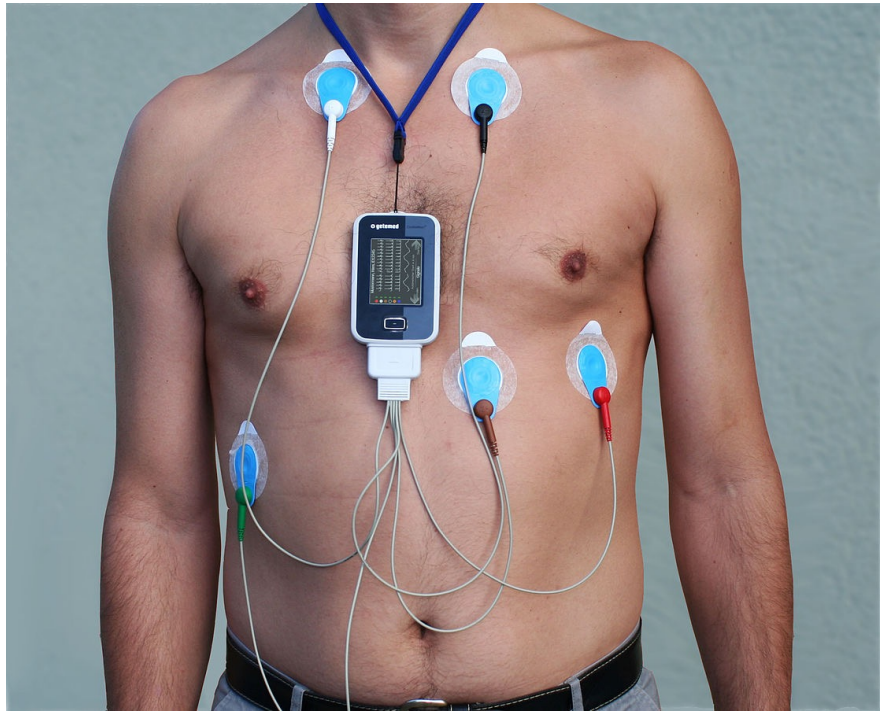
Heart disease: rhythm disturbances of the heart.



Christopher Whitty
Gresham College 2023

Misscurry

The heart normally beats steadily and very efficiently.

- It has a resting beat, in humans typically 60-100 beats per minute (bpm). Lower in very fit.
- Can rapidly accelerate up to 130-150bpm if needed for physical exertion, stress or infection.
- Blue whale 33 beats per minute on the surface, dropping to 4 beats per minute in dives.
- Some small land mammals, bats and birds over 1000 bpm- e.g. Etruscan pygmy shrew.

NOAA, Trebol-a

Three broad groups of things can lead to the heart failing or stopping.

- Myocardia ischaemia- lack of oxygen usually due to narrow or blocked coronary arteries (coronary heart disease).

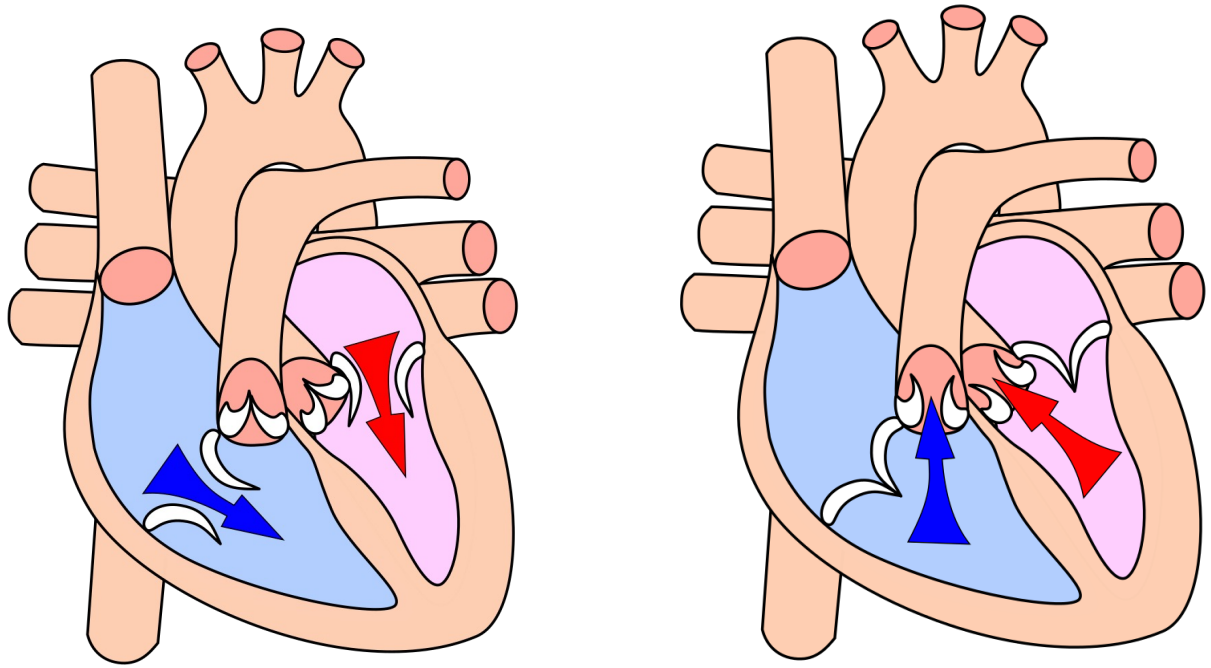
- The heart rhythm is abnormal- either too fast or too slow (arrhythmia).

- The structures of the heart are damaged including muscle and valves.

