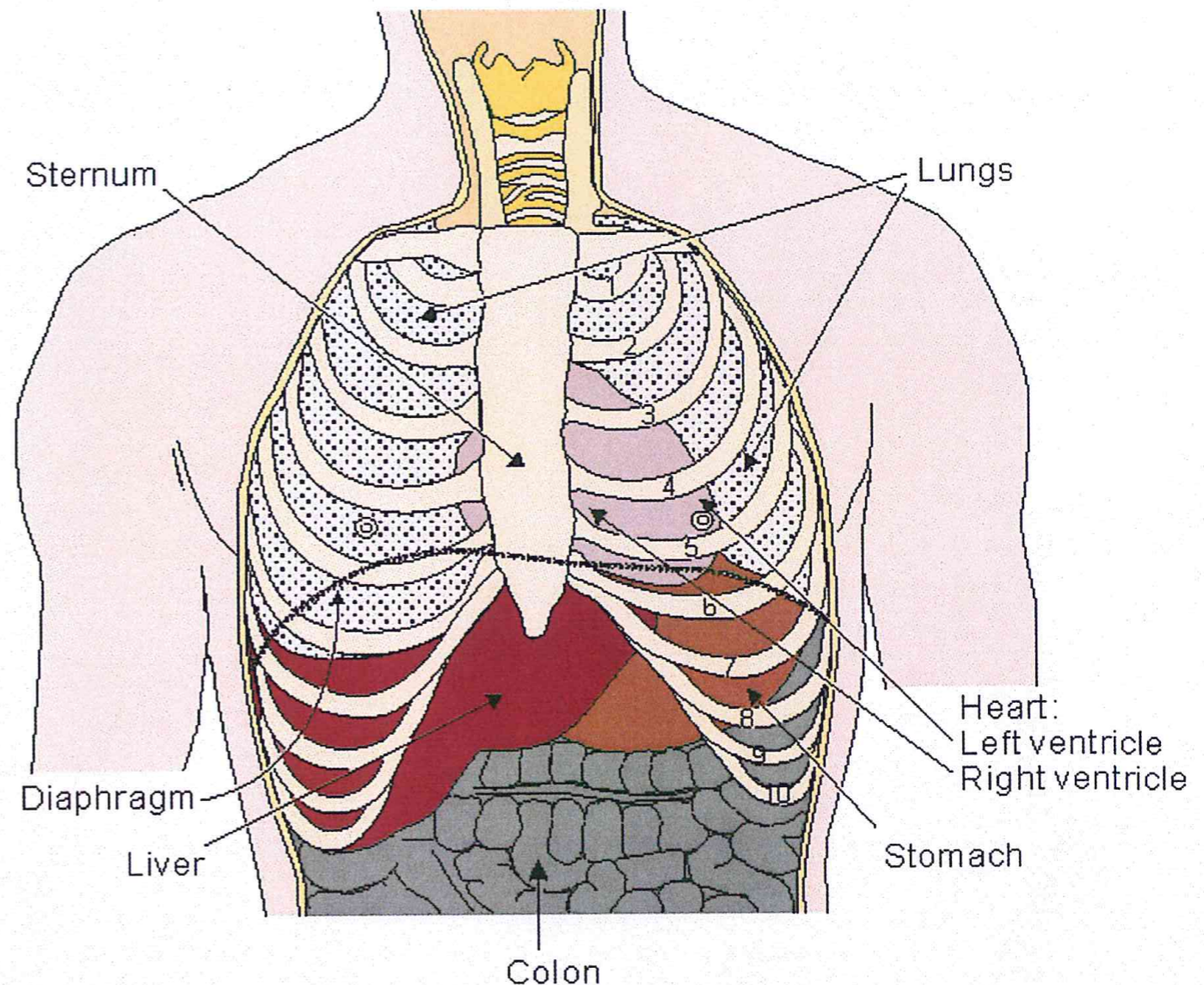
Cuore

Materiale grafico di supporto alla lezione

Estratto da:
"Bioelectromagnetism" cap. 6,15,19

Cenni su anatomia e fisiologia

- Situato nel torace, dietro lo sterno e davanti ai polmoni
- Circondato dal pericardio
- Dimensioni di un pugno chiuso, peso 250-300g
- Parte superiore: grandi vasi (vena cava superiore inferiore, arteria e vena polmonare, aorta)



Cenni su anatomia e fisiologia

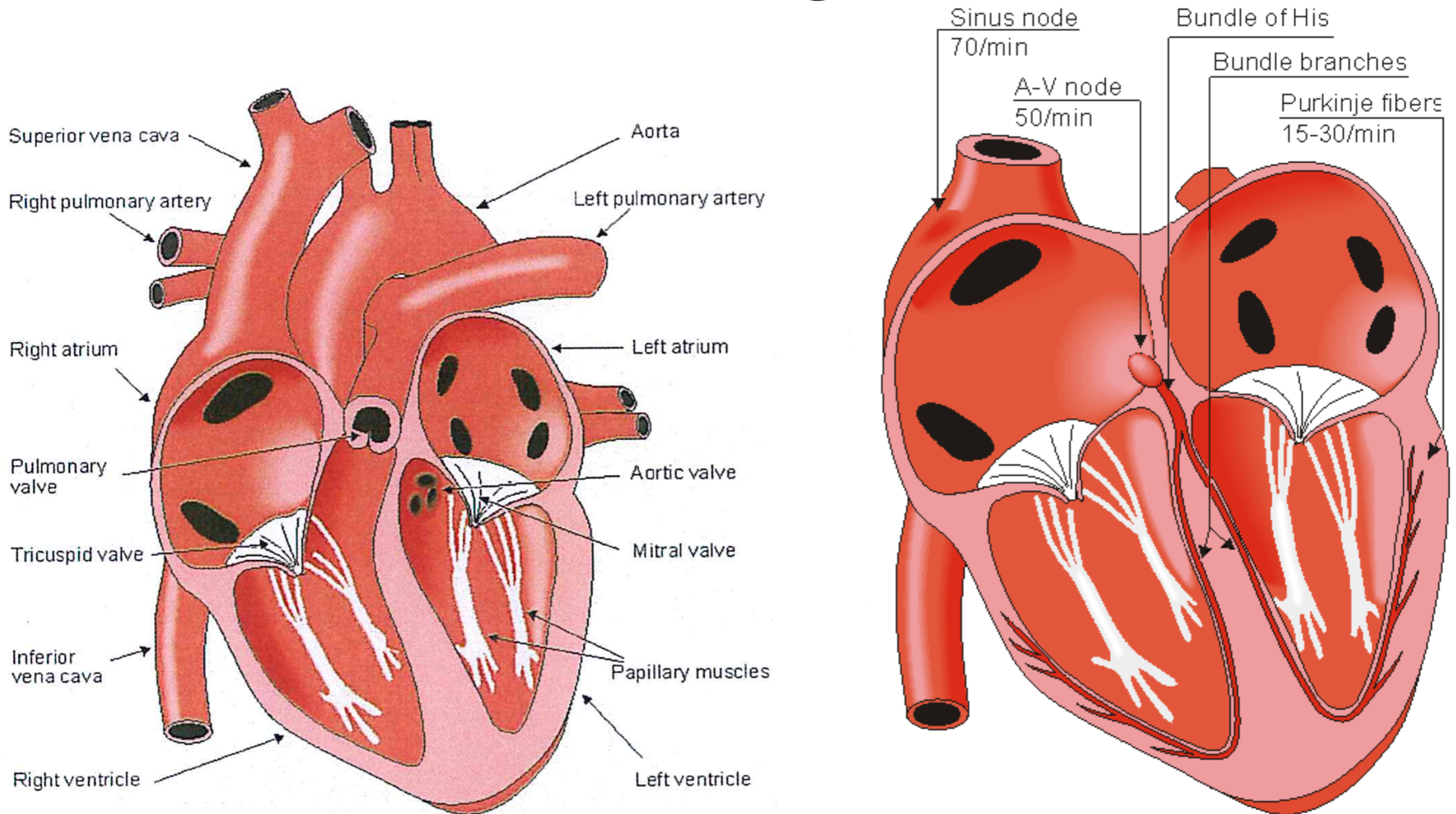


fig.2: Anatomia del cuore e vasi ad esso associati

Cenni su anatomia e fisiologia

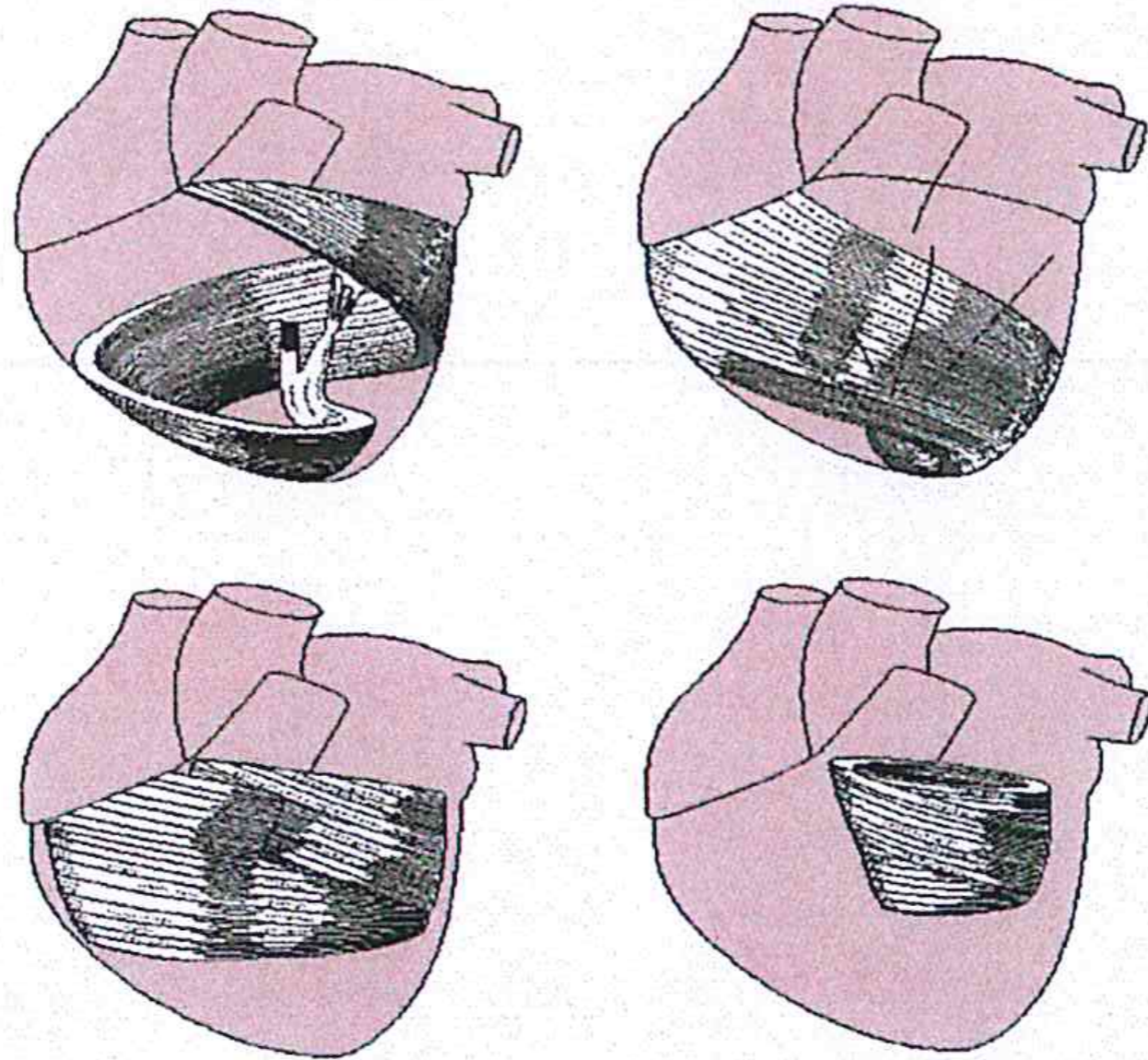


Fig.3: Orientazione delle fibre del muscolo cardiaco

Propagazione

Table 6.1. Electric events in the heart

Location in the heart	Event	Time [ms]	ECG-terminology	Conduction velocity [m/s]	Intrinsic frequency [1/min]
SA node	impulse generated	0		0.05	70-80
atrium, Right	depolarization *)	5	P	0.8-1.0	
Left	depolarization	85	P	0.8-1.0	
AV node	arrival of impulse	50	P-Q interval	0.02-0.05	
	departure of impulse	125			
bundle of His	activated	130		1.0-1.5	20-40
bundle branches	activated	145		1.0-1.5	
Purkinje fibers	activated	150		3.0-3.5	
endocardium			QRS	0.3 (axial)	
Septum	depolarization	175			
Left ventricle	depolarization	190		-	
epicardium			QRS	0.8 (transverse)	
Left ventricle	depolarization	225			
Right ventricle	depolarization	250			
epicardium				0.5	
Left ventricle	repolarization	400			
Right ventricle	repolarization	400			
endocardium			T		
Left ventricle	repolarization	600			

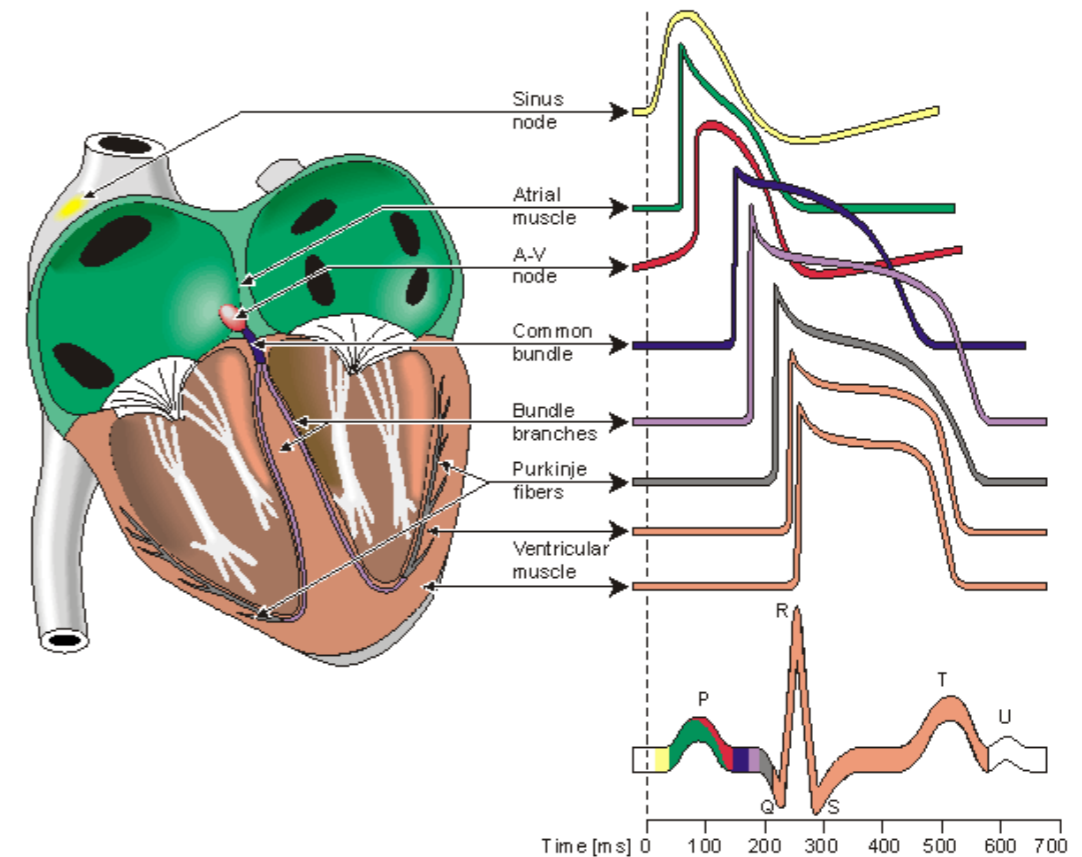
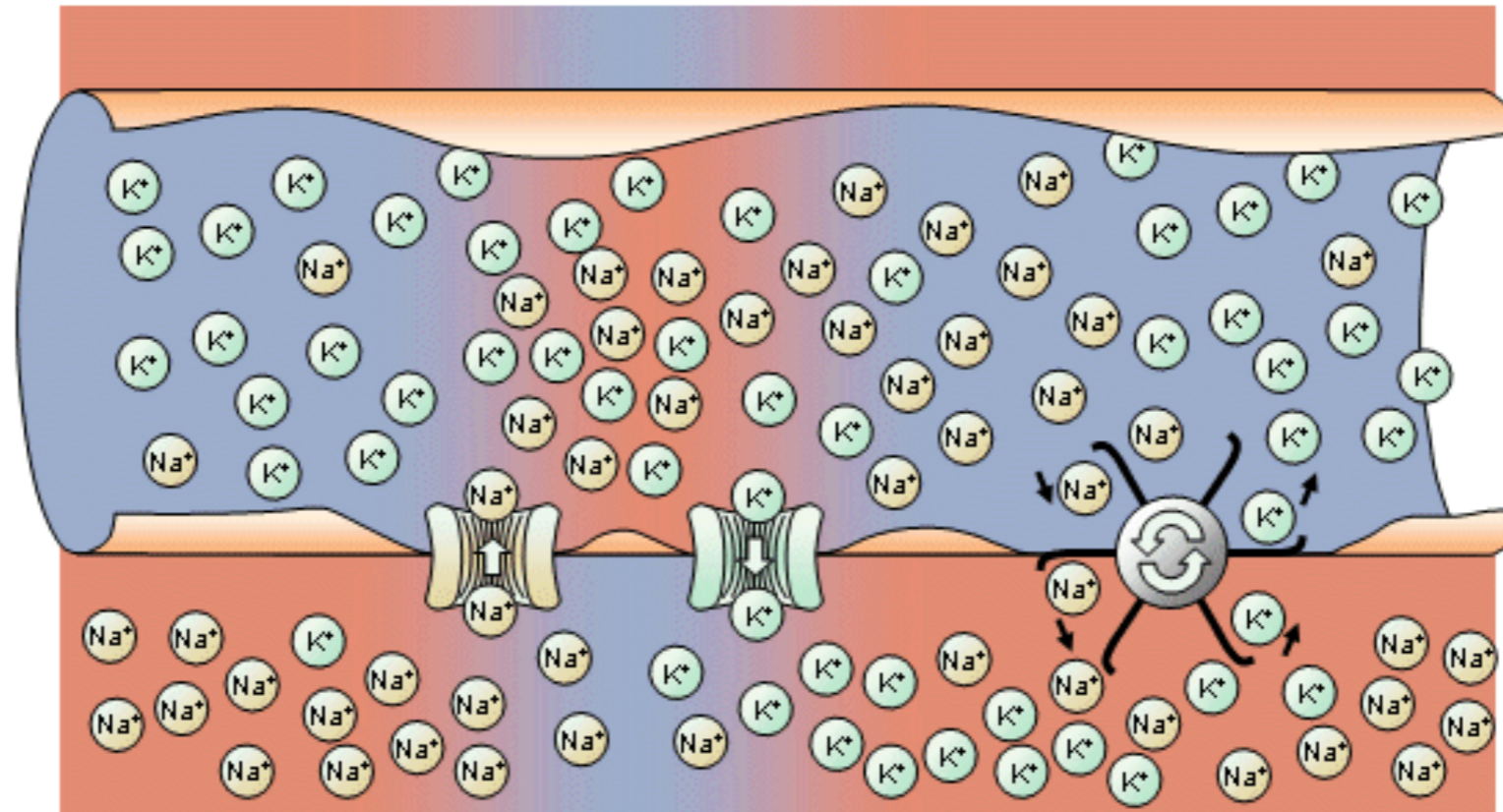
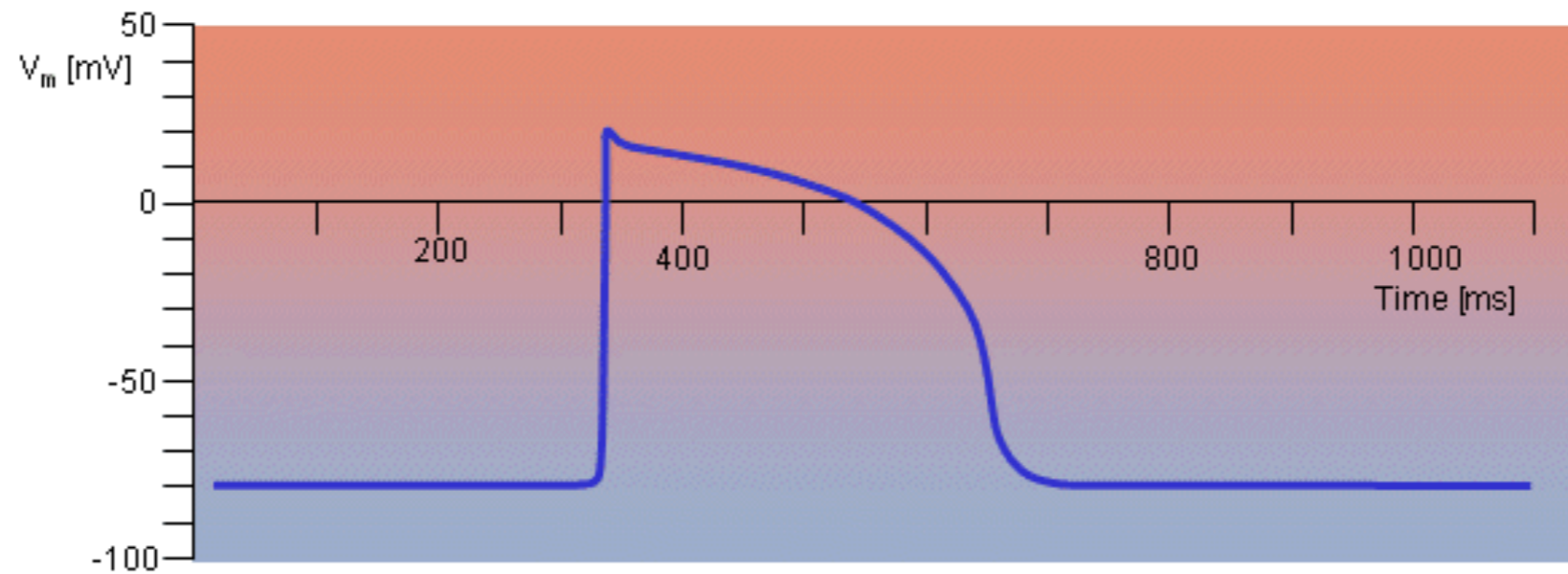


Fig. 6.7. Electrophysiology of the heart. The different waveforms for each of the specialized cells found in the heart are shown. The latency shown approximates that normally found in the healthy heart.

