ECG PEDIA.ORG
part of cardionetworks.org

Before you start

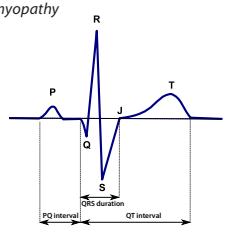
Check name, date, time, paperspeed (25 mm/sec), scale (10 mm/mV). Continue with the 7+2 step-plan.

Step 1: Rhythm

Sinus rhythm(SR) (60-100/min): every P wave is followed by a QRS
Narrow QRS tachycardias (QRS<120ms; >100/min) are always supraventricular tachycardias (SVT):

Sinustachycardia: sinusrhythm > 100/min. *Eg. Fever / Psych. stress / Cardiomyopathy*
Atrial fibrillation (AFIB): irregular
- Permanent = chronic.
- Persisting = recurring after chemical / electrical cardioversion
- Paroxysmal = comes and goes spontaneously: SR ⟶ AFIB ⟶ SR

Atrial flutter: flutter waves on baseline. Often regular 300 / min with a 2:1, 3:1 or 4:1 block.
AVNRT: AV nodal re-entry tachycardia. Regular, 180-250 / min. P in QRS complex (resulting in RsR' in V1), often young patients and paroxysmal. *Valsalva / carotid massage / adenosine can terminate episode.*



Wide complex tachycardias (QRS>120ms): possible risk of sudden death, always consult with cardiologist.

Ventricular tachycardia. Arguments for VT (Brugada criteria): fusion (sudden narrow beat), absence of RS precordialy, RS > 100ms, AV dissociation, atypical LBBB. *Typically in older patient with previous MI. Unconscious? ⟶ proceed to immediate defibrillation.*
SVT with aberrancy. Typical in younger patient. How was the QRS duration / shape on a previous non-tachycardic ECG?
Ventricular fibrillation = no QRS-complexes, but chaotic ECG-pattern, like 'noise' ⟶ mechanical cardiac arrest ⟶ *resuscitate. If patient is conscious it probably is noise.*

Bradycardia (<60/min). Consider stop / reduce beta-blocker / digoxin / Ca-antagonist. *Asymptomatic sinusbradycardia with a normal blood pressure in general doesn't require treatment.*
- **1st degree AV-block**: prolonged PQ-interval (> 200ms)
- **2nd degree AV-block type I (Wenkebach)**: PQ interval increases until 1 QRS complex is blocked. *Good prognosis.*
- **2nd degree AV-block type II (Mobitz)**: PQ interval is normal, but not every P wave is followed by QRS. *Requires pacemaker.*
- **3rd degree AV-block** = complete block. AV dissociation: no relationship between P waves and QRS. *Requires pacemaker.*
- **Ventriculair escape rhythm:** wide complex rhythm < 40/min; dangerous. *Consult cardiologist. Ischemia? Severe electrolyte shift?*

Step 2: Heart rate

Count the number of large grids between two QRS complexes: 1 box in between = 300/min, 2=150/min - 100 - 75 - 60 - 50 - 40. Or use methods at the bottom of this page.

Step 3: Conduction intervals (PQ, QRS, QT)

Normal: PQ <200ms (5 small squares), QRS < 120ms (3 squares), QTc ♂< 450 ms, ♀< 460 ms, preferably measured in lead II or lead V5.

$$QTc = \frac{QT}{\sqrt{RR(\text{in sec})}}$$

PQ > 200ms = AV block (above)
PQ < 120ms + delta-wave = Wolff-Parkinson-White syndrome (WPW), risk of a circus movement tachycardias (= AVRT: AV re-entry tachycardia)
QRS > 120ms = wide QRS complex, check V1:
- **Left Bundle Branch Block (LBBB)** Latest activity towards the left, away from V1, so QRS ends **negatively in V1**. *New LBBB? Consider ischemia.*
- **Right Bundle Branch Block (RBBB)** RsR' (rabbit ear) latest activity rightwards, (on average) **positive in V1**
- **Intraventricular conduction delay=** if it's not LBBB nor RBBB

Maximal QTc per given heart rate: what QT value at what heart rate results in a QTc of 450ms?	
50/min:	QT 493ms
60/min:	QT 450ms
70/min:	QT 417ms
80/min:	QT 390ms
90/min:	QT 367ms
100/min:	QT 349ms

QTc > 450ms: *consider: hypokalemia, post myocardial infarction, long QT syndrome, medication (full list on torsades.org). Risk of torsade de pointes deteriorating into ventricular fibrillation (risk increases especially >500ms).*

Step 4: Heart axis

Heart axis: vector of the average electrical activity. Normal between –30° and +90°. Expecially axis deviation compared to previous ECG is relevant.
Normal hart axis: QRS positive in II and AVF
Left axis: AVF and II negative. *Eg. left anterior fascicular block (LAFB), LVH.*
Right axis. I negative, AVF positive. *Eg. pulmonary embolism, COPD.*