Jer5150. Ventricular fibrillation.

The structure of the heart is important in understanding normal and abnormal rhythms.

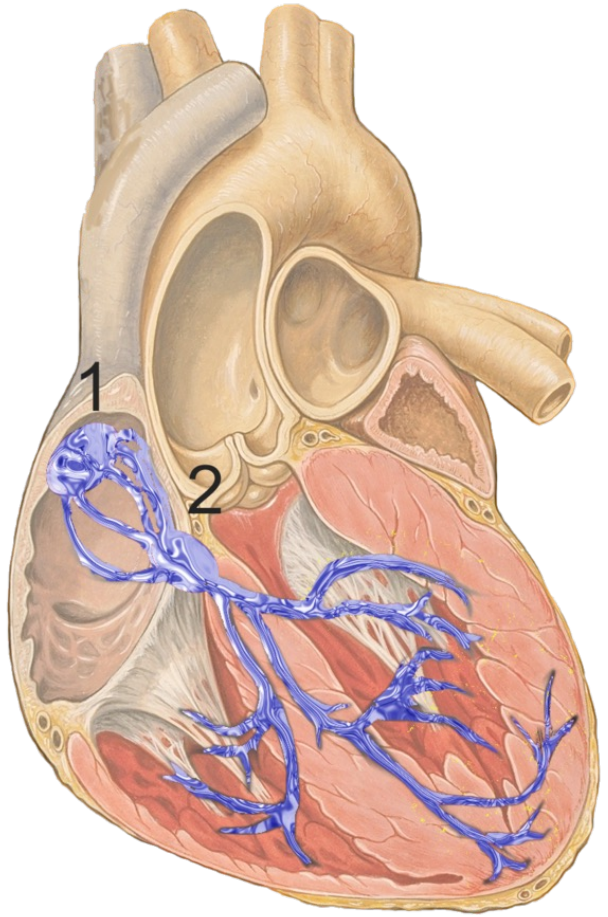
- Four chambers. Left and right sided systems.
- Upper pump (atrium) and lower pump (ventricle).
- Atrium beats first, and primes the main ventricular pump on both sides.
- Then the ventricle beats- much more powerful (systole).



Wapcaplet, Reytan, Mtcv

To achieve this sequence the heart has an electrical conduction system.

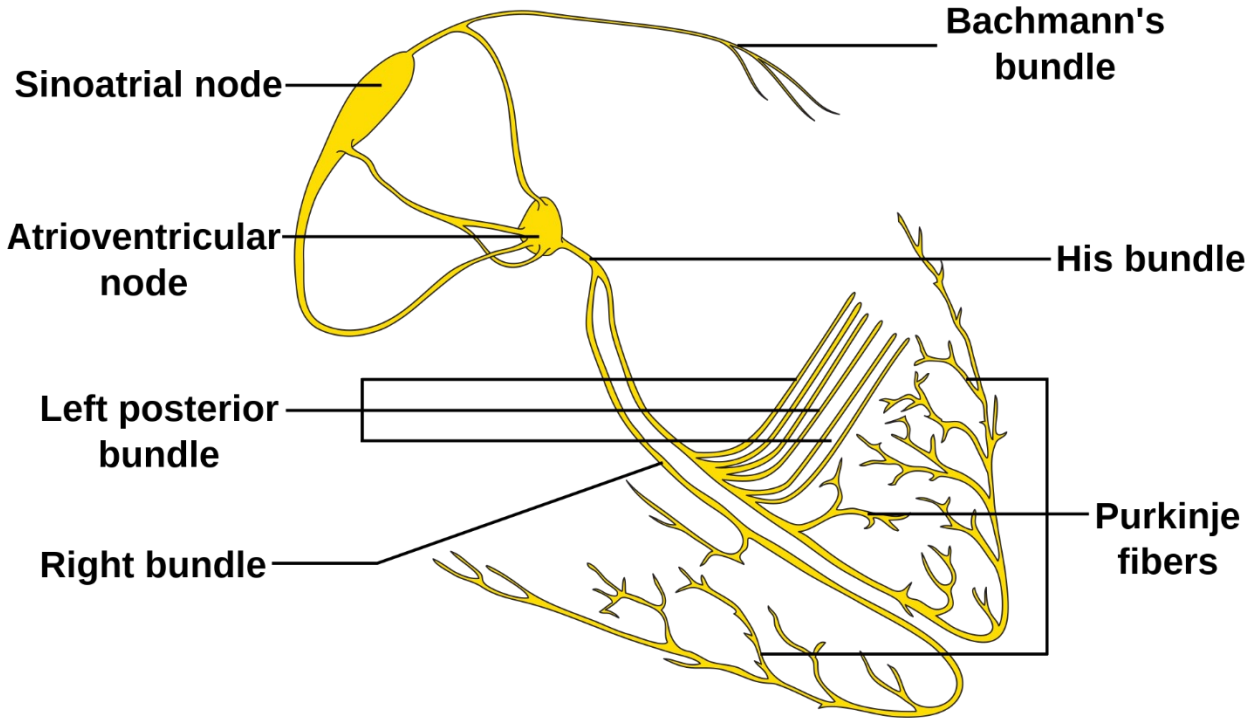
- Atrium contraction initiated at a specialised pacemaker, the sinoatrial (SA) node (1).
- Electrical wave spreads over the atrium rapidly, leading to a synchronised atrial contraction.
- Then there is a deliberate delay as the impulse passes through the atrioventricular (AV) node (2).
- Then rapidly conducted around the whole ventricle by the bundle of His and Purkinje fibres, and spreads out from there.
- This ensures a synchronised ventricular contraction after the atrial contraction.