*) Atrial repolarization occurs during the ventricular depolarization; therefore, it is not normally seen in the electrocardiogram.

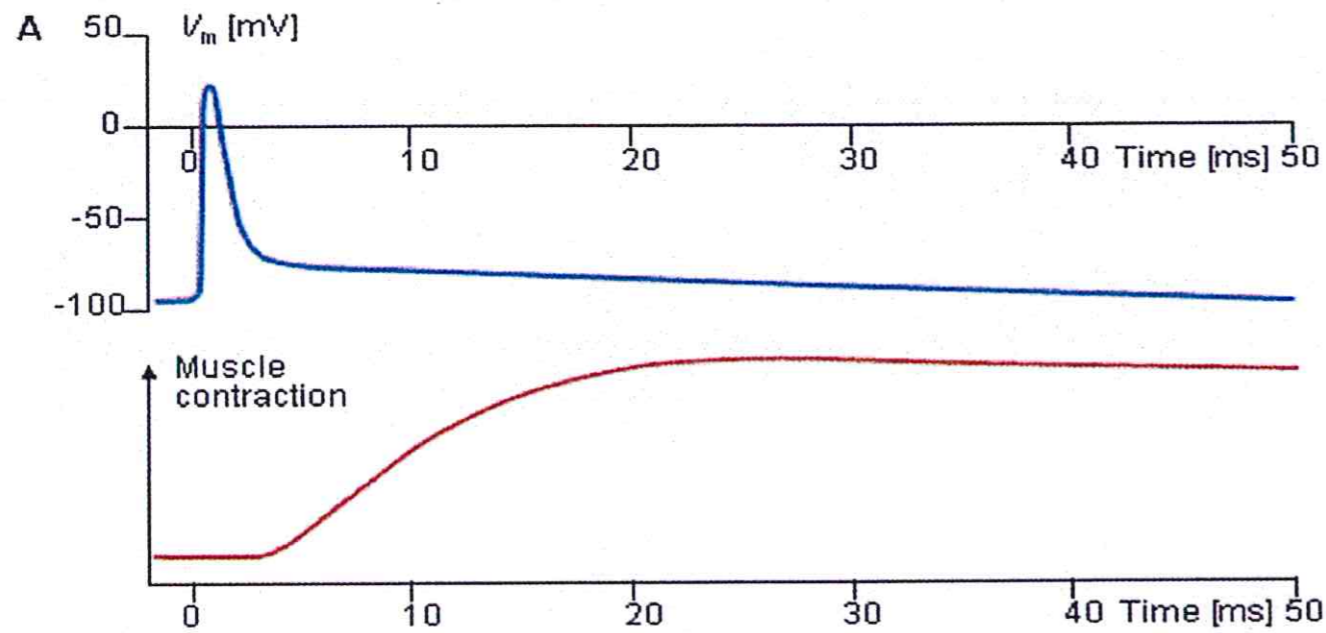
Attivazione elettrica del cuore



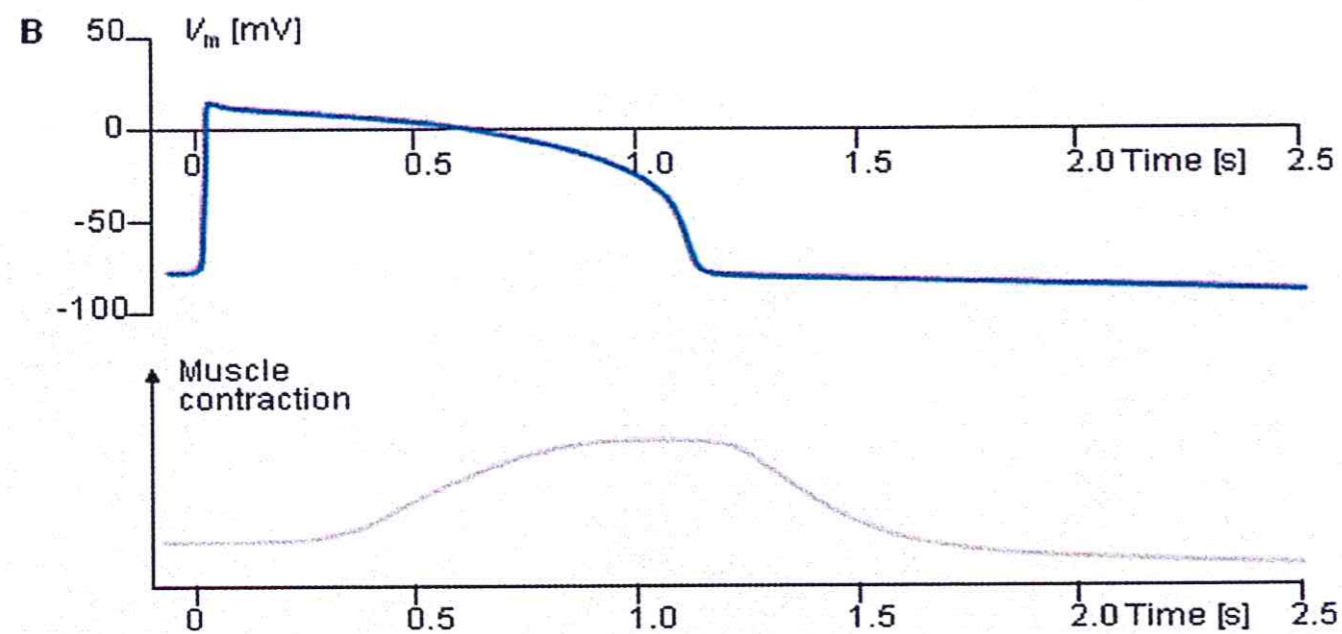
DEPOLARIZATION REPOLARIZATION

RESTORATION OF IONIC BALANCE

Attivazione elettrica del cuore

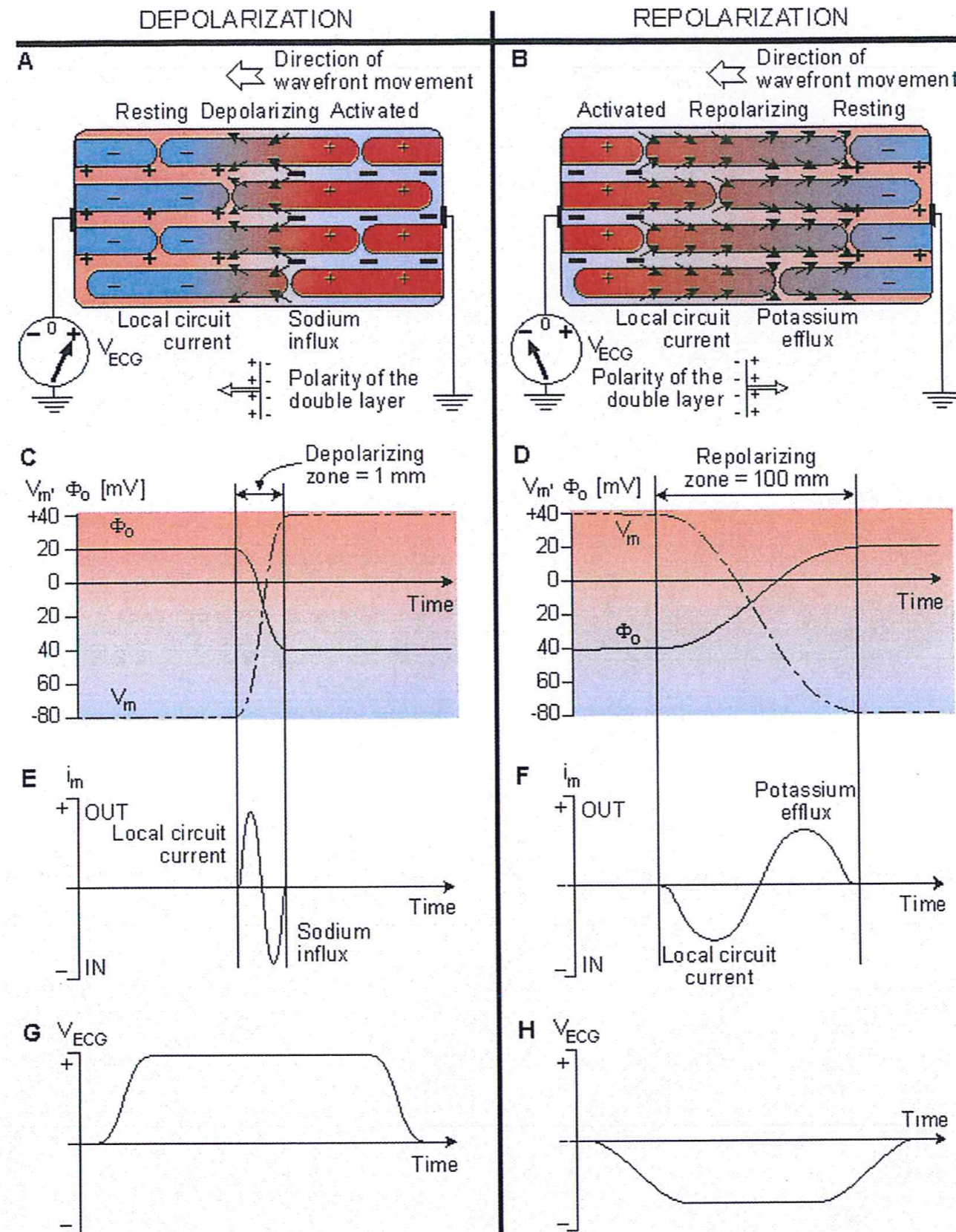


muscolo
scheletrico

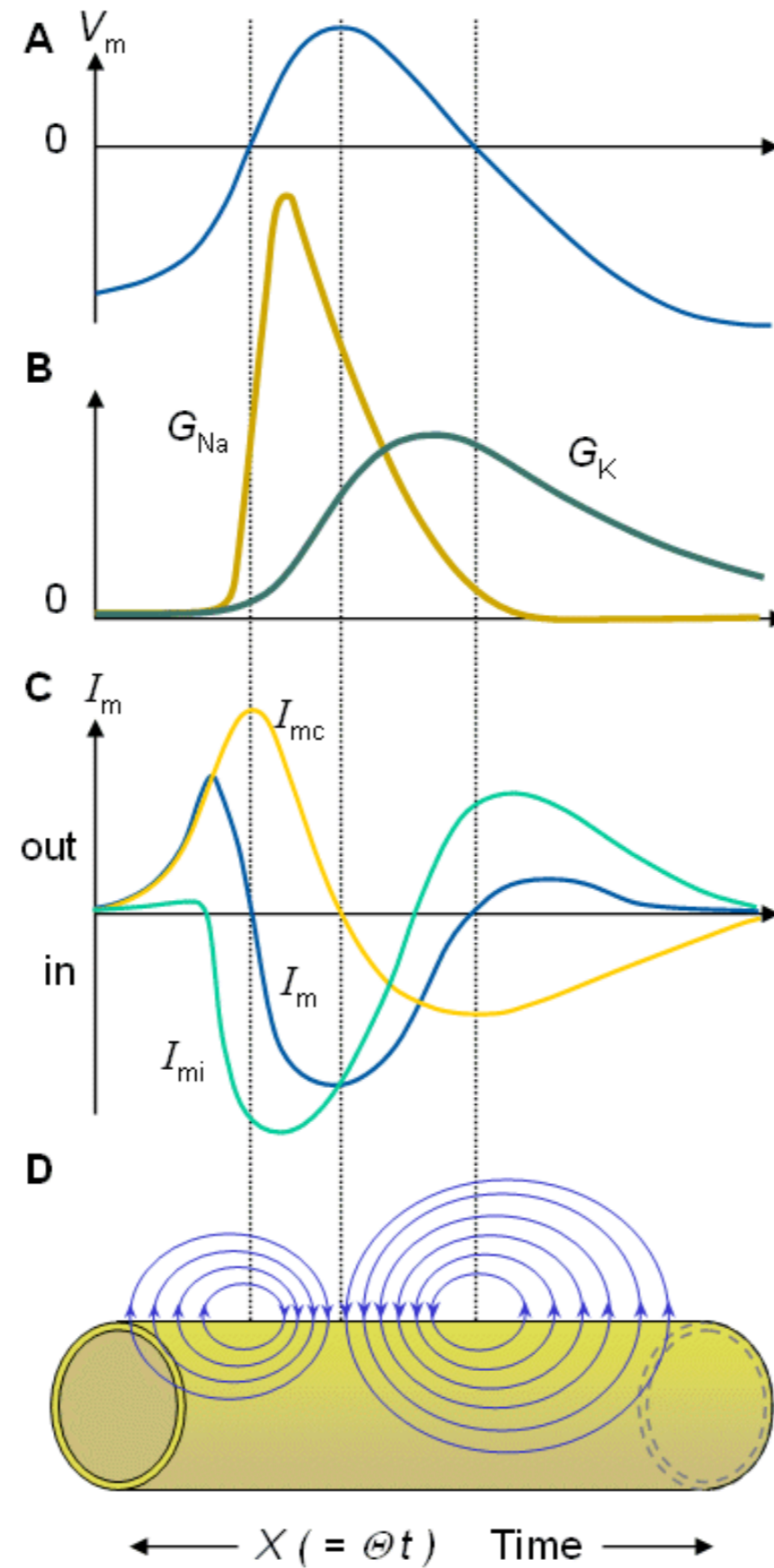


cuore

Genesi elettrocardiogramma



Confronto con neurone



Genesi elettrocardiogramma

- Modelliamo il sistema come un conduttore lineare

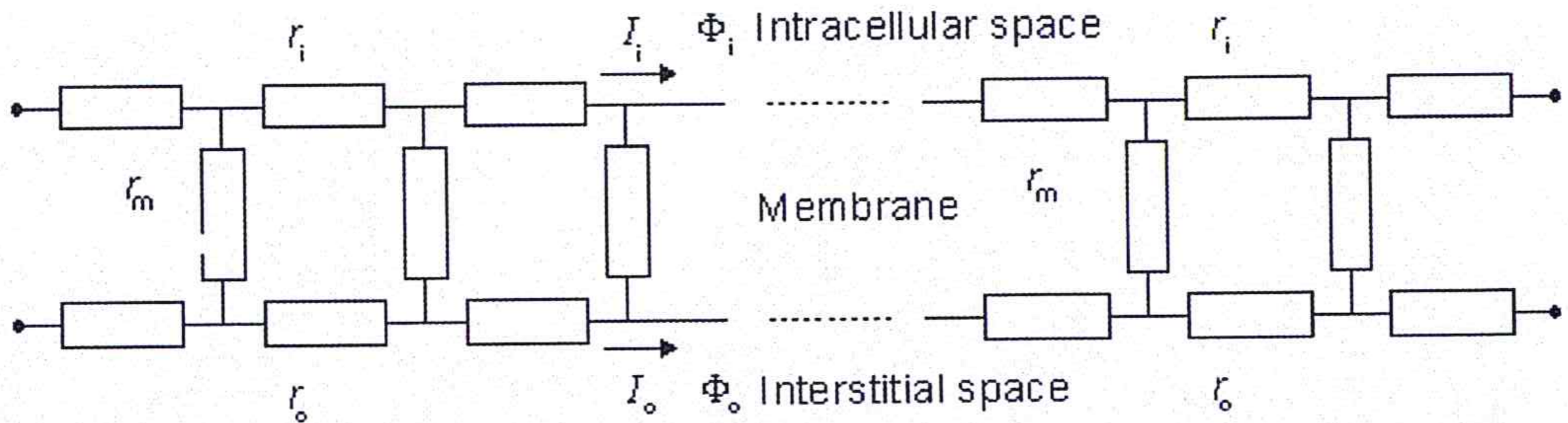


fig.9: Modello circuitale equivalente

Genesi elettrocardiogramma

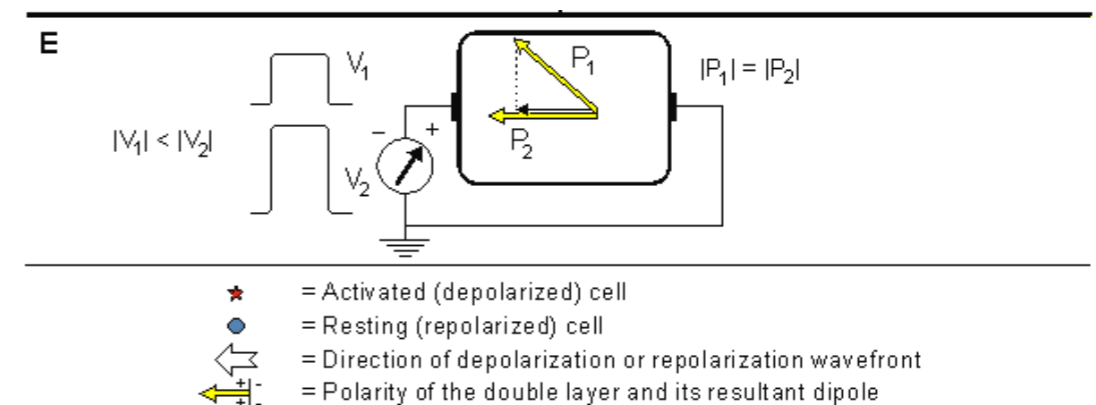
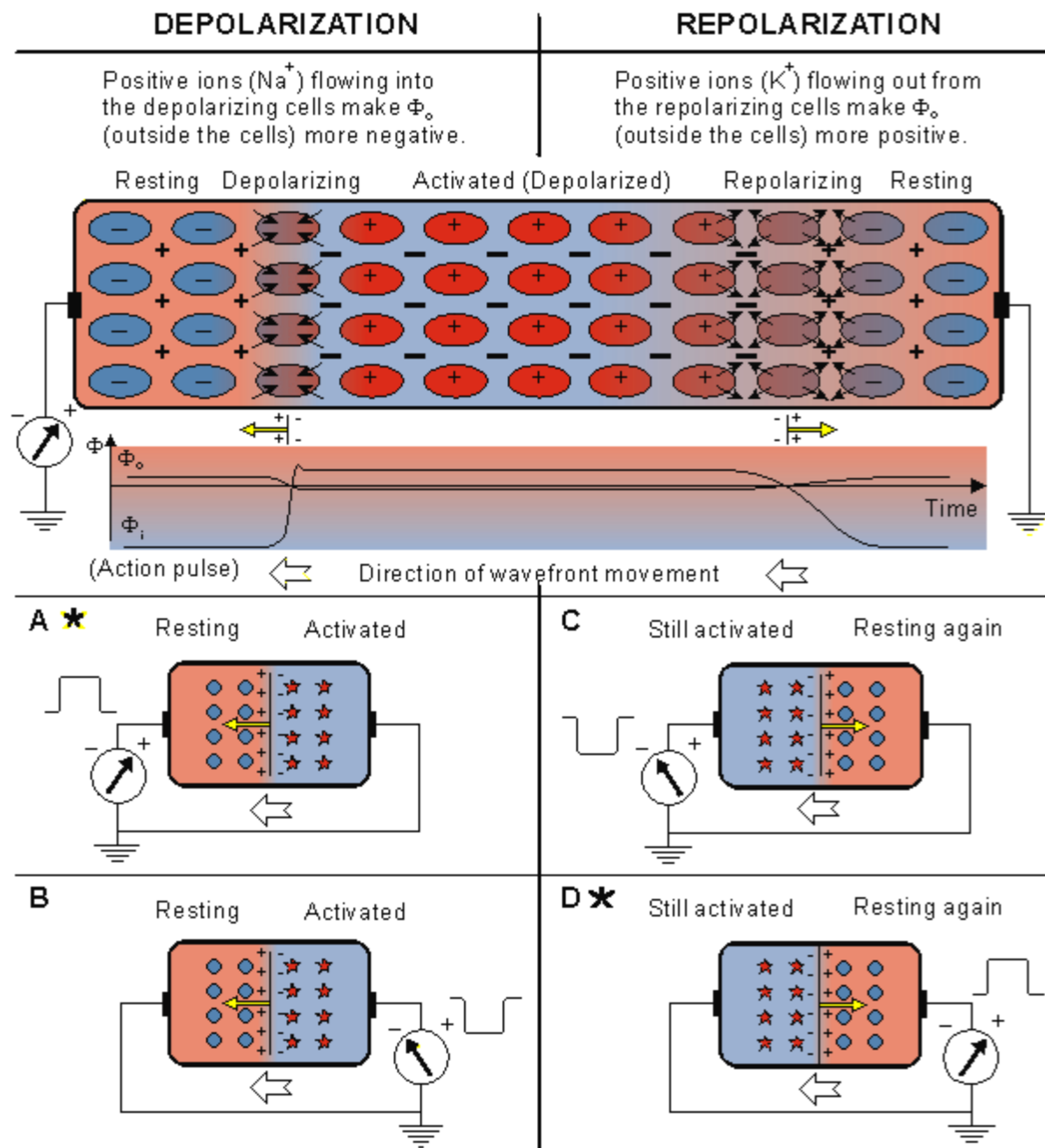
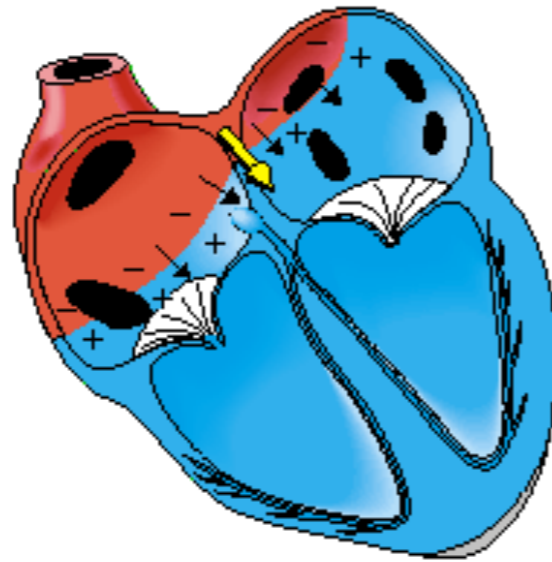
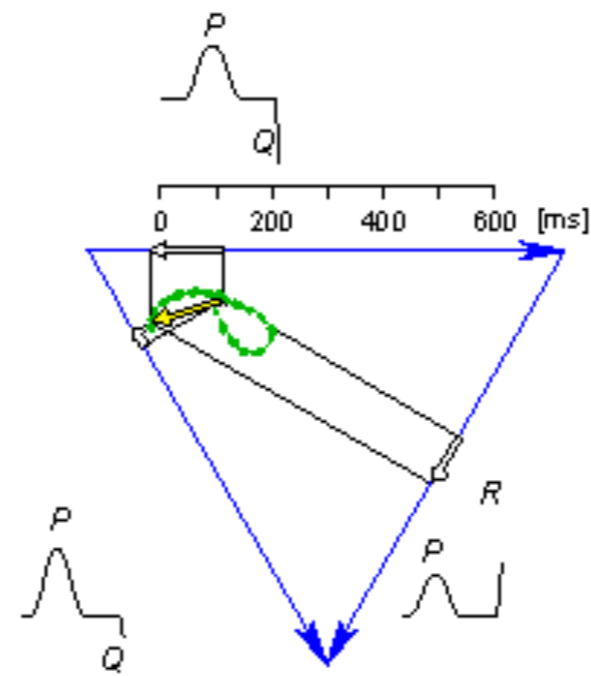