Step 5: P wave morphology

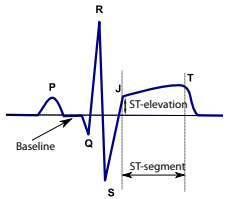
Normal P wave: positive in I and II, bifasic in V1, similar shape in every beat.*Otherwise consider ectopic atrial rhythm.*
Left atrial enlargement: terminal negative part in V1 > 1mm². *e.g. mitral-regurgitation.*
Right atrial enlargement P>2.5mm high in II, III, AVF and / or P>1.5mm in V1. *e.g. COPD*

Step 6: QRS morphology

Pathologic Q waves? Old myocardial infarction (*see ischemia*)
Left ventricular hypertrophy (LVH): R in V5/V6 + S in V1 > 35 mm. *Seen in e.g. hypertension, aortic valve stenosis.*
R wave progression: R increases V1-V5. R>S beyond V3
Microvoltages (<5mm in extremity leads): *E.g. cardiomyopathy, tamponade, obesity, pericarditis*
Wide QRS complex (QRS > 120ms): see Step 3

Step 7: ST morphology

ST elevation: *consider ischemia, pericarditis, LVH, benign ST elevation, 'early repolarisation'*
ST depression: *can be reciprocal in ischemie, strain pattern in LVH, digoxin intoxication*
Negative T wave: (not in the same direction as the QRS complex) *consider (subendocardial) ischemia, LVH*
Flat T wave (<0.5 mm): *aspecific*



How to measure ST elevation?

Heart rate = 10 times number of QRS complexes within these 15 cm (= 6 seconds x 25 mm/sec)

Step +1: Compare with previous ECG

New LBBB? Change in axis?. New pathologic Q waves? Reduced R wave height?

Step +2: Conclusion (1 sentence)

Example: Sinustachycardia with ST elevation in the chest leads with a trifascicular block consistent with an acute anterior myocardial infarction

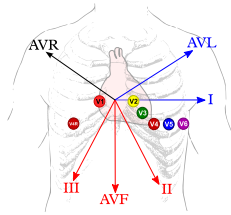
Ischemia

Acute myocardial infarction (AMI): symptoms (chest pain, vagal response), ECG consistent with transmural ischemia (ST elevations (+reciprocal depressions), new LBBB, sometimes already pathologic Q waves), sometimes already elevated cardiac markers for AMI (Troponin / CKMB). 'Time is muscle'. If you suspect AMI ⟶ consult cardiologist immediately (< 5 min.)
ST-elevation points at the infarcted area:
- **Anterior:** V1-V4. Coronary territory: LAD. *sometimes tachycardia*
- **Inferior:** II, III, AVF. Coronary: 80% RCA (bradycardia, elevation III>II; depression in I and / or AVL), otherwise RCX (in 20%).
- **Right ventricular MI:** ST↑ in V1 and V4R. *IV fluids if hypotensive*
- **Posterior:** high R wave and ST depressie in V1-V3
- **Lateral:** elevation in I, AVL, V6. Coronary: LAD (Diagonal branch)
- **Left main:** diffuse ST depression with ST elevation in AVR. Very high risk of cardiogenic shock

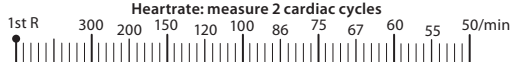
Reciprocal depression: depression in reciprocal territory (e.g. ST depression in II, III, AVF during anterior MI).
IPL-infarction: inferior-posterior-lateral. They frequently come together
Pathologic Q-wave (any Q in V1-V3 or Q width > 30ms in I, II, AVL, V4-V6; minimal in 2 contiguous leads, minimal depth 1 mm): previous MI. Leads III and AVR may have a Q wave, which is non-pathological.

Miscellaneous

VPB (ventricular premature beat, VES: ventricular extrasystole, PVC, Premature ventr. contr.). QRS > 120ms. Seen in 50% of healthy men. Increased risk of arrhythmias if: complex form, very frequent occurence (> 30 / hour) or R on T. Consider: Ischemia? Previous MI? Cardiomyopathy?
PAC (premature atrial contraction, AES): abnormal P wave, mostly narrow (normal) QRS complex
Pericarditis: ST elevation in all leads. PTA depression in II (between the end of the P wave and the beginning of Q wave)
Hyperkalemia: tall T waves. QRS wide, flat P
Hypokalemia: QT prolongs, U wave, torsade
Hypocalcemia: ST prolongs, 'normal' T
Hypercalcemia: QT short, high T
Digoxin-intoxication: sagging ST depressions
Pulmonary embolism: sinustachycardia, deep S in I, Q wave and negative T in III, negative T V1-V3, right axis, sometimes RBBB
Chest lead positioning: V1= 4th intercostal space right (IC4R), V2=IC4L, V3=between V2 en V4, V4=IC5 in midclavicular line, V5=between V4 and V6, V6= same height as V4 in axillary line. To register V4R, use V3 in the right mid-clavicular line.