J. Heuser

For optimal heartbeat the whole system has to be working. But the heart has escape pacemakers if necessary.

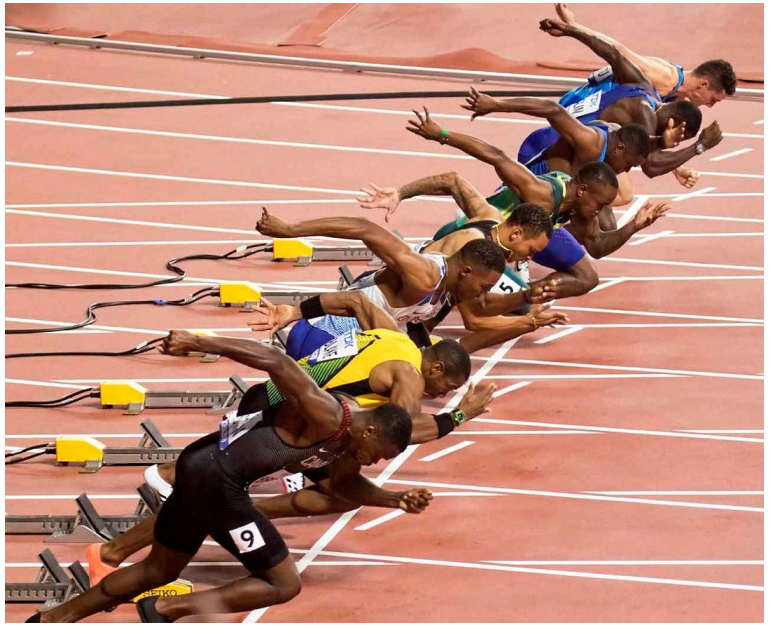
- The SA node can speed up or slow down.
- Sympathetic nerve system speeds it up, parasympathetic slows it down.
- The AV node has a pacemaker that is slower than the SA node- but can take over if the SA node fails (40-60 bpm).
- The Purkinje fibres have a very slow pacemaker that can take over if AV node fails (20-40 bpm).



Madhero88; Angelito7

How the sympathetic and parasympathetic system control the heart is important for response, and also how drugs work.

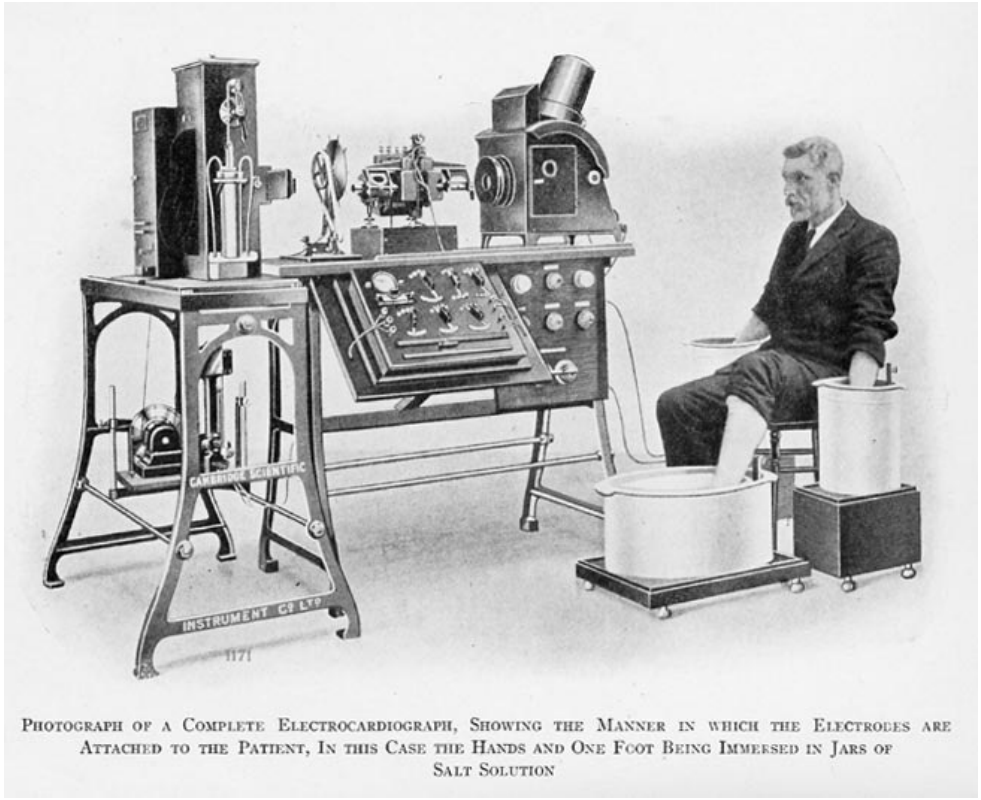
- The sympathetic system (fight or flight). Releases norepinephrine (NE) / noradrenaline.
- Multiple effects on the body, but for heart rhythm main effect via β1 adrenergic receptors. Increase heart rate (SA node) and speed of conduction (AV node).
- Parasympathetic uses acetylcholine to M2 receptors in the heart- slow pacemaker and AV speed of conduction.
- During exercise first parasympathetic reduces, then sympathetic kicks in.



filip bossuyt / wiki

The ECG- central to diagnosing heart rhythm problems.

- Electrocardiogram (ECG) measures electrical impulses.
- Developed in stages from the 1880s.
- The heart beating produces a big enough electrical impulse to be measurable on the surface.
- Has many uses, including diagnosing severe myocardial infarction (heart attack).
- Tells us a lot about heart rhythm disturbance.