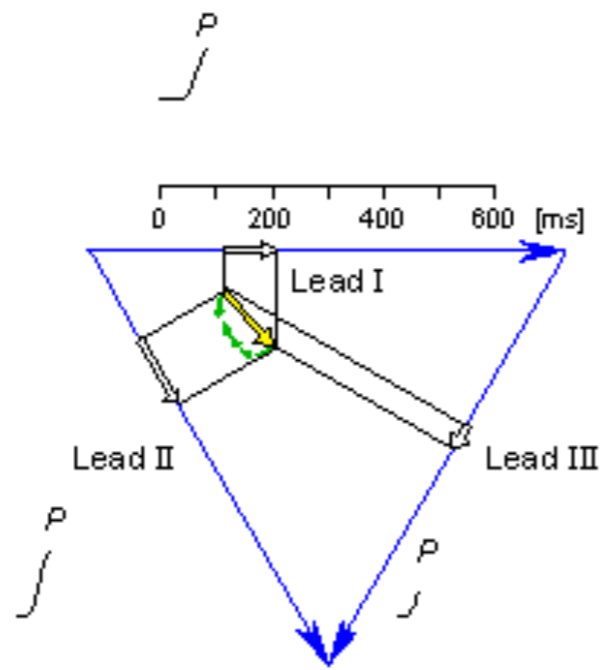


Fig. 15.2. The signal produced by the propagating activation front between a pair of extracellular electrodes.

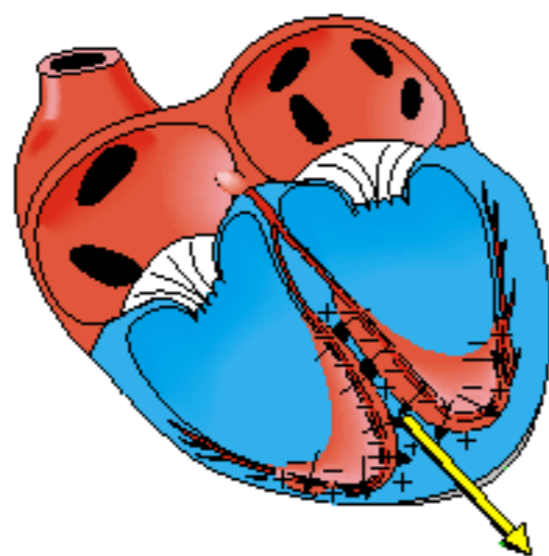
ATRIAL
DEPOLARIZATION
80 ms



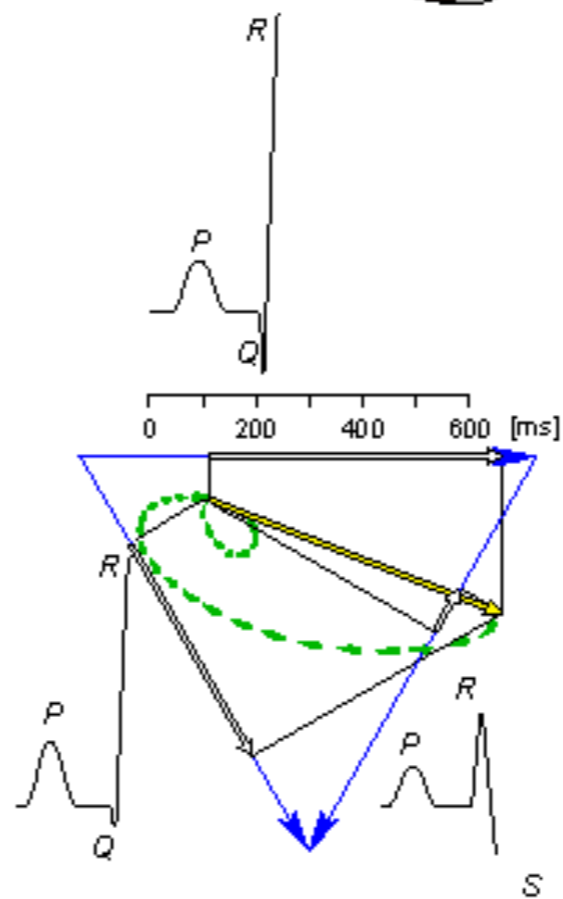
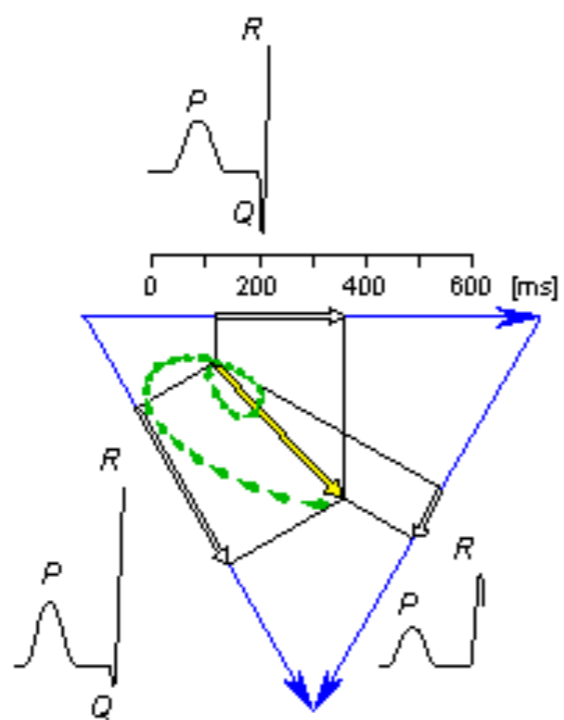
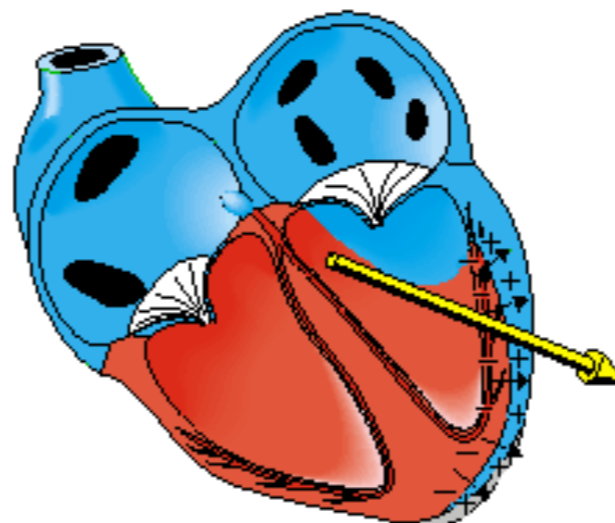
SEPTAL
DEPOLARIZATION
220 ms



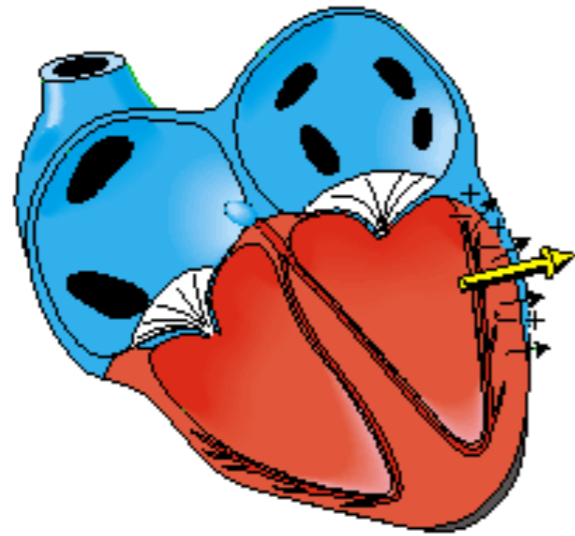
APICAL
DEPOLARIZATION
230 ms



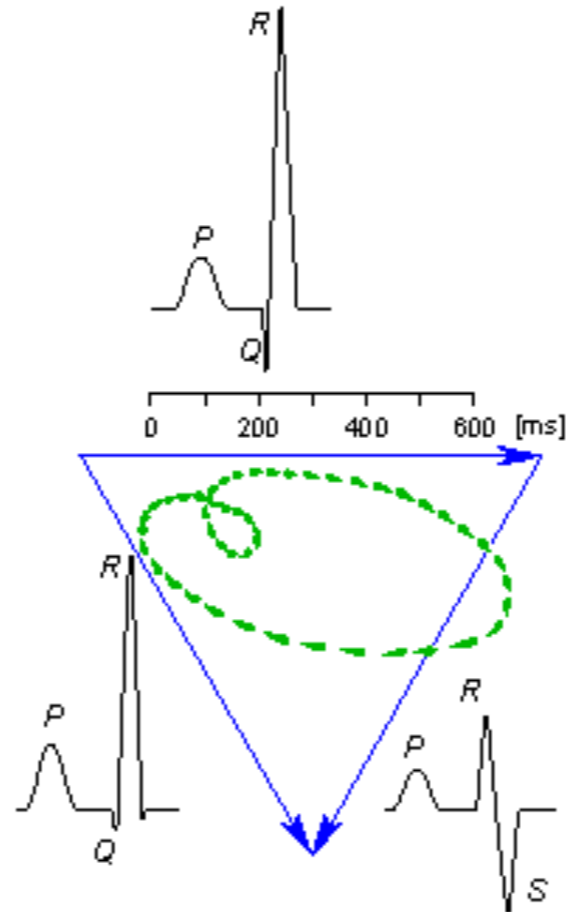
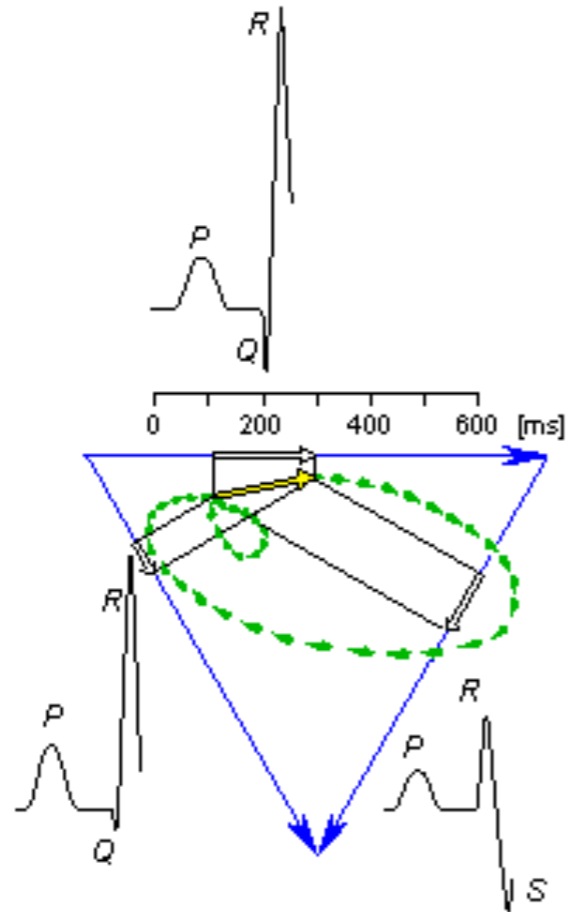
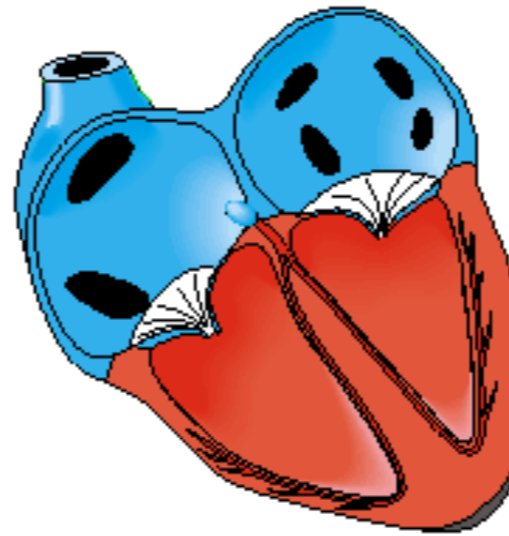
LEFT VENTRICULAR AR
DEPOLARIZATION
240 ms



LATE LEFT VENTRICULAR
DEPOLARIZATION
250 ms

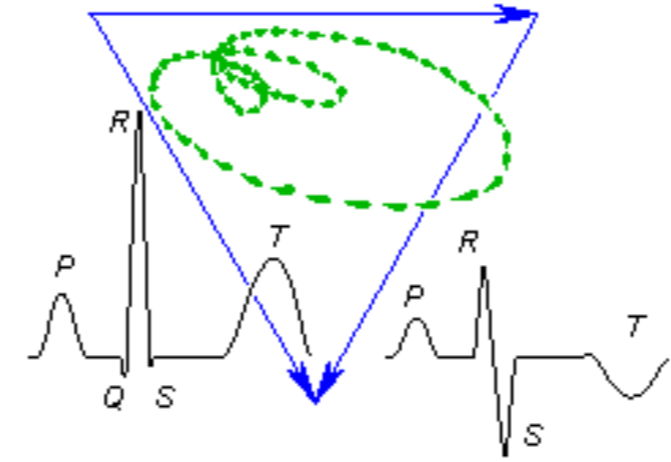
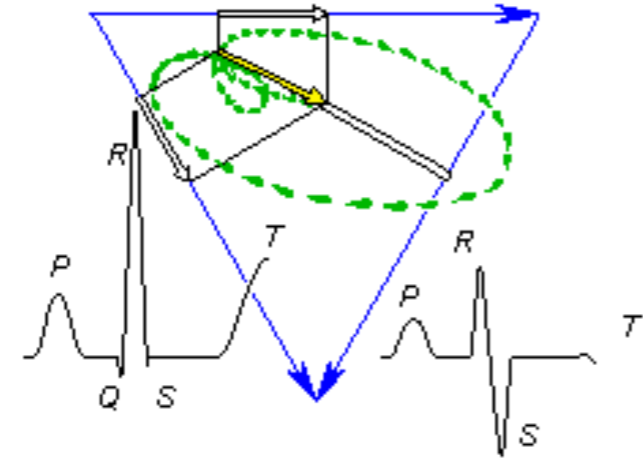
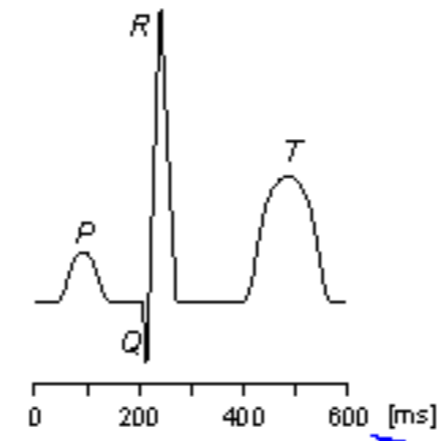
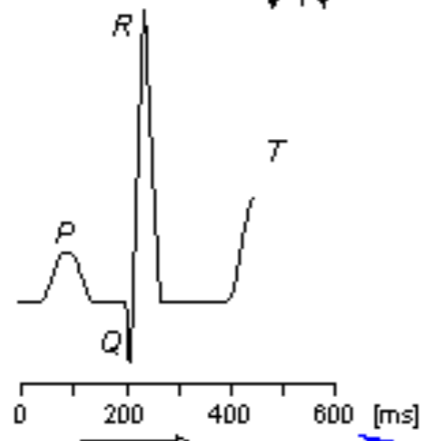
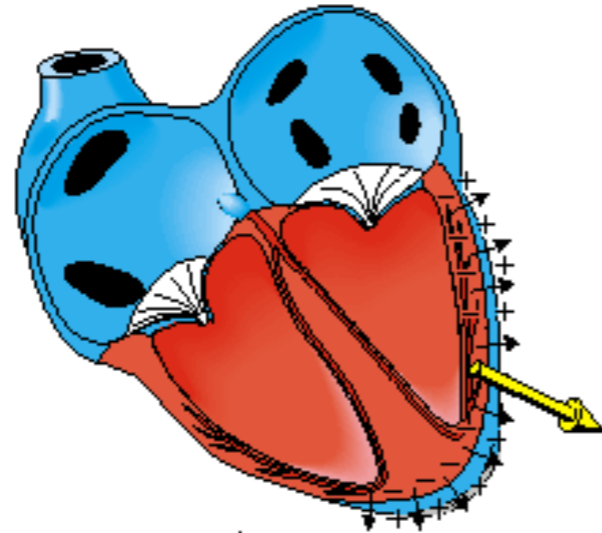