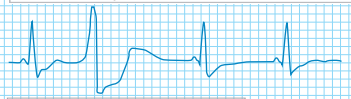


Heartrate: measure 2 cardiac cycles

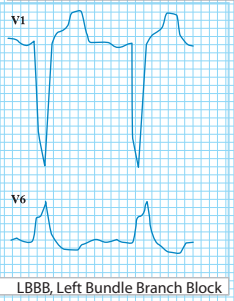


large square = 5 mm = 0.20 sec small square = 1 mm = 0.04 sec

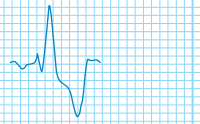
Normal sinus rhythm. Every P wave is followed by a QRS complex. Heart rate between 60-100 /min.



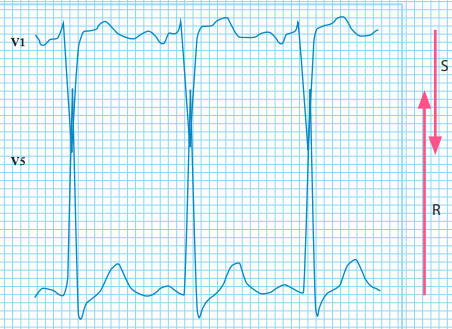
Ventricular Premature Beat (VPB)



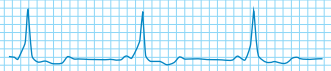
LBBB, Left Bundle Branch Block



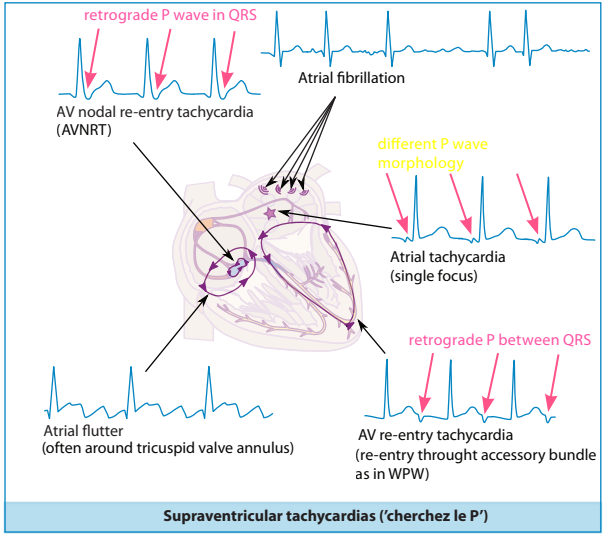
RBBB, Right Bundle Branch Block



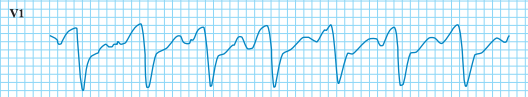
Left Ventricular Hypertrophy (LVH, R in V5/V6 + S in V1 > 35 mm)



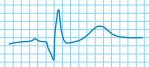
Delta wave and short PQ interval in WPW-syndrome



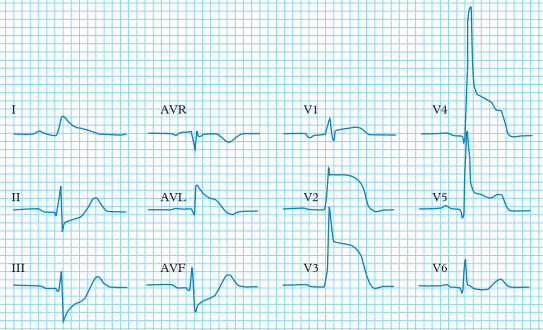
Supraventricular tachycardias ('cherchez le P')



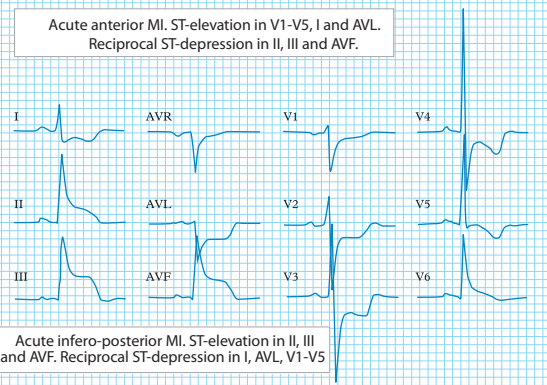
Ventricular tachycardia



Pathologic Q wave, sign of a previous MI



Acute anterior MI. ST-elevation in V1-V5, I and AVL. Reciprocal ST-depression in II, III and AVF.



Acute infero-posterior MI. ST-elevation in II, III and AVF. Reciprocal ST-depression in I, AVL, V1-V5

I Lateral	V1 Septal
II Inferior	V2 Septal
III Inferior	V3 Anterior
aVR Left Main	V4 Anterior
aVL Lateral	V5 Lateral
aVF Inferior	V6 Lateral

Color scheme to facilitate MI localisation. The colors mark contiguous leads. Example: (see above): ST elevation in II, III, AVF acute inferior MI