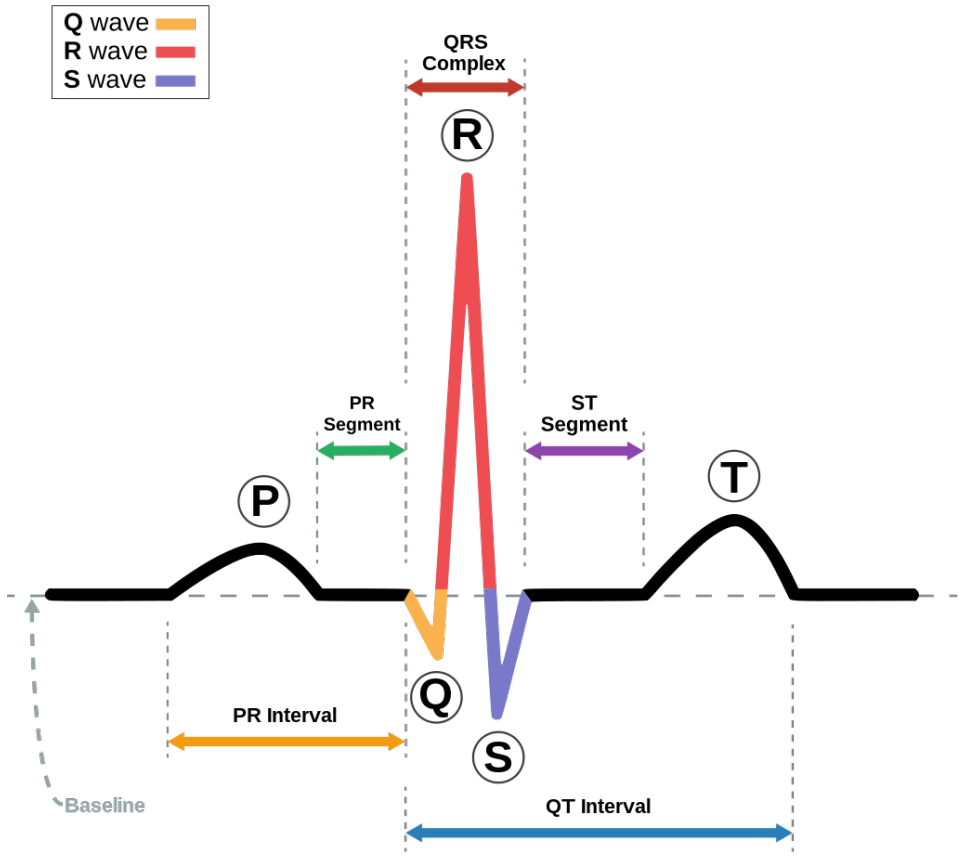


PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

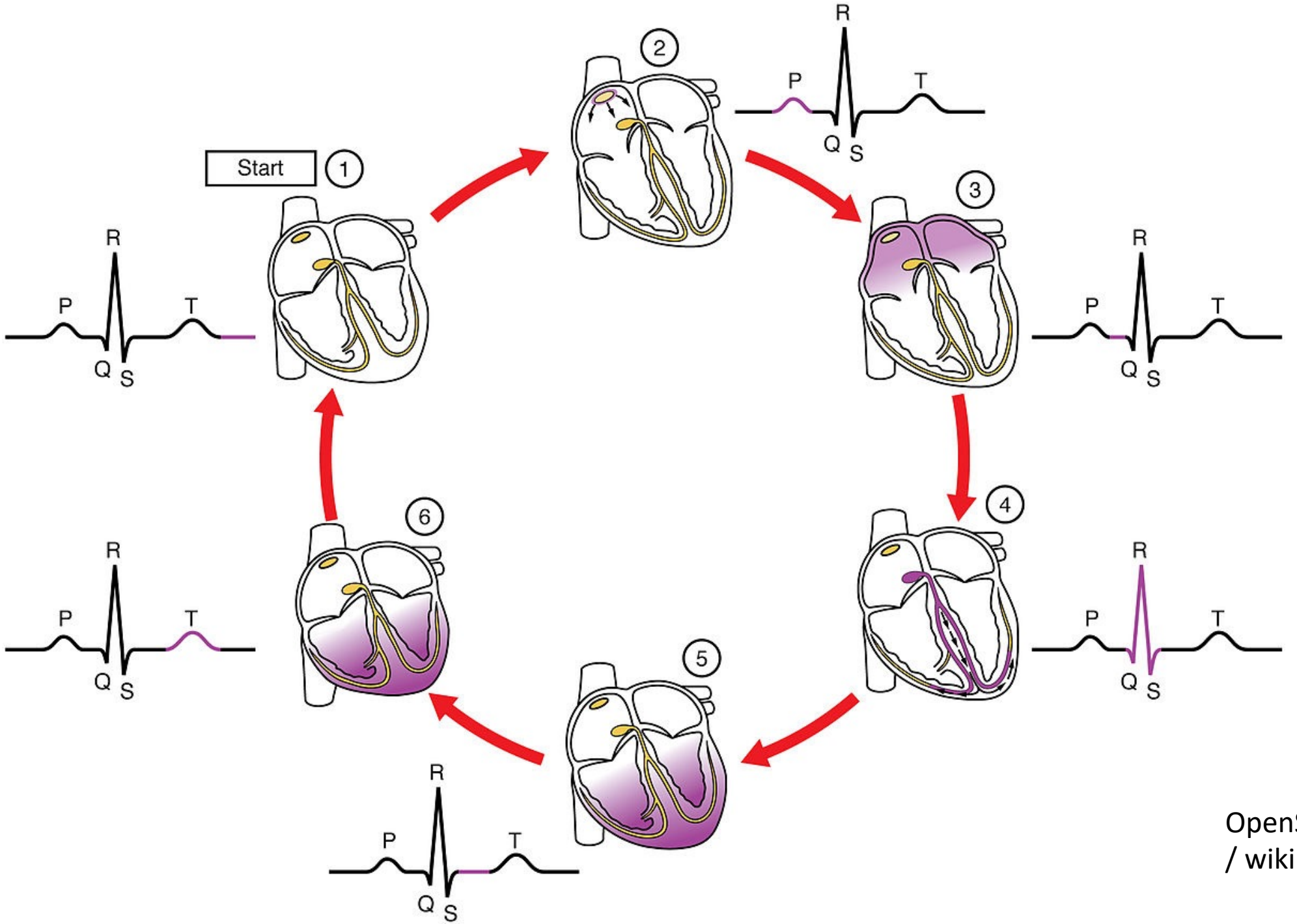
ECG circa 1911.