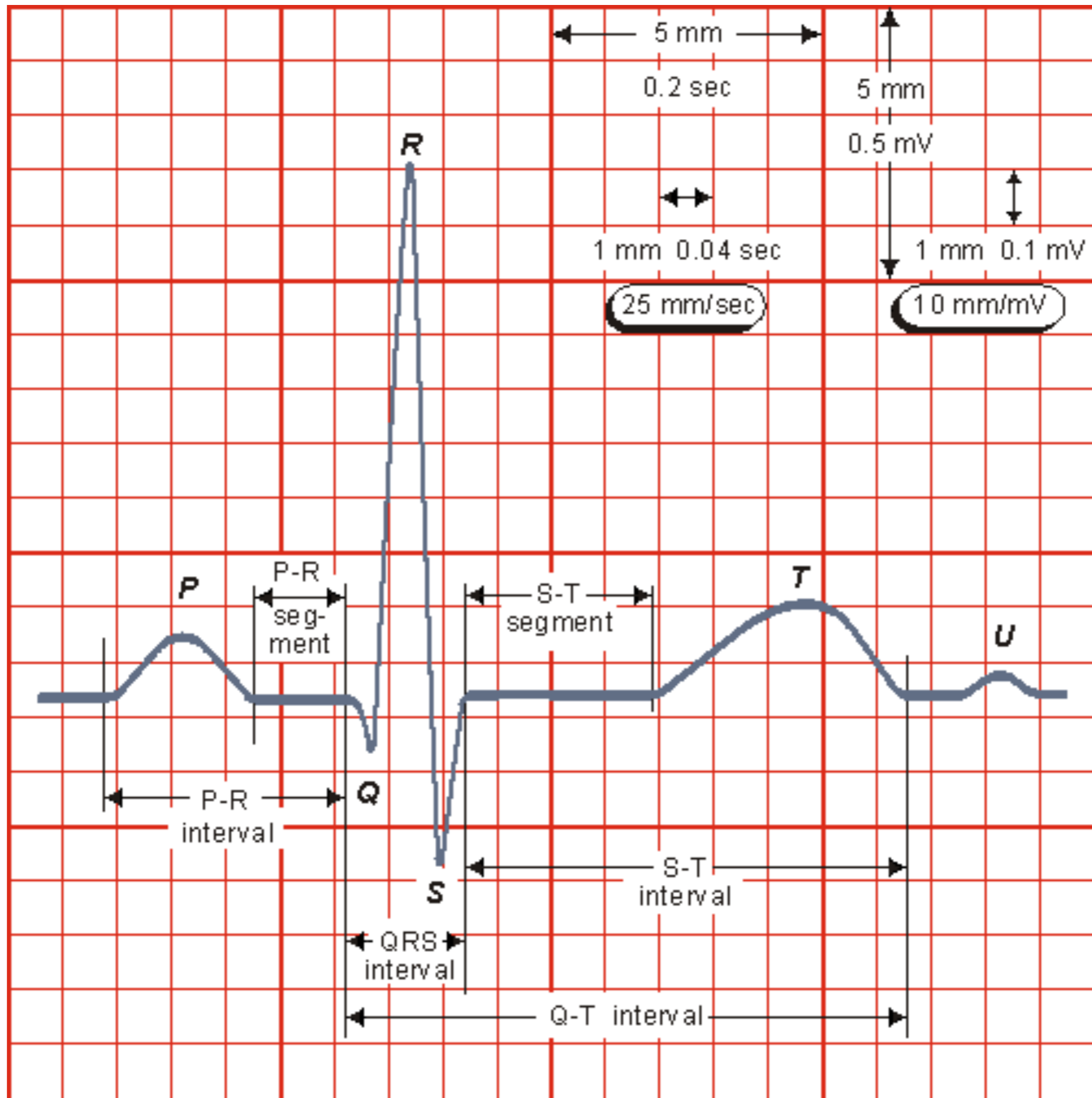
VENTRICLES
DEPOLARIZED
350 ms



VENTRICULAR
REPOLARIZATION
450 ms

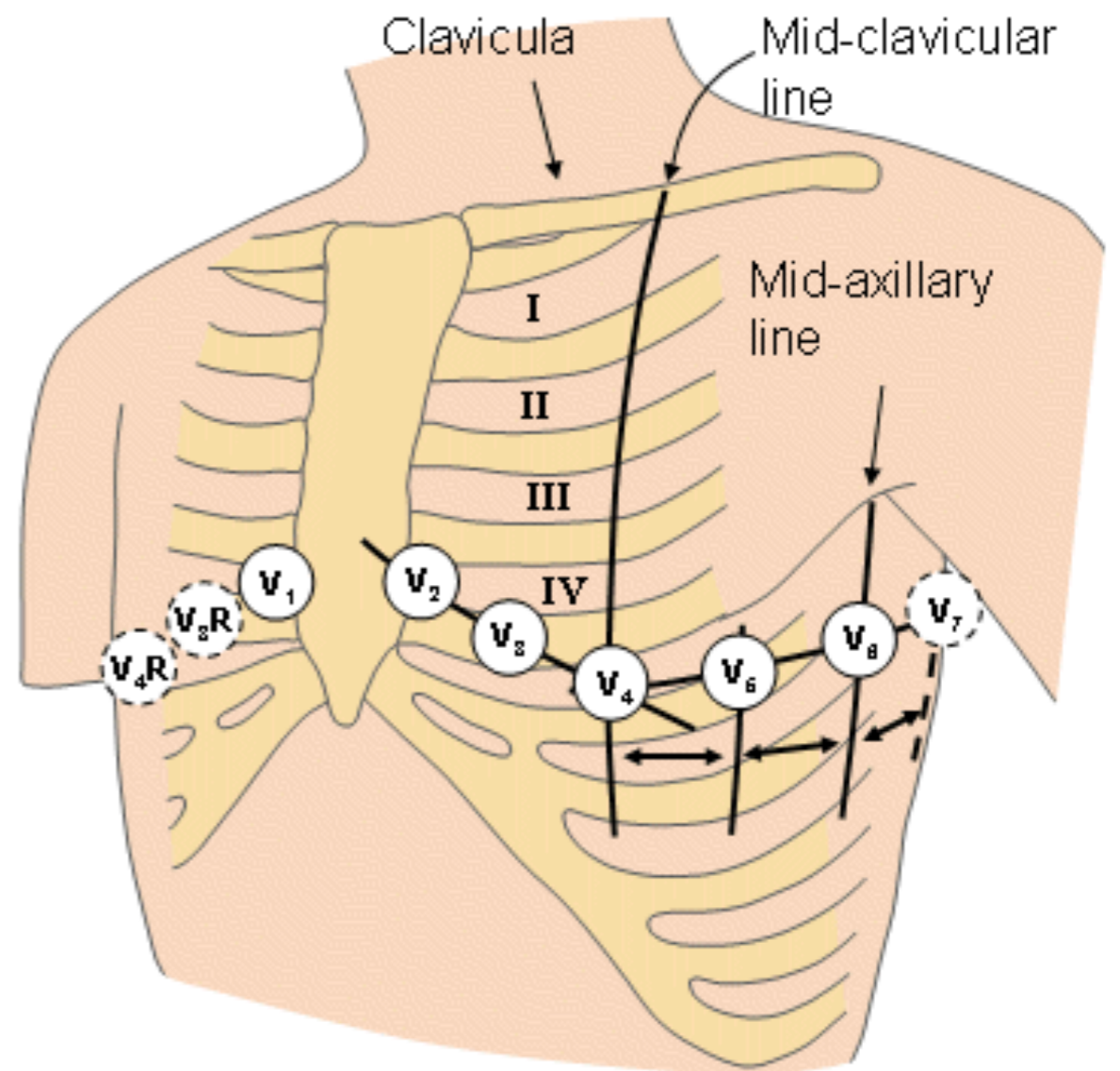
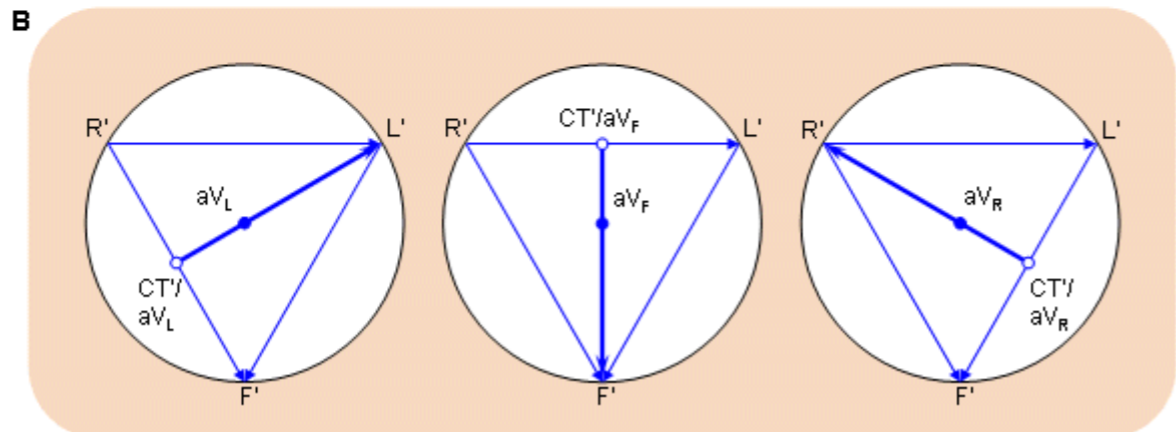
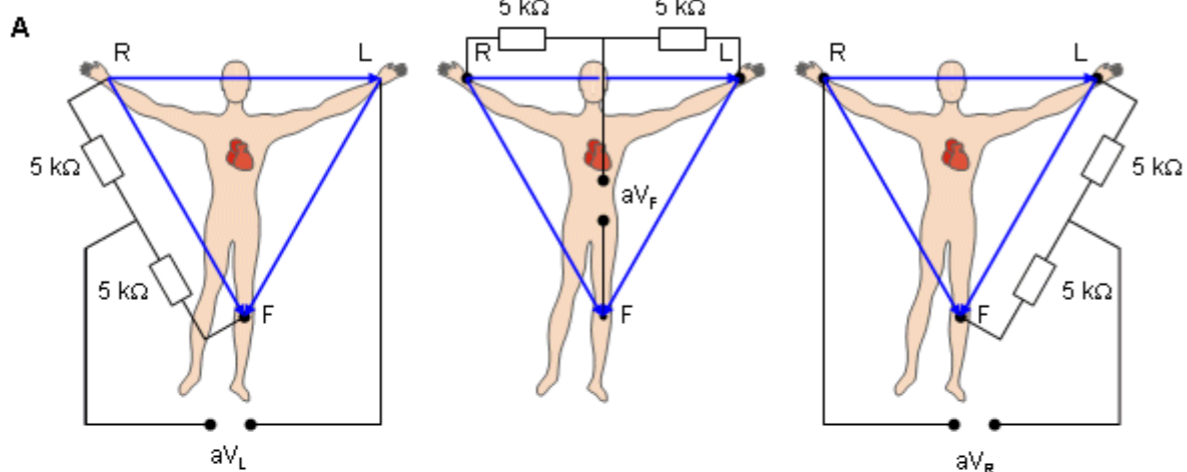
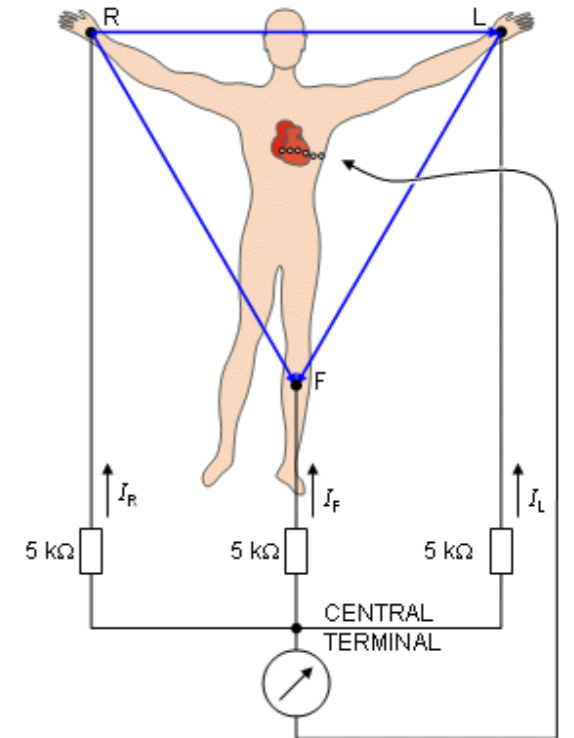
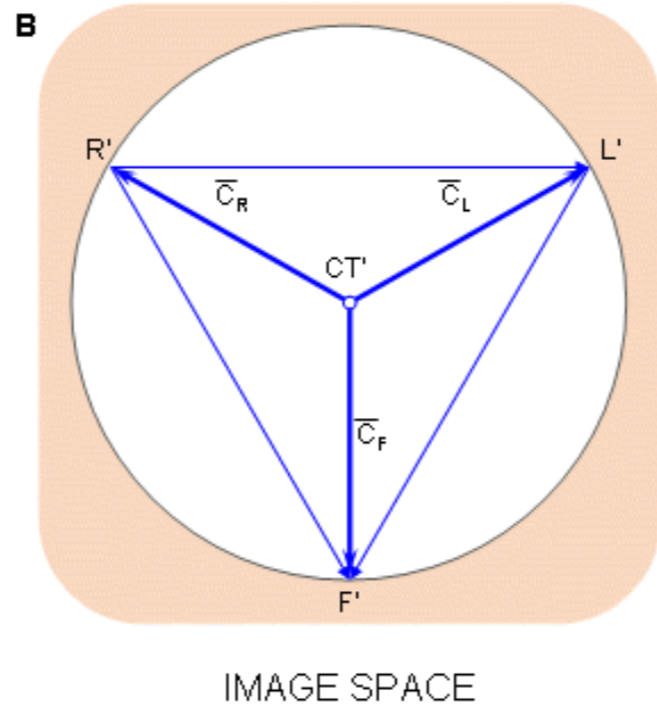
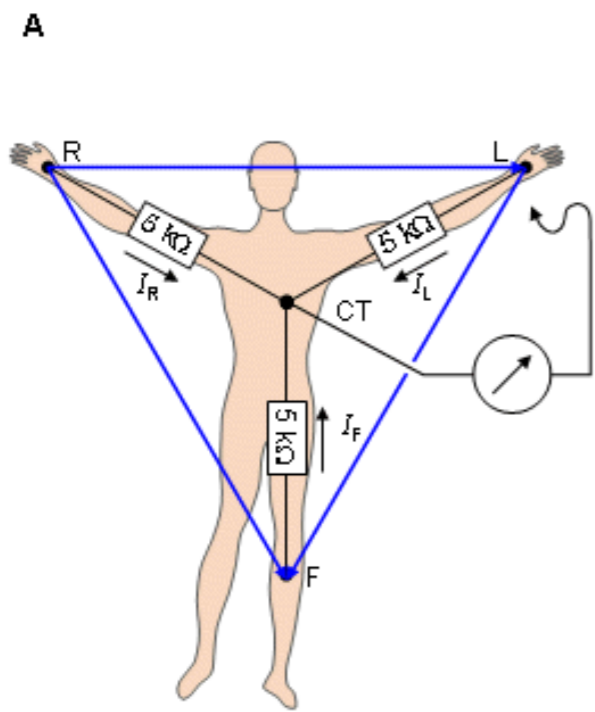
VENTRICLES
REPOLARIZED
600 ms