The ECG will provide a record of the rate and regularity.

- But it also helps explain where in the heart any problem is.
- Atrial wave: P wave at the start- atrial contraction.
- Ventricle wave conduction: QRS wave.
- Ventricle relaxing: T wave.

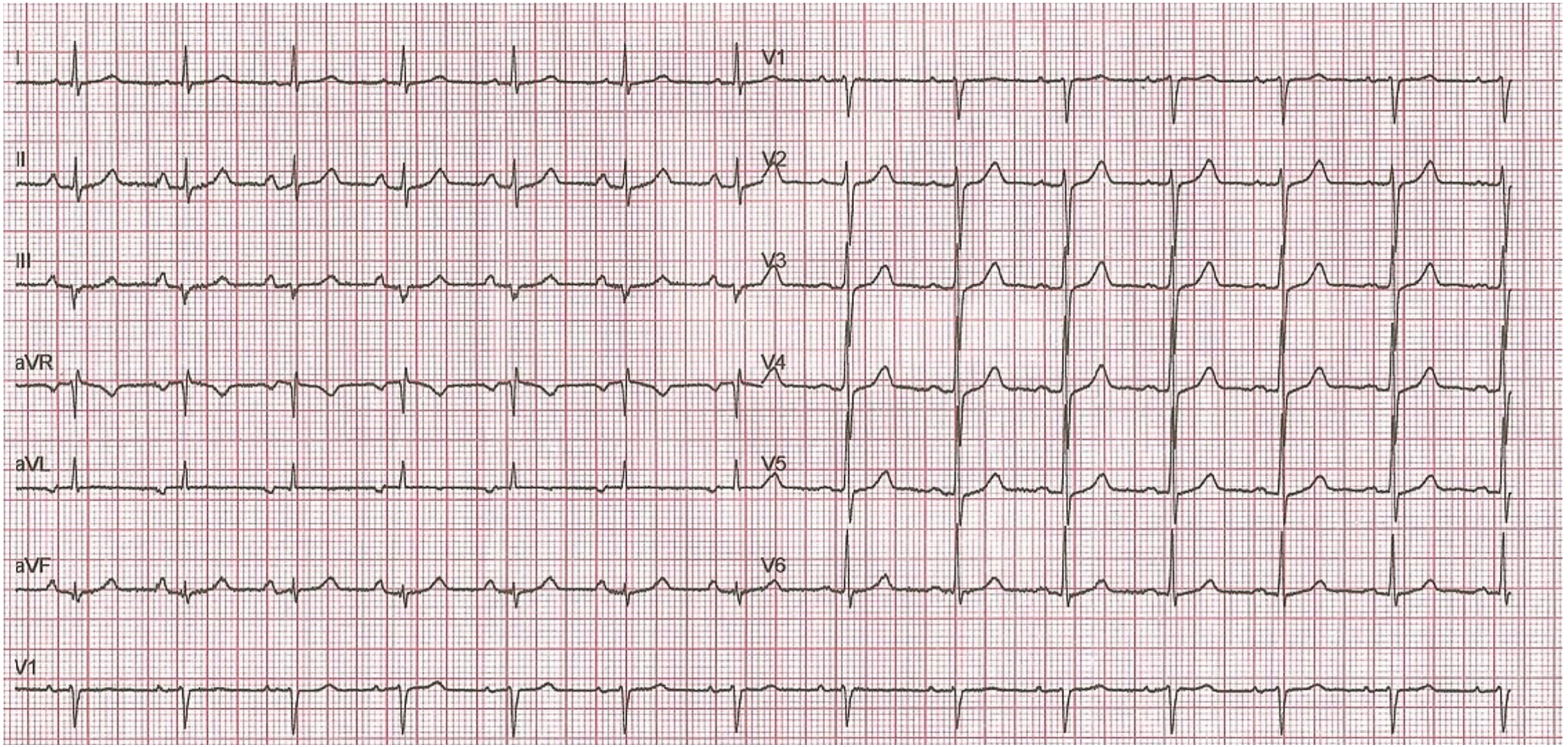


Agateller

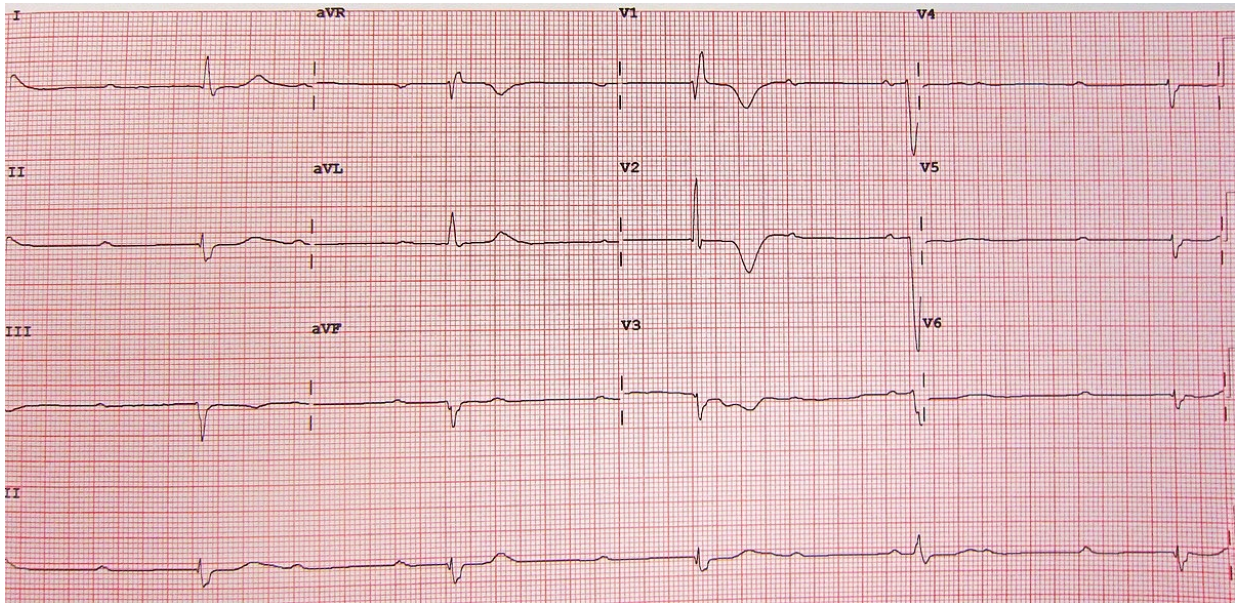


OpenStax College
/ wiki

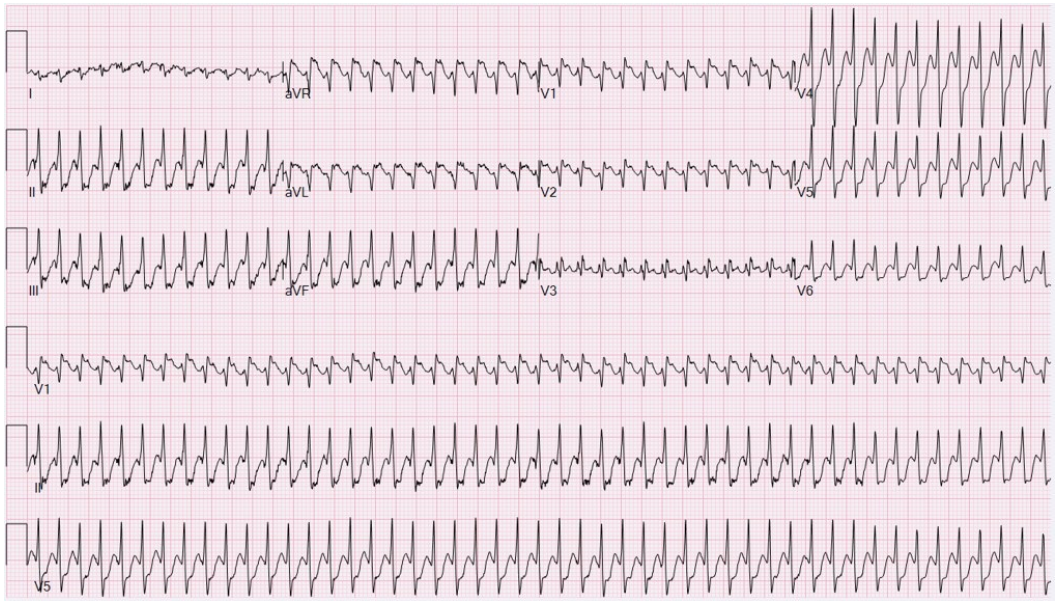
Normal ECG.



Bradycardia (the heart going too slowly); tachycardia (heart going too quickly).



Complete heart block. James Heilman



Atrial flutter 1:1 around 300bpm. Ewingdo.

Presentation with arrhythmia (whether fast or slow) include:

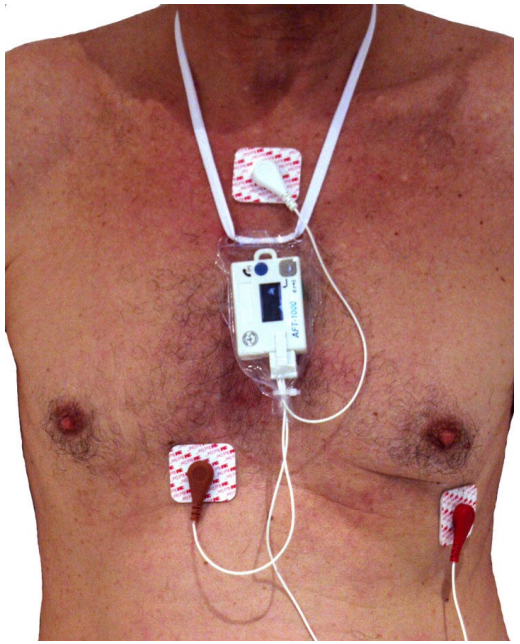
- Identified on routine testing- for example before an operation with no previous symptoms.
- ‘Palpitations’ but no serious symptoms.
- Sudden intermittent dizziness, faintness, chest pain.
- New onset shortness of breath.
- Urgent presentation with collapse, or shortness of breath.
- Emergency presentation including cardiac arrest.