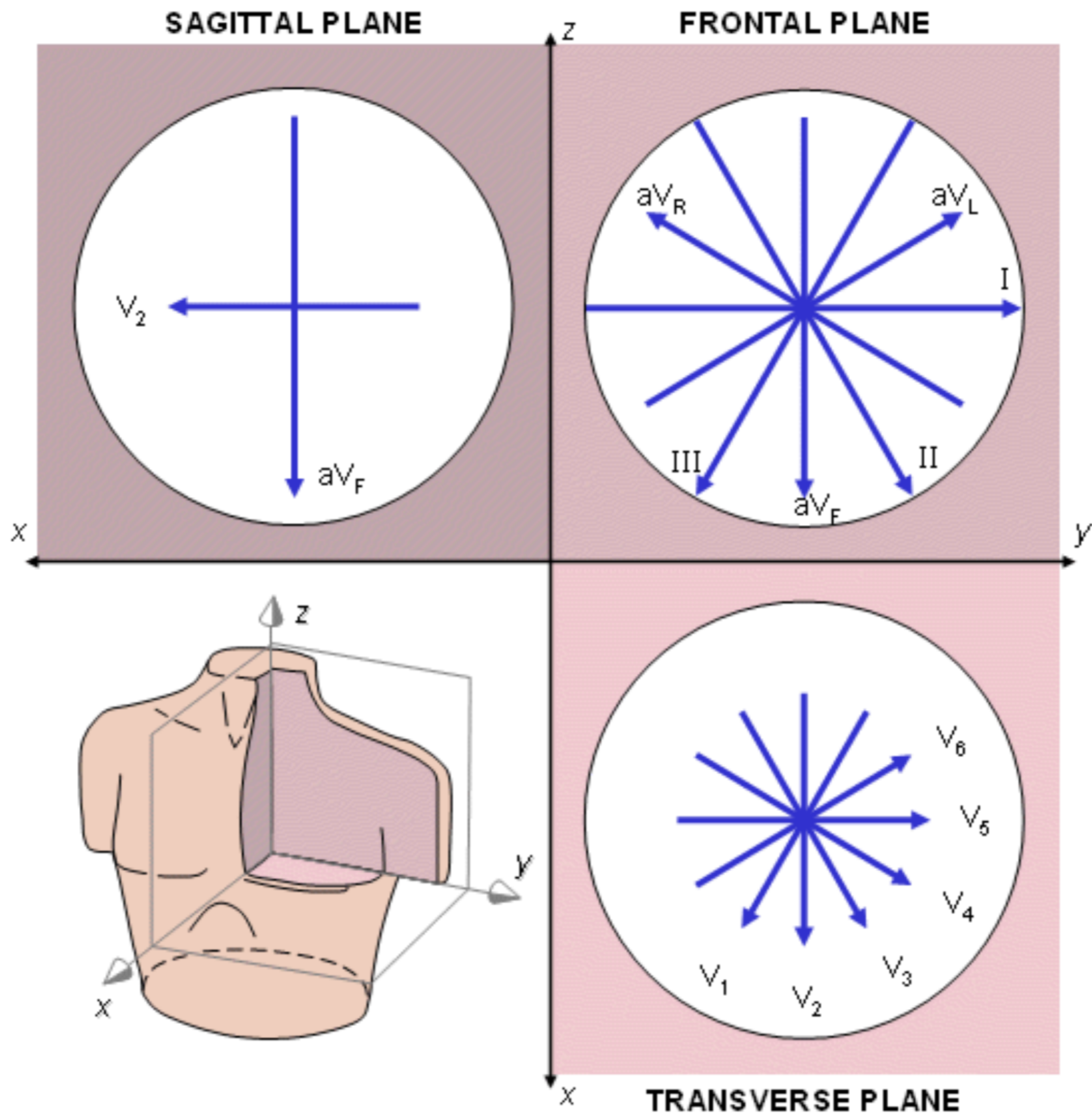




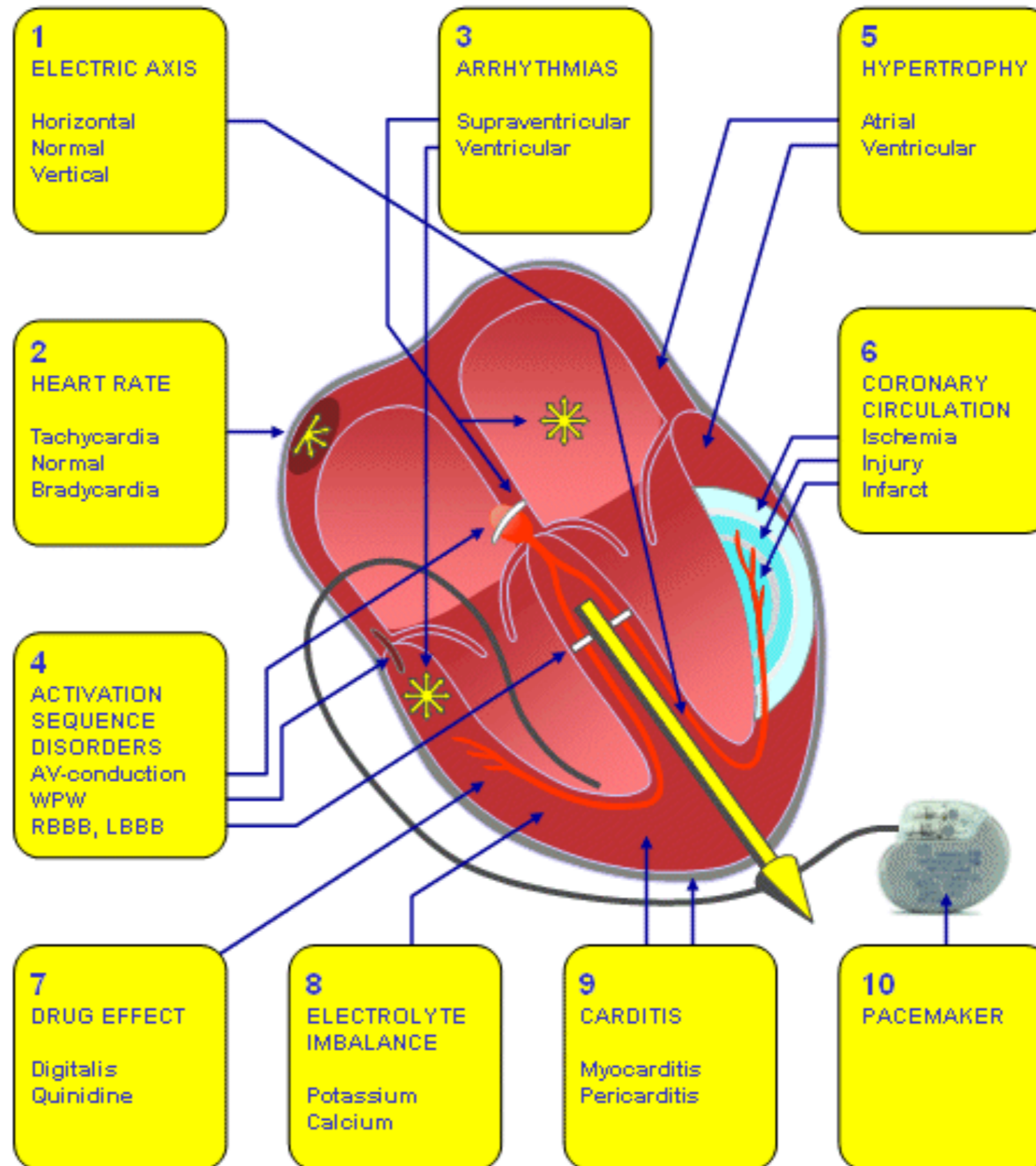
Forma d'onda ECG

Evento	Durata (sec)	Ampiezza (mV)	Significato
ONDA P	0.07-0.12	0.2-0.4	Depolarizzazione atri
COMPLESSO QRS	0.06-0.10	1-2	Depolarizzazione ventricoli
ONDA T	0.18-0.20	0.4-0.5	Ripolarizzazione ventricoli
INTERVALLO P-R	0.12-0.20		Tempo di conduzione atrio-ventricolare
INTERVALLO Q-T	0.40-0.42		Tempo depolarizzazione e ripolarizzazione ventricoli
INTERVALLO S-T	0.30-0.34		Tempo dalla fine della depolarizzazione all'inizio della ripolarizzazione ventricoli
INTERVALLO R-R	0.8-0.9		Durata ciclo cardiaco





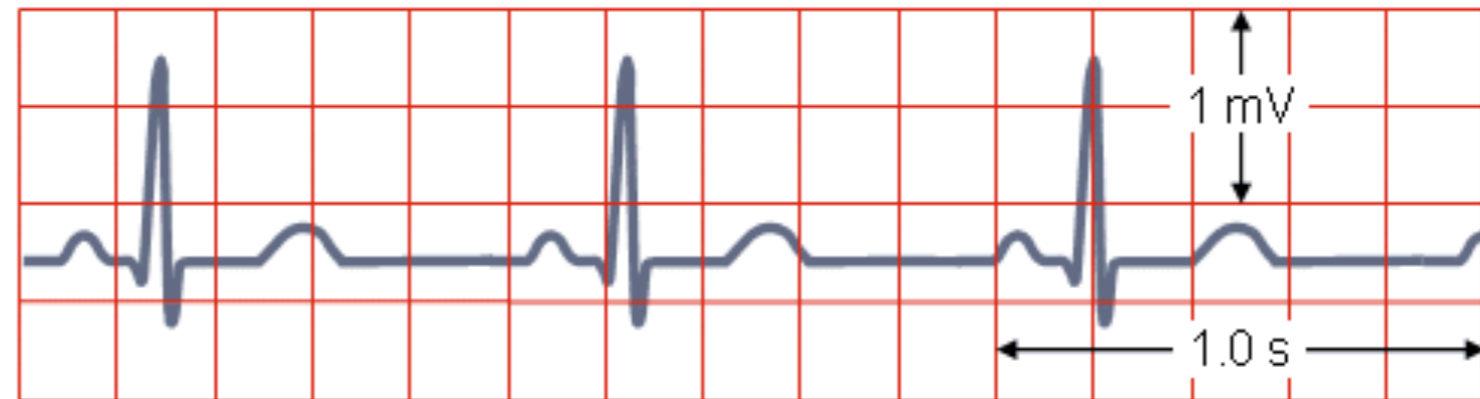
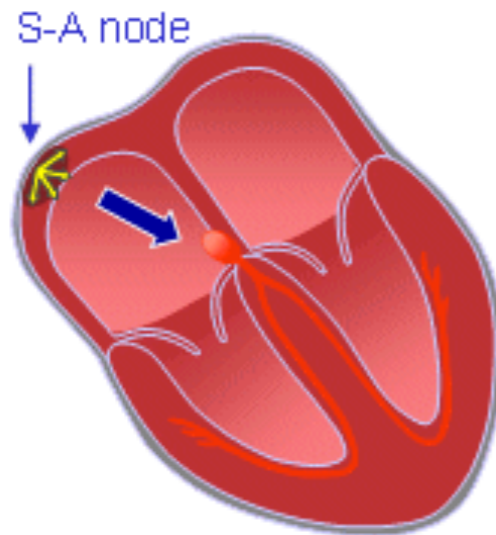
Diagnosi ECG



Ritmi sopraventricolari (generati agli atri o al nodo AV) -
ritmi sinusali
(generati nodo SA - complessi normali)

NORMAL SINUS RHYTHM

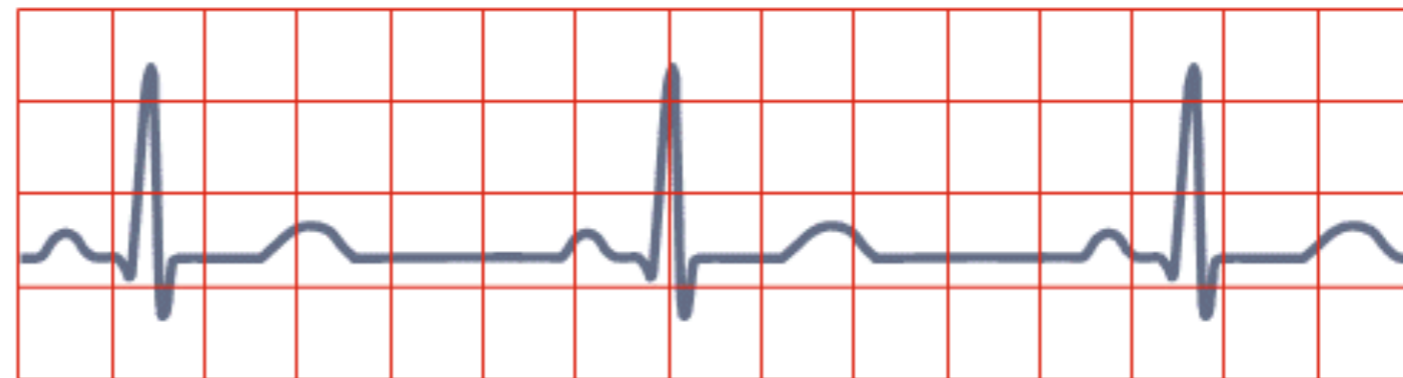
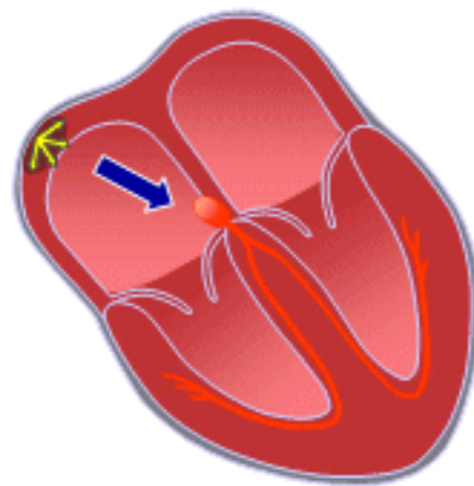
Impulses originate at S-A node at normal rate



All complexes normal, evenly spaced. Rate 60 – 100/min.

SINUS BRADYCARDIA

Impulses originate at S-A node at slow rate

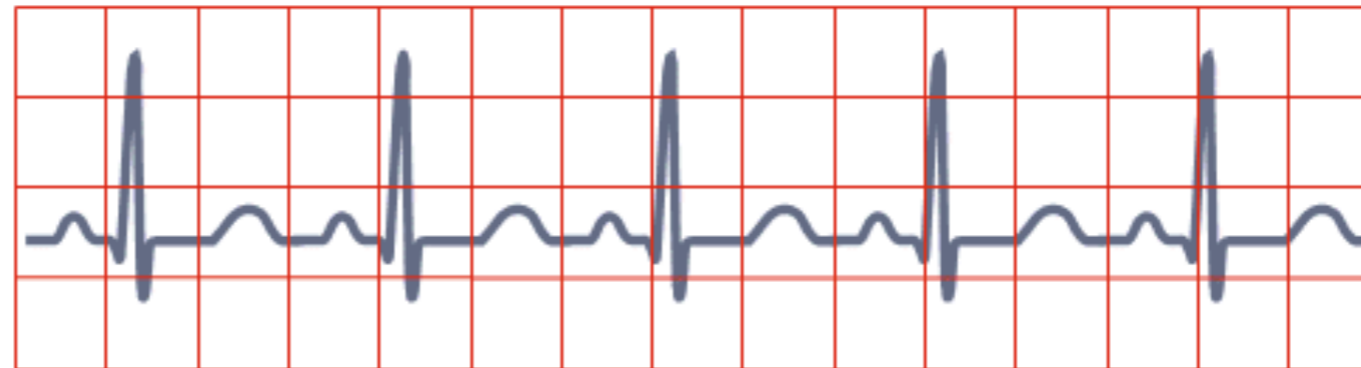
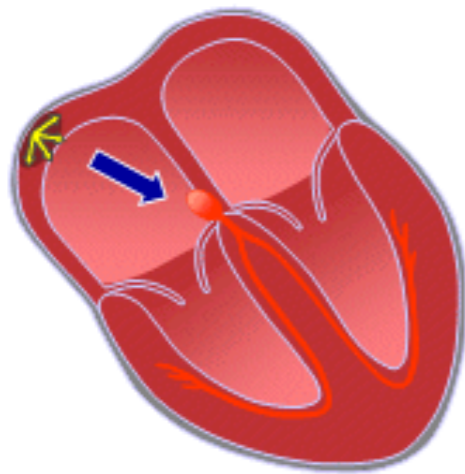


All complexes normal, evenly spaced. Rate < 60/min.

Come identificarli con una procedura automatica?

SINUS TACHYCARDIA

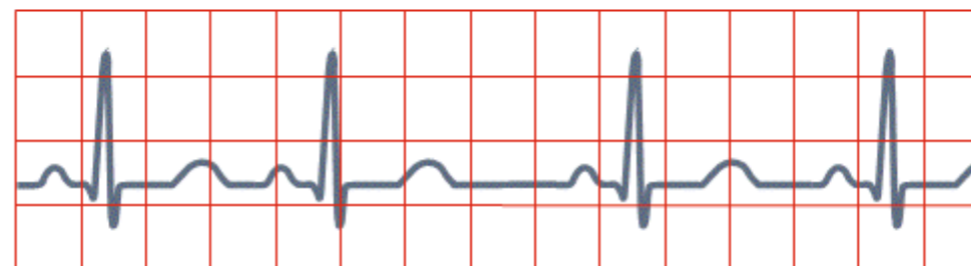
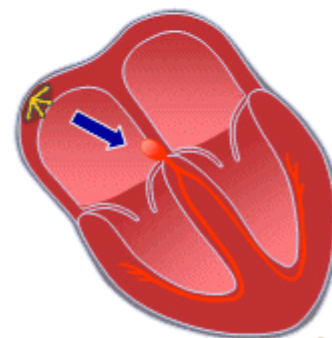
Impulses originate at S-A node at rapid rate



All complexes normal, evenly spaced. Rate $>100/\text{min}$.

SINUS ARRHYTHMIA

Impulses originate at S-A node at varying rate

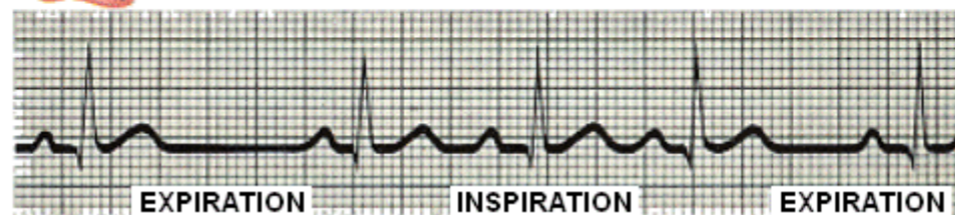
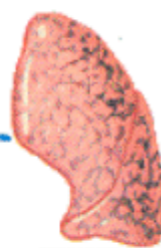


All complexes normal, rhythm is irregular
Longest R-R interval exceeds shortest $> 0.16 \text{ s}$

MEDULLA
OBLONGATA

VAGUS NERVE

S-A NODE
PACEMAKER
ACTIVITY
VARIES
REFLEXLY
WITH
RESPIRATION



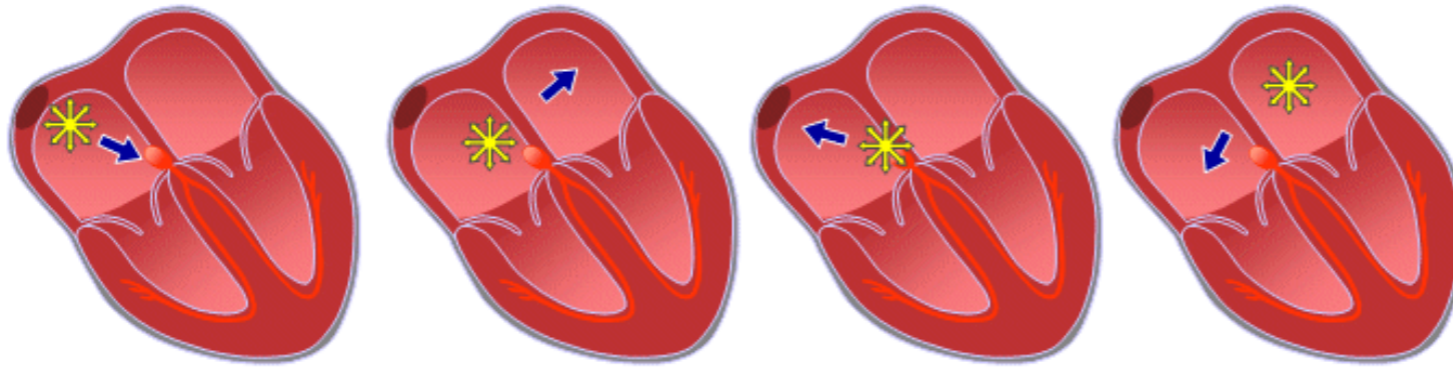
Ritmi sopraventricolari -

ritmi non-sinusali

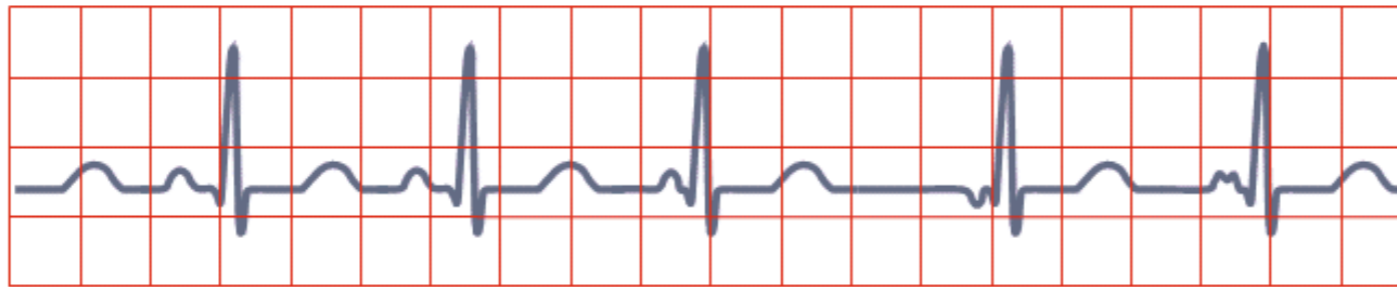
(non generati nel nodo SA - se vicini ad AV direzione opposta e segno onda P opposto - in generale onde P - complessi QRS normali anche se non spaziate regolarmente)

WANDERING PACEMAKER

Impulses originate from varying points in atria



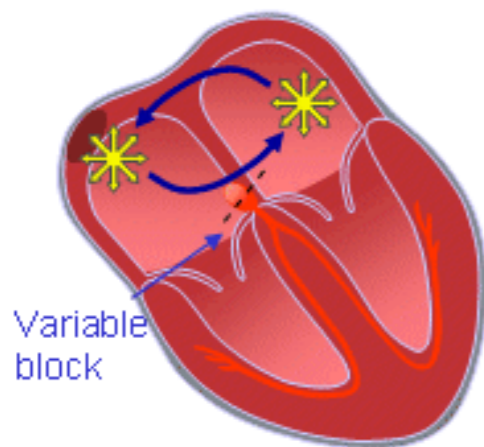
l'origine dell'attivazione si sposta



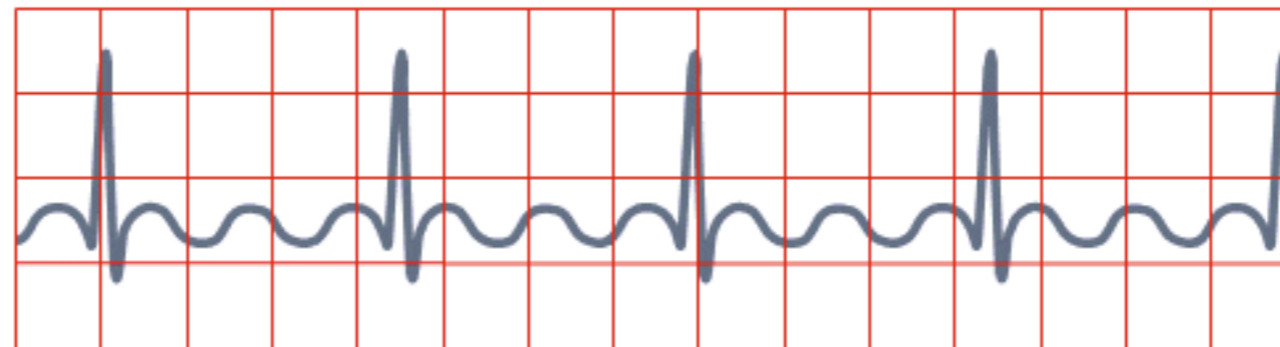
Variation in P-wave contour, P-R and P-P interval and therefore in R-R intervals