NHS

Often need continuous monitoring over time.

- Many people have intermittent symptoms that could be arrhythmia. Most are not.
- Holter monitor can identify runs of arrythmia over 24 hours or longer during normal activity.

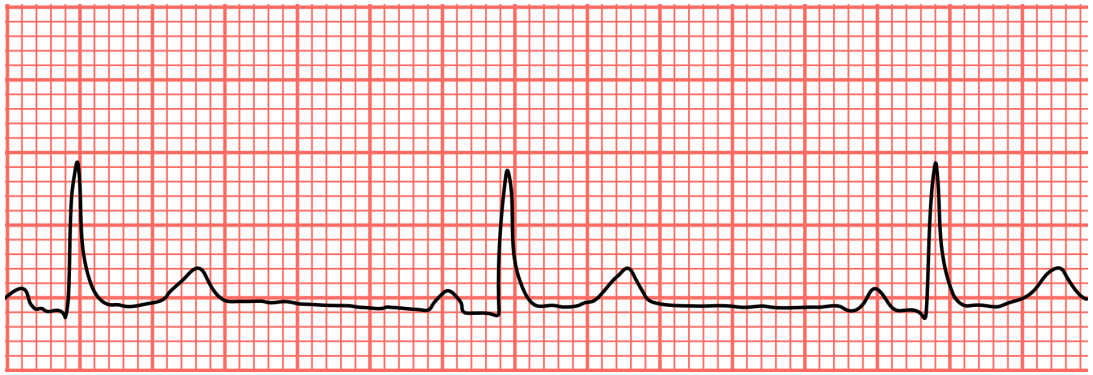
Norman Holter. Cardioworks.



Faisandier

Sinus bradycardia- the heartbeat slow but AV conduction normal.

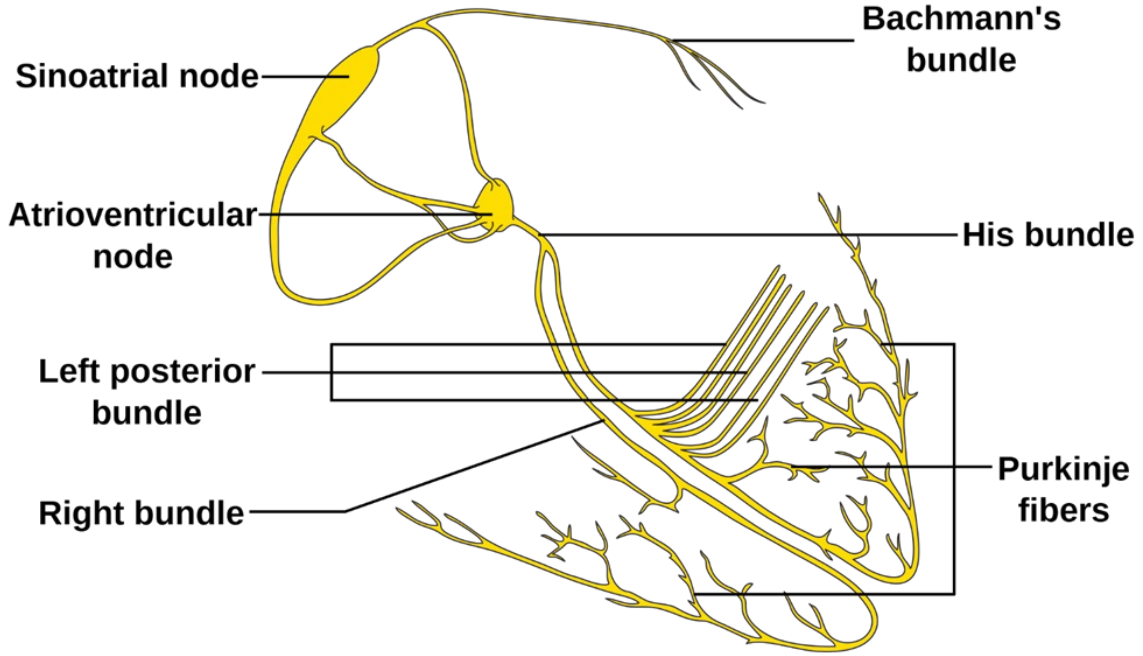
- Often no symptoms, but can cause lightheadness, dizziness.
- Can be normal e.g. in athletes.
- Many reversable causes, including:
- Hypothyroidism
- Hypothermia
- Some drugs
- Some infections
- Recent myocardial infarction.



50bpm. James Heilman/Mysid

Sick sinus syndrome.

- Sinoatrial node may fire too slowly or too fast (or both).
- Generally age related.



Madhero88; Angelito7

Sino-atrial block.

Usually relatively minor symptoms.
SA node blocked.
Miss atrial beats.

Adapted from Jer 5150

AV node block: first and second degree block.

- First degree AV node prolonged PR. Seldom medically important.
- Second degree Mobitz I. Predictable drop of 1 beat. Seldom medically important.
- Second degree Mobitz II. Unpredictable dropping of 1 or more beats. Usually needs treatment if symptomatic.