ATRIAL FLUTTER

Impulses travel in circular course in atria



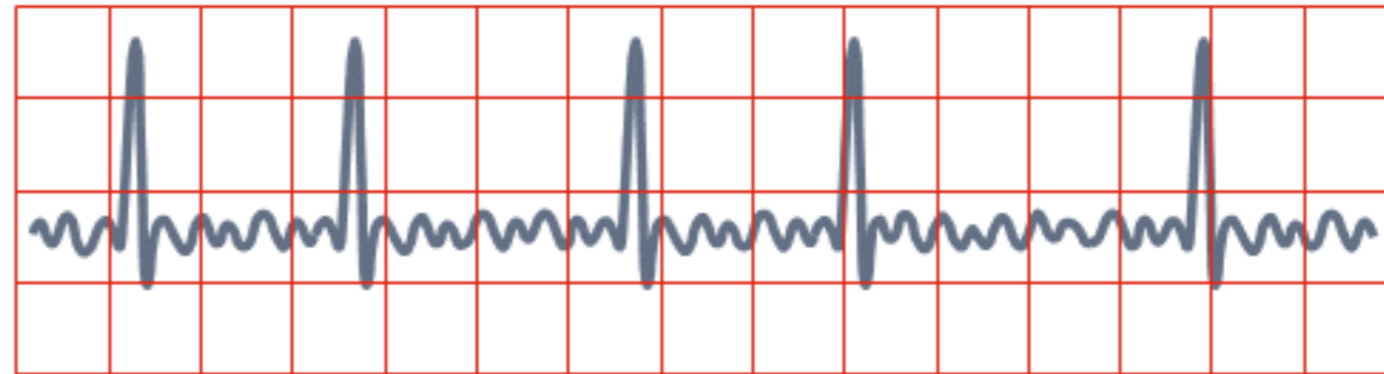
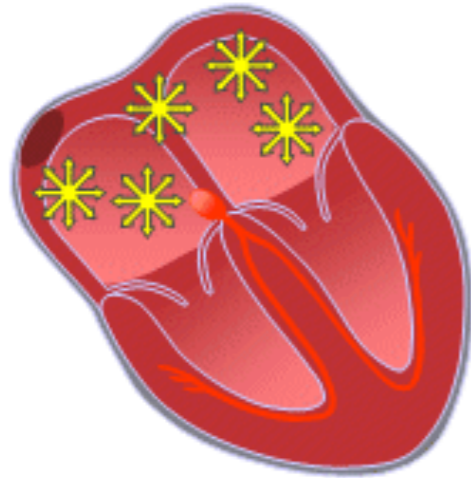
impulsi atriali 200-300/min
1:2 o 1:3
attivano nodo AV, non si discrimina P da T



Rapid flutter waves, ventricular response irregular

ATRIAL FIBRILLATION

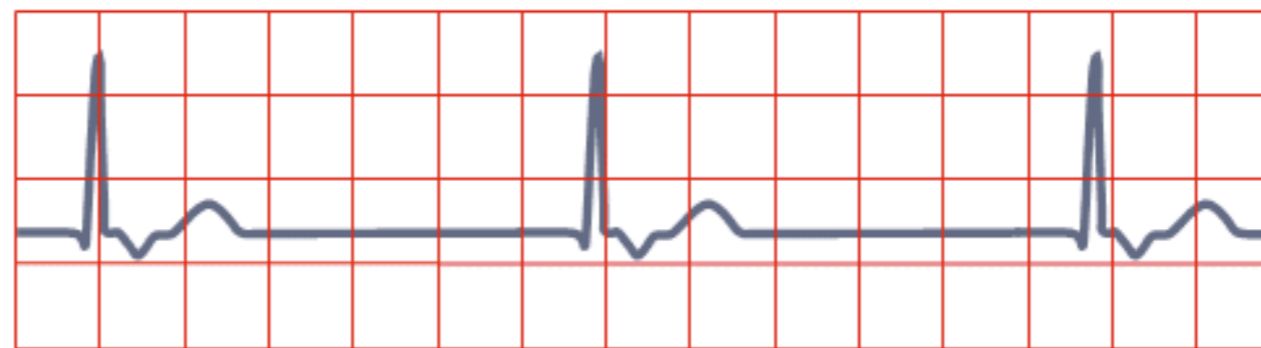
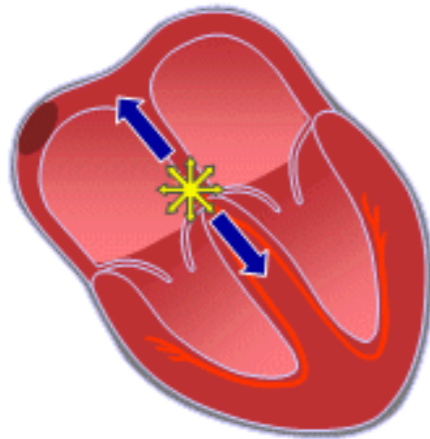
Impulses have chaotic, random pathways in atria



Baseline irregular, ventricular response irregular

JUNCTIONAL RHYTHM

Impulses originate at AV node with retrograde and antegrade direction



P-wave is often inverted, may be under or after QRS complex

Heart rate is slow

origine nel nodo AV -> frequenza
attivazione più bassa (onda P può
sovrapporsi a QRS)

Aritmie ventricolari

L'attivazione non si origina dal nodo AV e non si propaga nei ventricoli in modo normale (in generale complessi QRS di forma anomala)

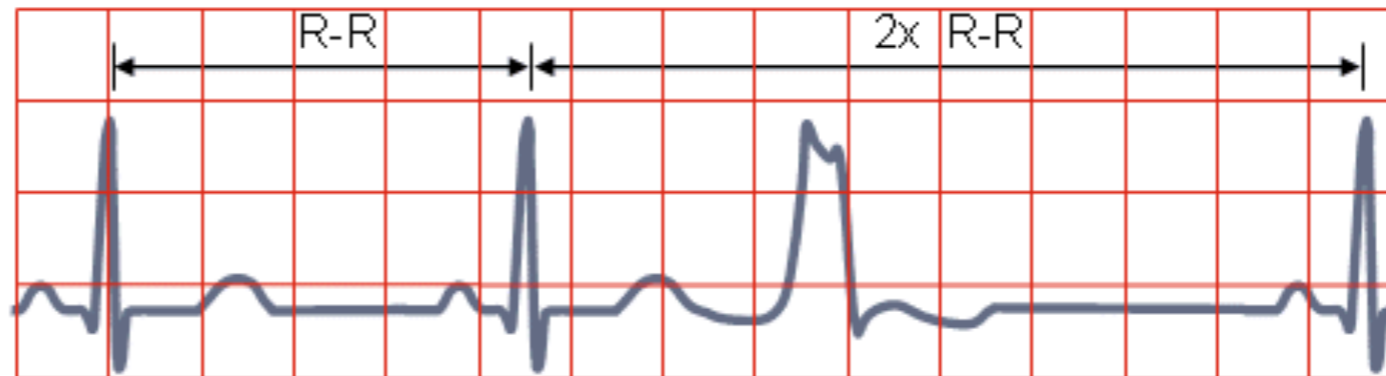
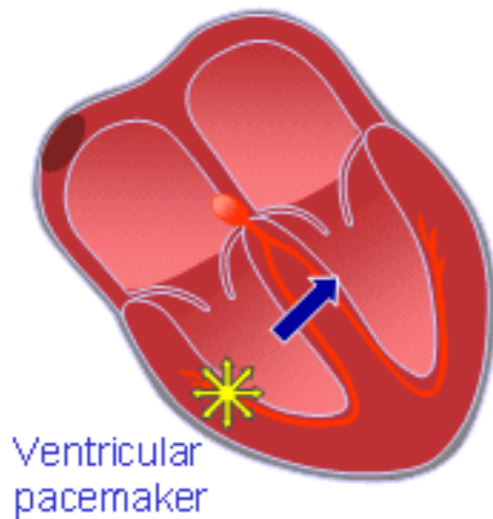
Se l'attivazione procede ai ventricoli dal sistema di conduzione: pareti interne attivate simultaneamente e il fronte procede radialmente verso le pareti esterne (QRS di durata breve)

Se il sistema di conduzione è danneggiato o l'attivazione inizia lontano dal nodo AV: più tempo necessario al fronte di attivazione per attraversare tutta la massa ventricolare (QRS di durata lunga).

Normale attivazione ventricolare: durata QRS < 0.1 sec

PREMATURE VENTRICULAR CONTRACTION

A single impulse originates at right ventricle

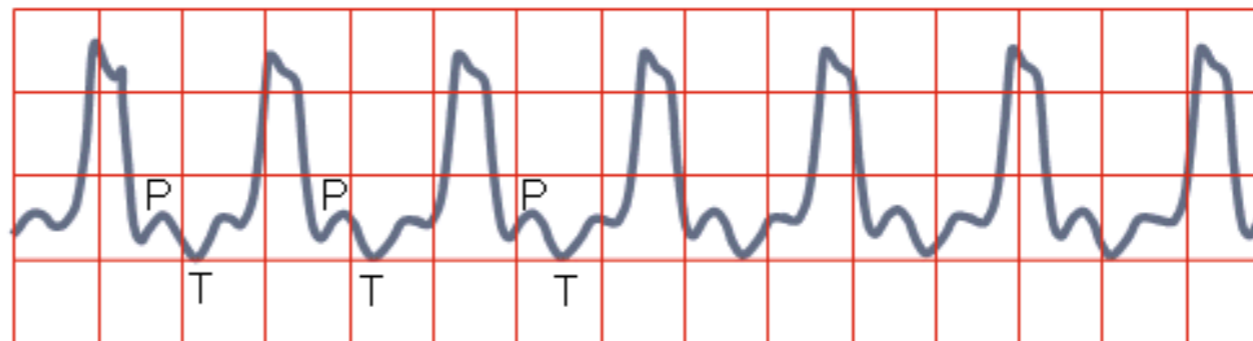
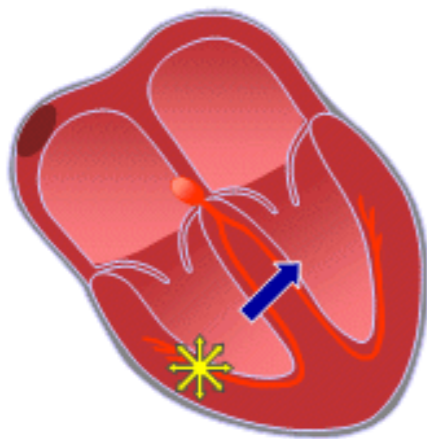


Time interval between normal R peaks is a multiple of R-R interval

Unico complesso di forma anomala, non è correlato con onda P, ha durata lunga se si genera nel muscolo ventricolare

VENTRICULAR TACHYCARDIA

Impulses originate at ventricular pacemaker

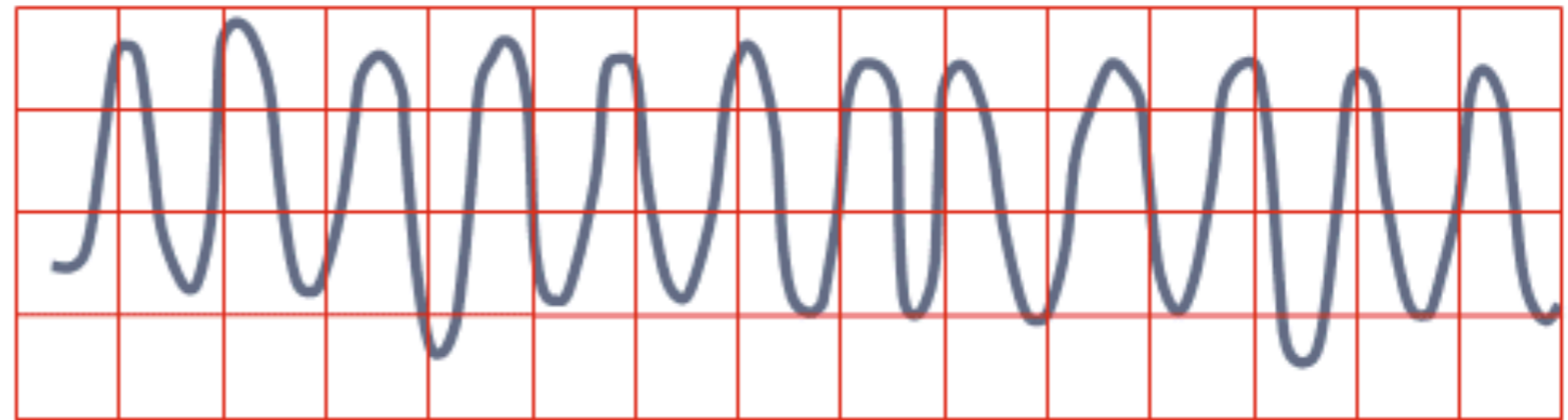
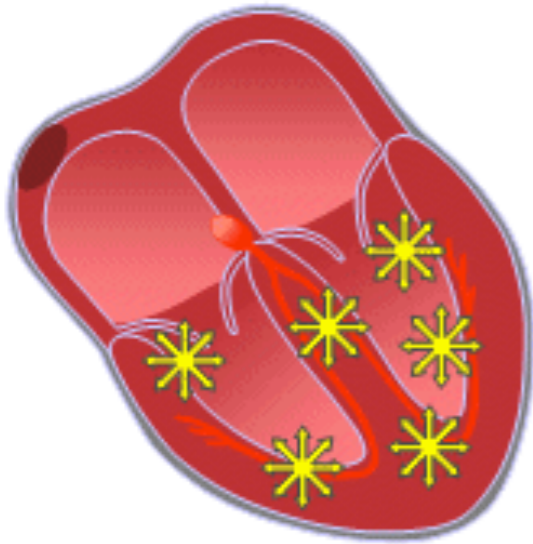


Wide ventricular complexes. Rate > 120/min

spesso conseguenza di ischemia e infarto miocardico (l'attivazione circolare, torna indietro -> attivazione ventricolare a alta frequenza 100-200 battiti/min). Può portare alla fibrillazione ventricolare

VENTRICULAR FIBRILLATION

Chaotic ventricular depolarization



Rapid, wide irregular ventricular complexes

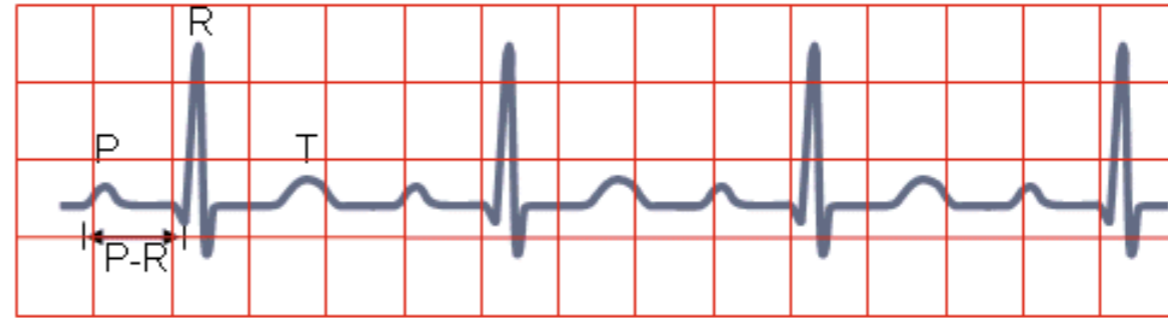
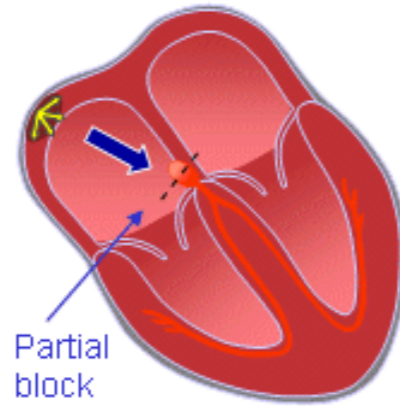
- Causata da multipli cicli di attivazione retrograda dovuti al muscolo cardiaco danneggiato
- Contrazione irregolare con non sufficiente pompaggio di sangue
- Conseguenze mortali

Disordini alla sequenza di attivazione

(blocchi AV - blocchi fascio HIS dx o sx)

A-V BLOCK, FIRST DEGREE

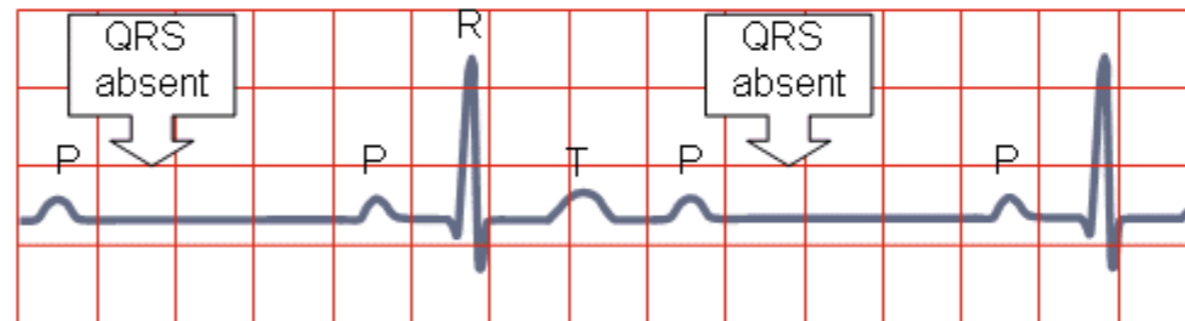
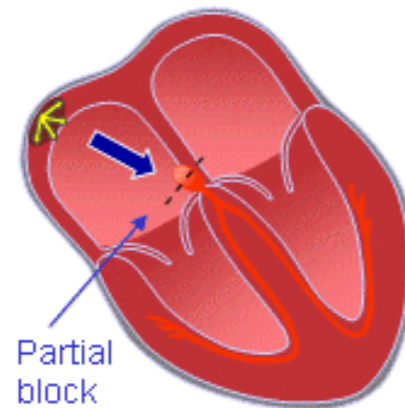
Atrioventricular conduction lengthened



P-wave precedes each QRS-complex but interval is > 0.2 s

A-V BLOCK, SECOND DEGREE

Sudden dropped QRS-complex

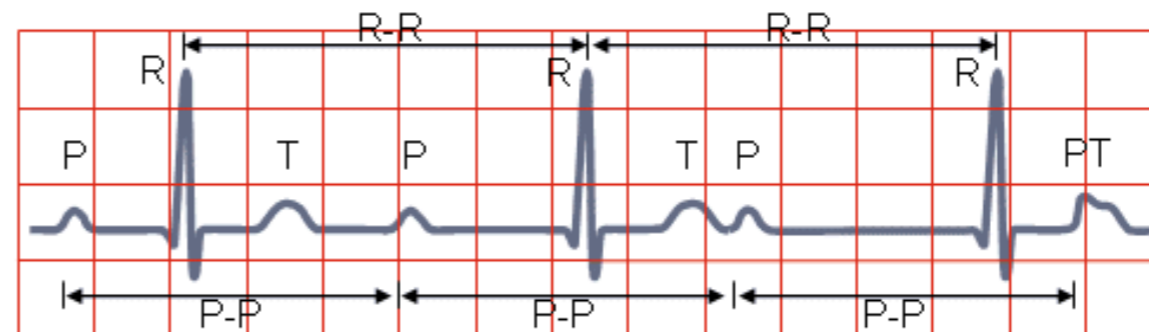
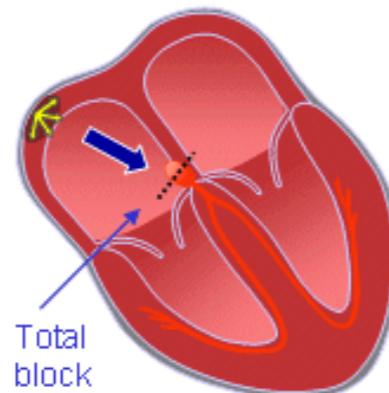


Intermittently skipped ventricular beat

A-V BLOCK, THIRD DEGREE

Impulses originate at AV-node and proceed to ventricles

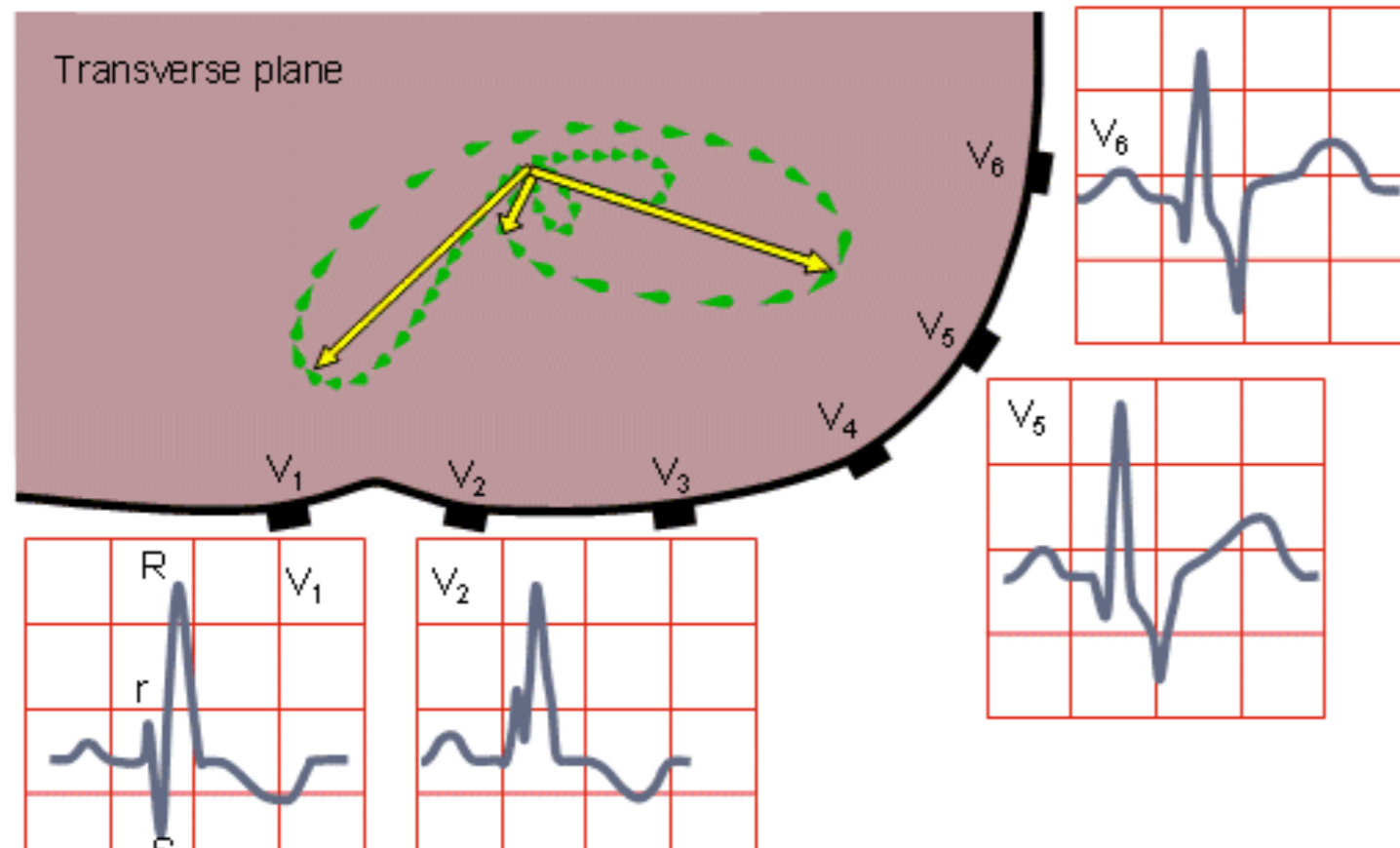
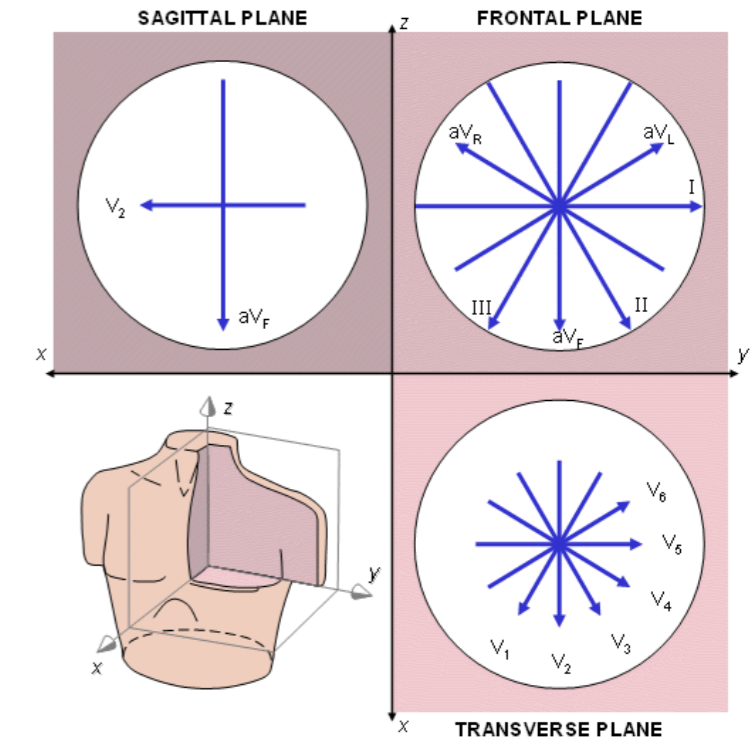
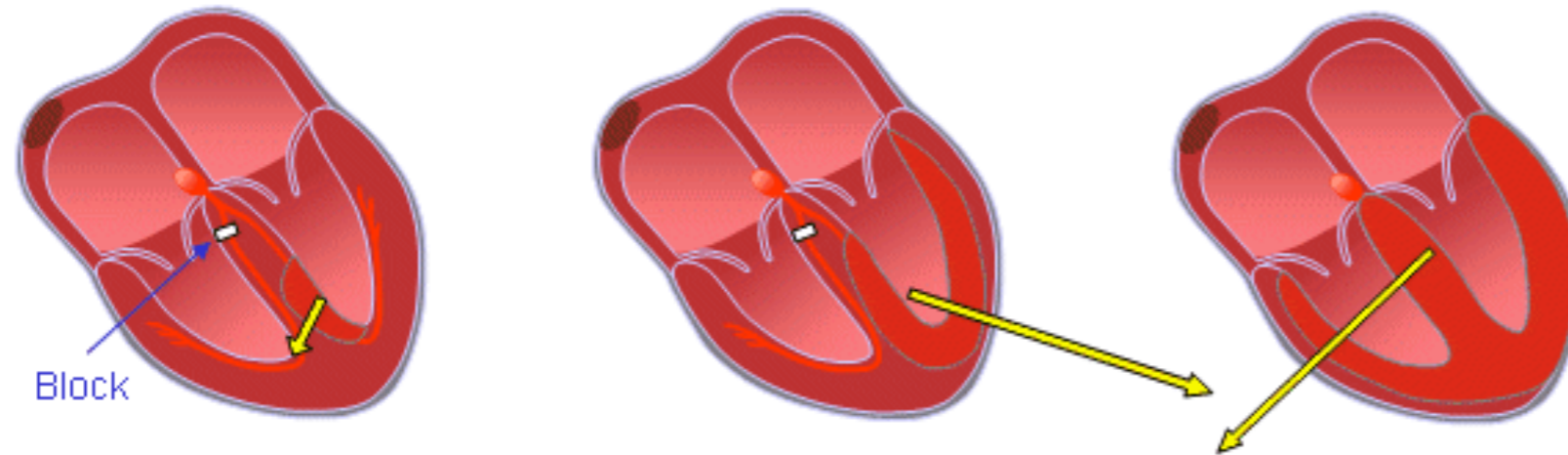
Atrial and ventricular activities are not synchronous



P-P interval normal and constant,
QRS complexes normal, rate constant, 20 – 55 /min

RIGHT BUNDLE-BRANCH BLOCK

QRS duration greater than 0.12 s
Wide S wave in leads I, V5, and V6



vettore P finale
diretto verso RV
(larga onda S in VI)

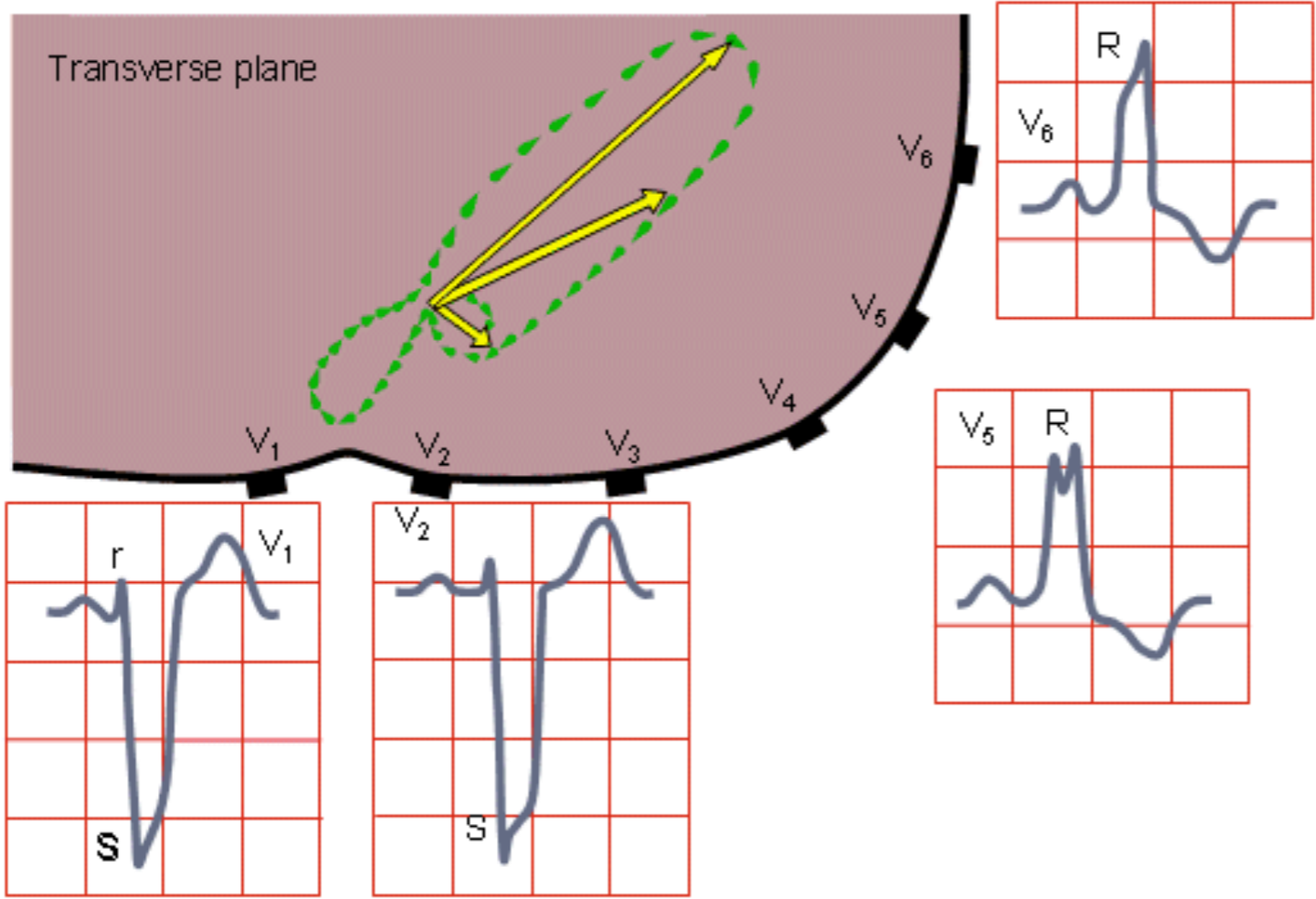
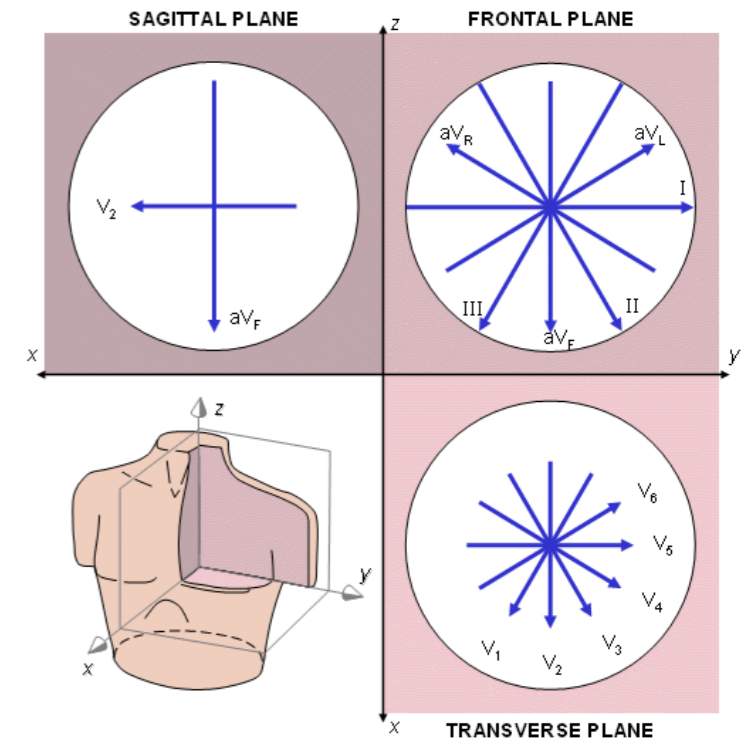
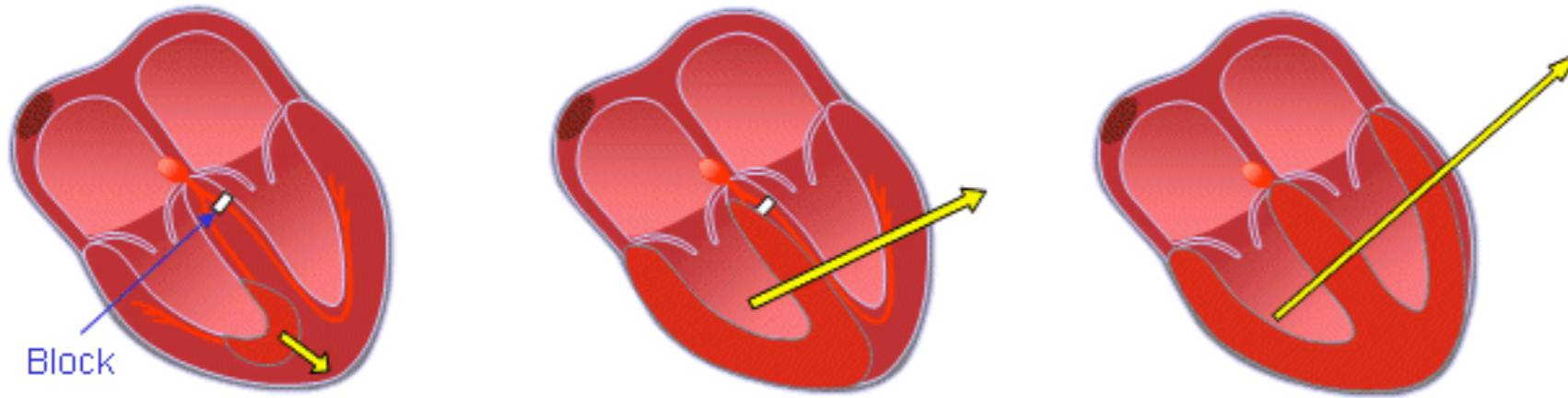
doppia onda R in
V1

durata QRS > 0.12sec

LEFT BUNDLE-BRANCH BLOCK

QRS duration greater than 0.12 s

Wide S wave in leads V1 and V2, wide R wave in V5 and V6



polarità normale
(impulso viaggia in
direzione normale)

più lento e vettore
più spostato a Sx
(VI, aVL, V5, V6).

durata QRS > 0.12sec

Incremento spessore pareti o
dimensioni di atri e/o ventricoli
(sovraccarico)

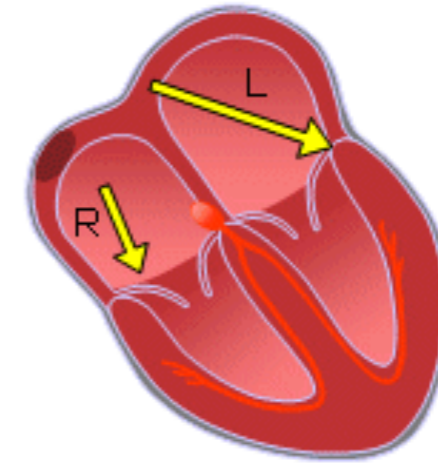
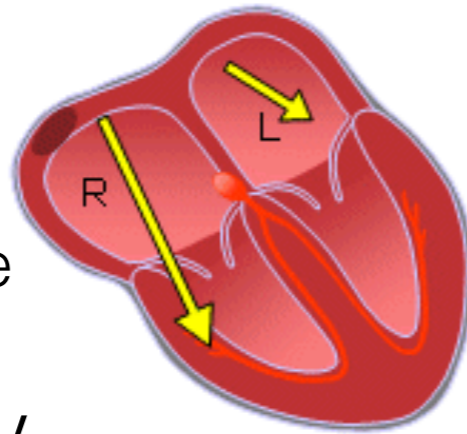
RIGHT ATRIAL HYPERTROPHY LEFT ATRIAL HYPERTROPHY

Tall, peaked P wave in leads I and II

Wide, notched P wave in lead II. Diphasic P wave in V1

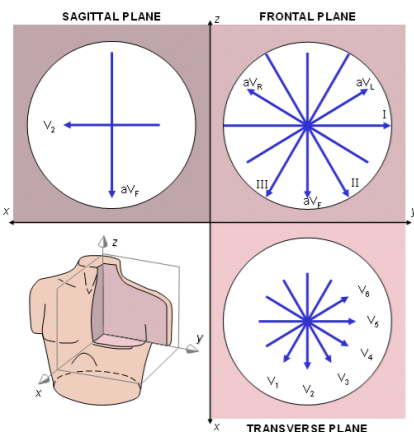
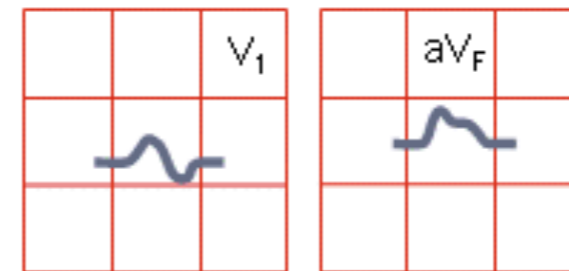
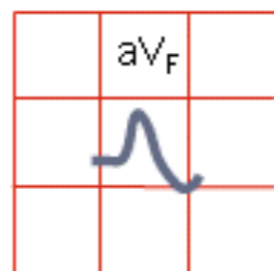
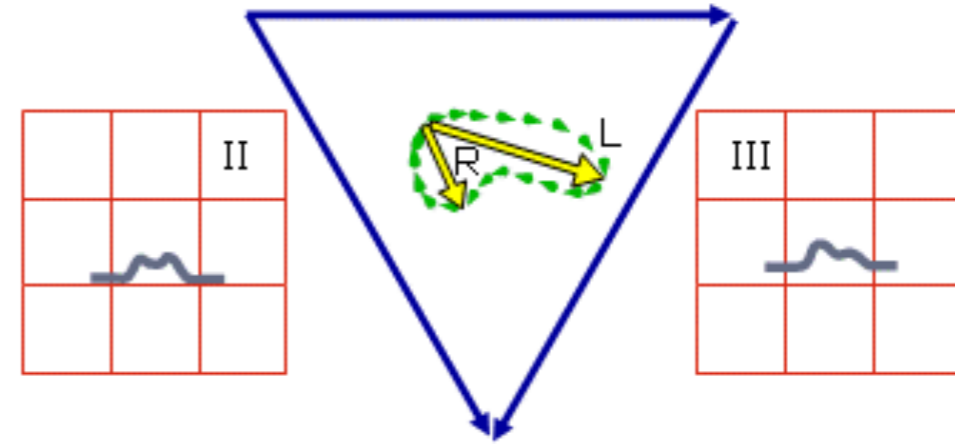
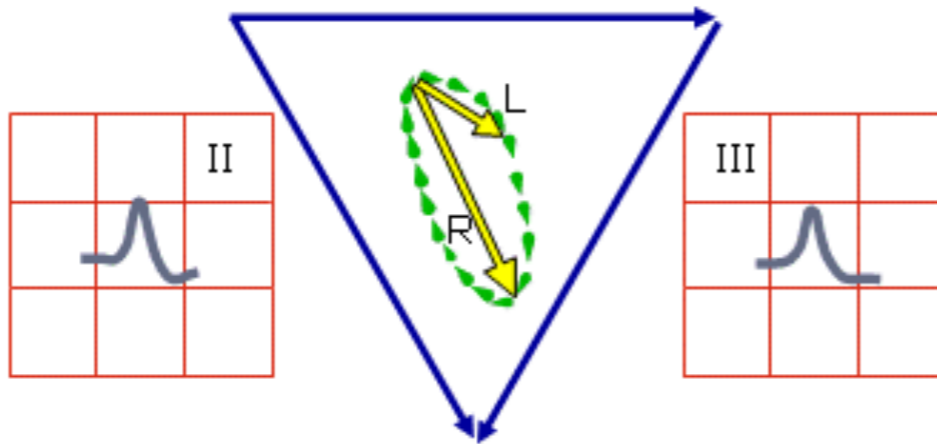
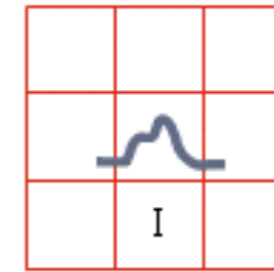
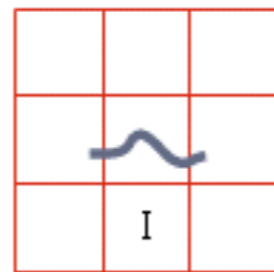
valvola tricuspide
valvola polmonare
ipertensione polmonare

onda P $\geq 25\text{mV}$



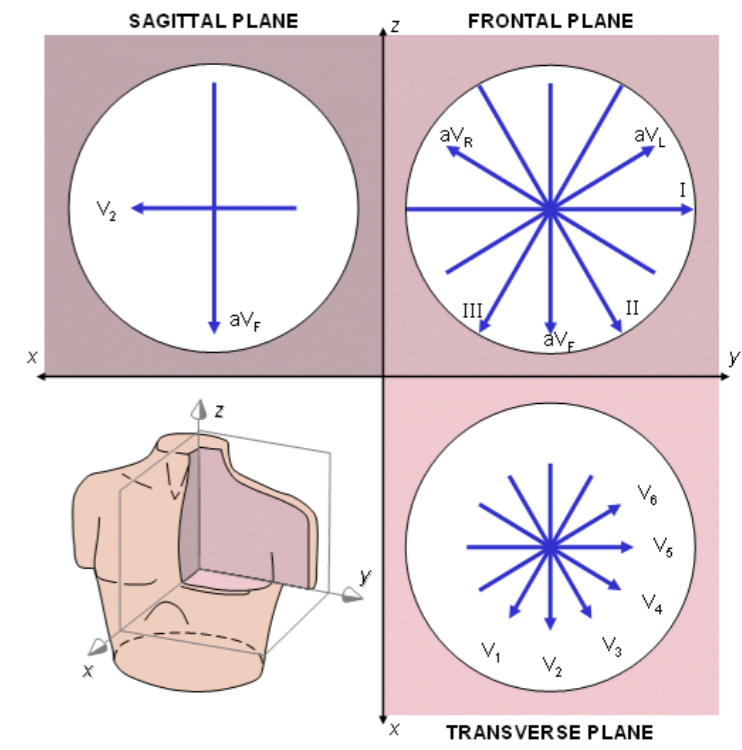
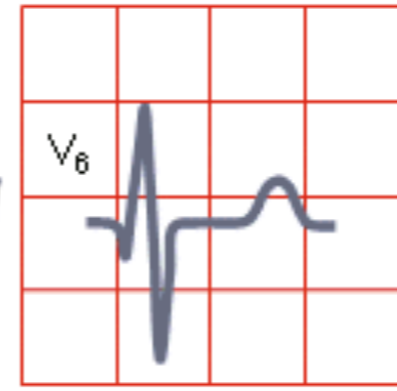
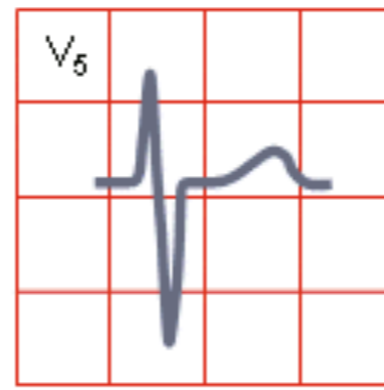
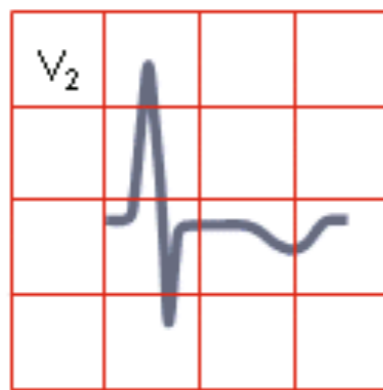
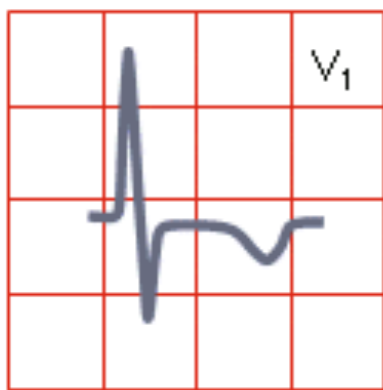
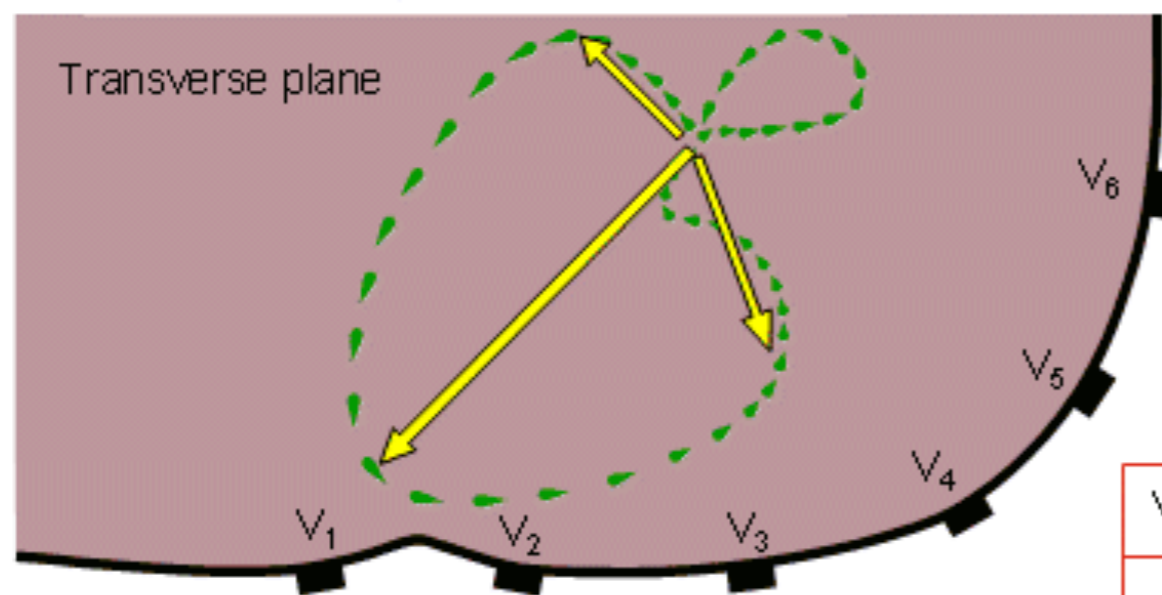
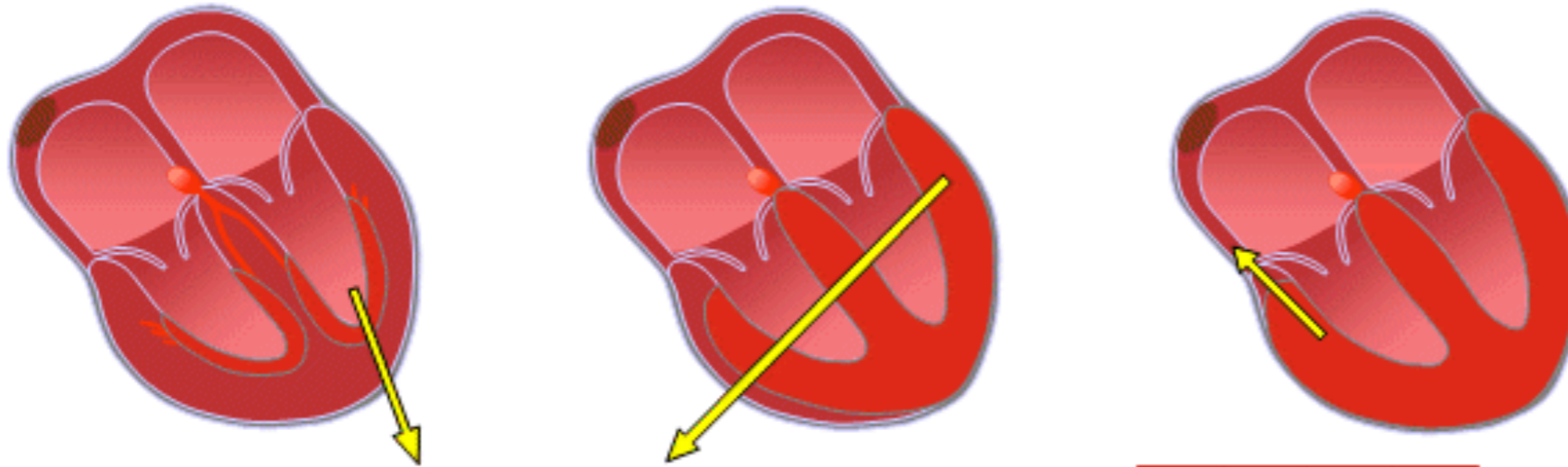
doppio picco
onda p
(impulso
generato ASx)

valvola mitrale
ipertensione
sistemica



RIGHT VENTRICULAR HYPERTROPHY

Large R wave in leads V1 and V2,
Wide S wave in leads V1 and V2, wide R wave in V5 and V6

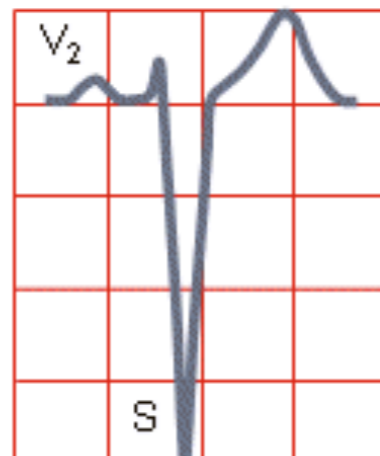
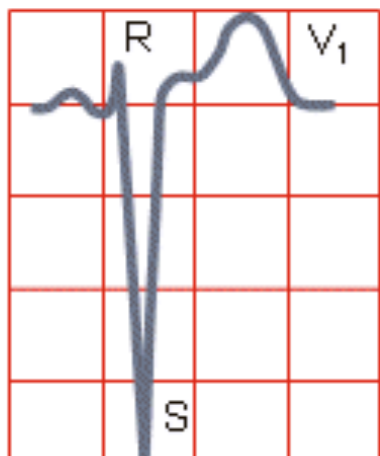
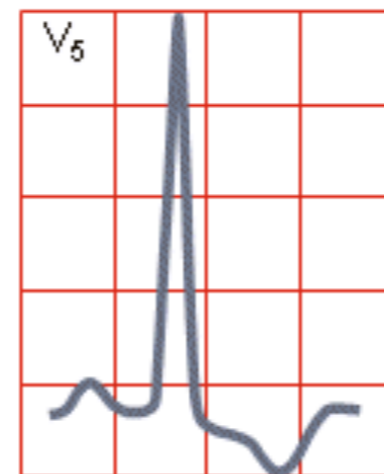
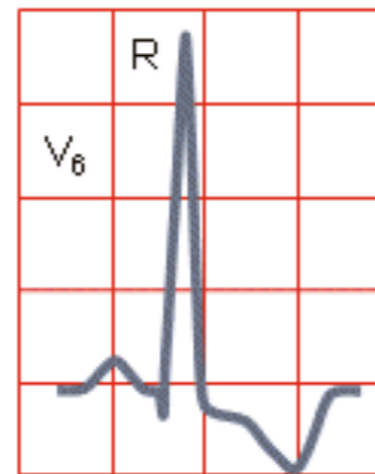
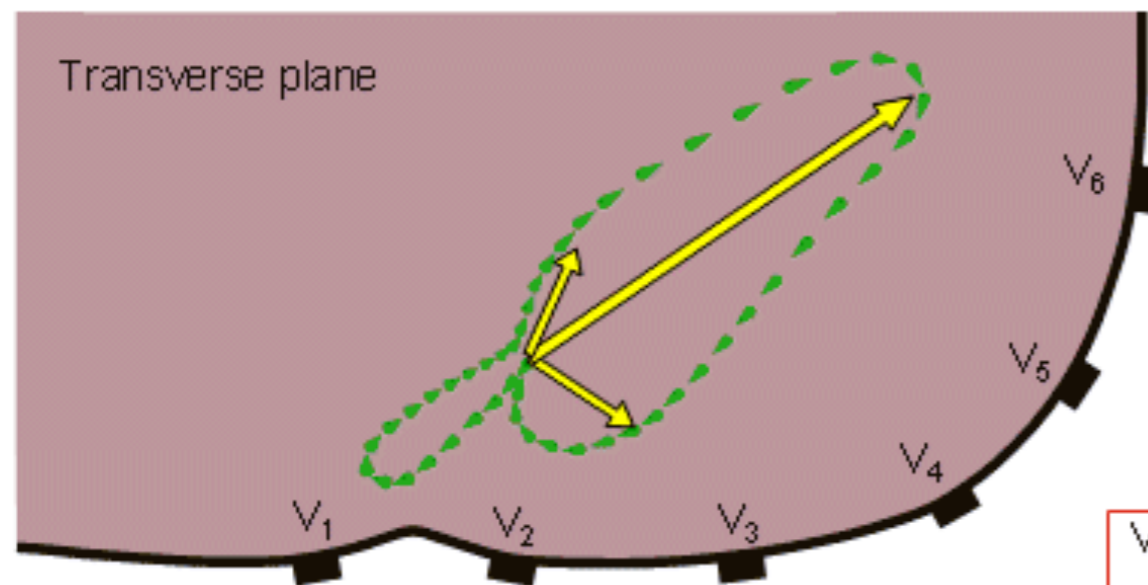
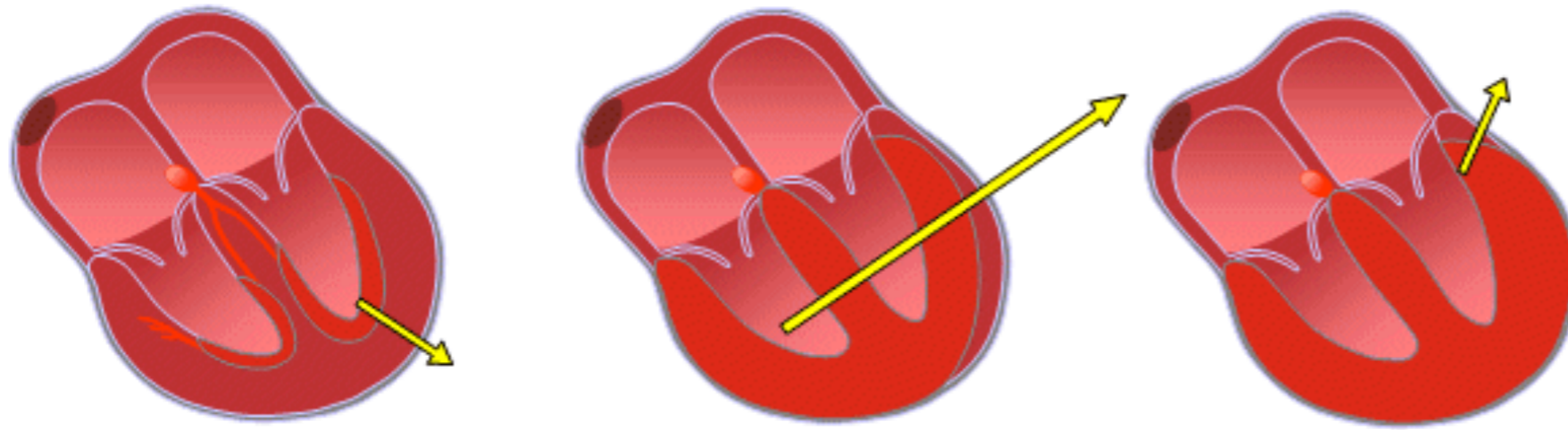


stenosi valvola polmonare
ipertensione polmonare
insufficienza v. tricuspide

onda R $\geq 0.7\text{mV}$

LEFT VENTRICULAR HYPERTROPHY

Large S wave in leads V1 and V2, large R wave in V5 and V6

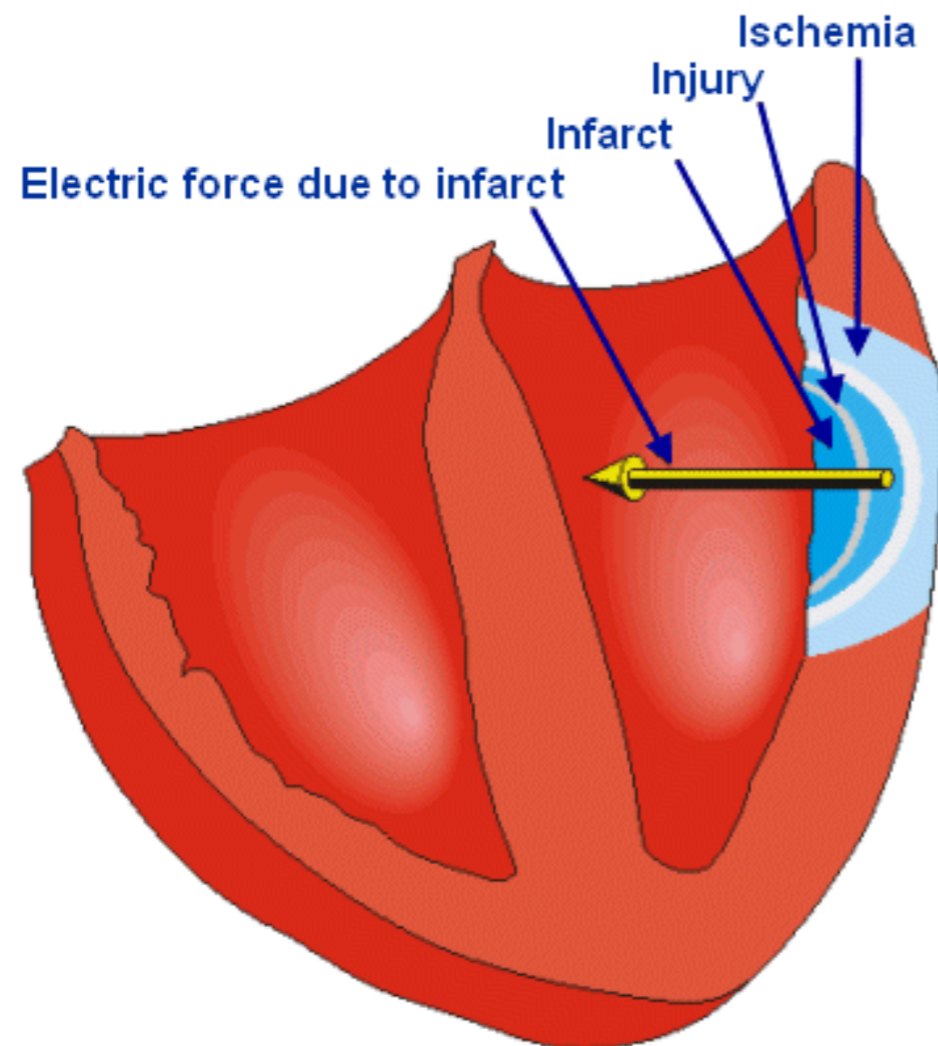


valvola mitrale
valvola aortica
ipertensione sistemica

ischemia e infarto

Arteria coronaria occlusa: carenza di ossigeno nel muscolo cardiaco (ischemia). L'ischemia causa una modifica dei potenziali di riposo e della ripolarizzazione (onda T).

Se in una certa area non arriva più ossigeno il tessuto muore (infarto).
Infarto: zona inerte elettricamente che perde l'eccitabilità.



Si può dimostrare che la perdita del dipolo "uscente" è assimilabile a un dipolo che punta all'interno (possibilità di identificare l'infarto dal tracciato ECG)

Utilizzo di database

- Il database Physionet contiene tracciati ECG registrati sotto le più disparate condizioni: <http://www.physionet.org/physiobank/database/#ecg>
- ECG con aritmie: <http://www.physionet.org/physiobank/database/mitdb/>