Second degree AV block (Mobitz I or Wenckebach)

Second degree AV block (Mobitz II)

Second degree AV block (2:1 block)

Adapted from NPatchett

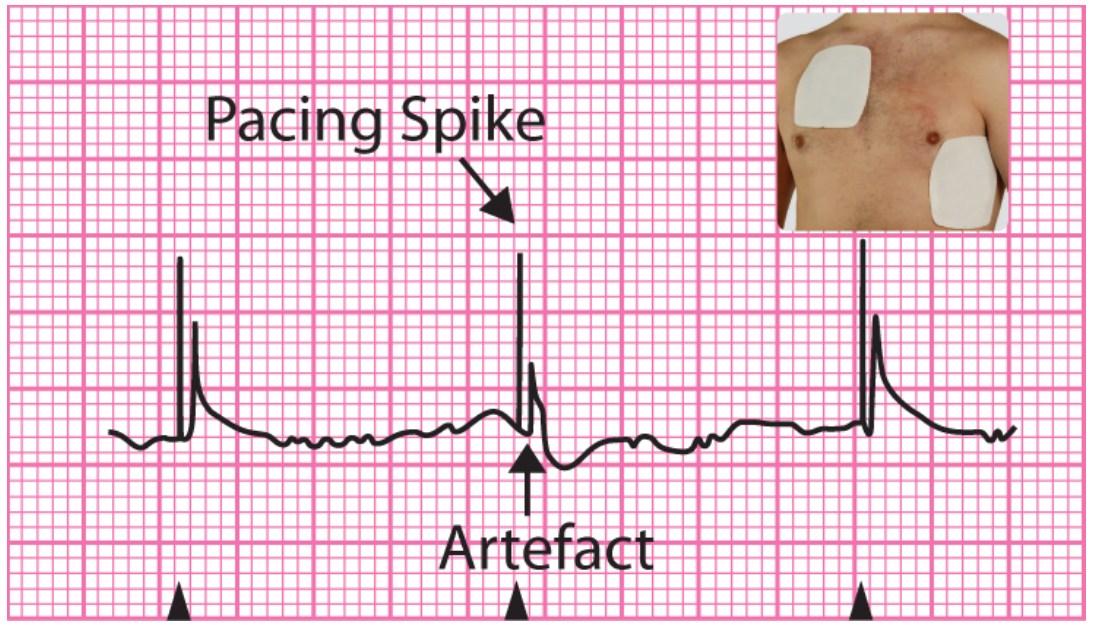
Complete heart block (Type III AV block).

- Atrium contracts but electrical impulse does not pass through AV node.
- Slow heart beat initiated from AV node or lower.
- Usually symptomatic- dizzy, faint, tired.
- Needs treatment.
- Look for a reversible cause- but normally need a pacemaker.

Adapted from Jer 5150

Initial treatment of bradycardia: is it reversible?

- When symptomatic normally needs treatment.
- If there is a reversable cause- for example drugs- reverse them.
- As a holding manoeuvre can use atropine, epinephrine (adrenaline).
- Or external (transcutaneous) pacing.
- Most need a permanent pacemaker unless reversable.



Resuscitation Council UK

Artificial pacemakers.

- For symptomatic bradycardias with no reversable cause the question is whether to insert a pacemaker.

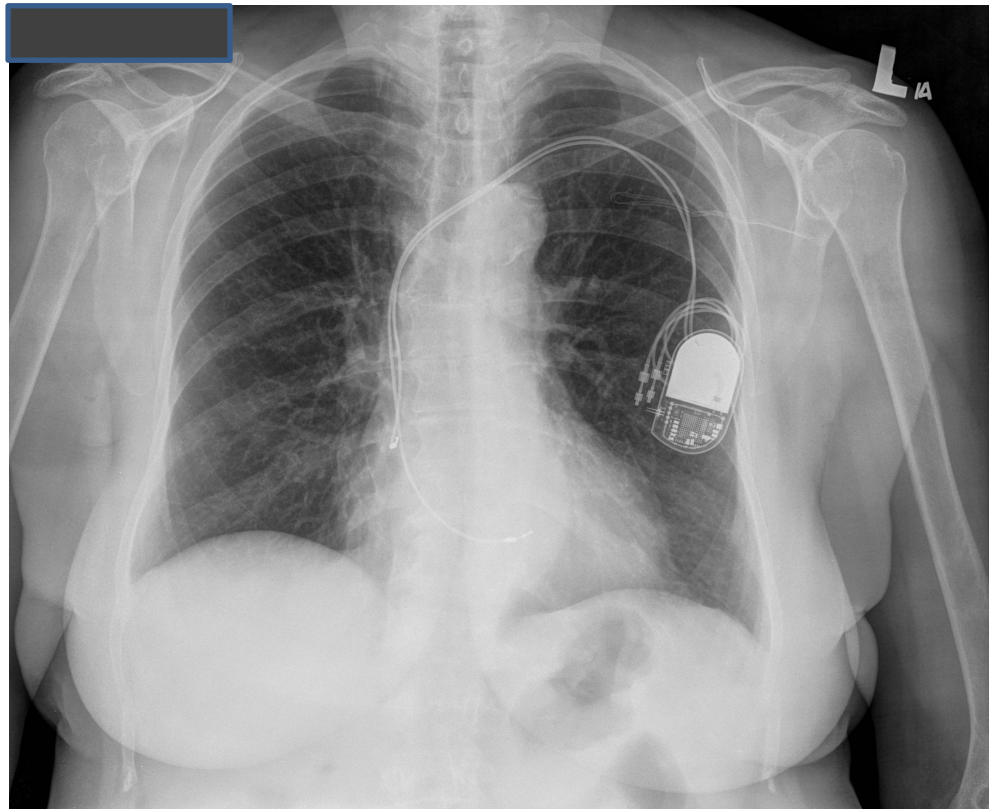
- Early pacemakers were large, external and only for severe cases.

- Modern pacemakers are small, durable and highly effective. Most are inserted in 1-2 hours under local anaesthetic. Batteries last 6-10 years.

Pacemaker 1962. Mayo Clinic.

Pacemakers come in several types depending on the problem.

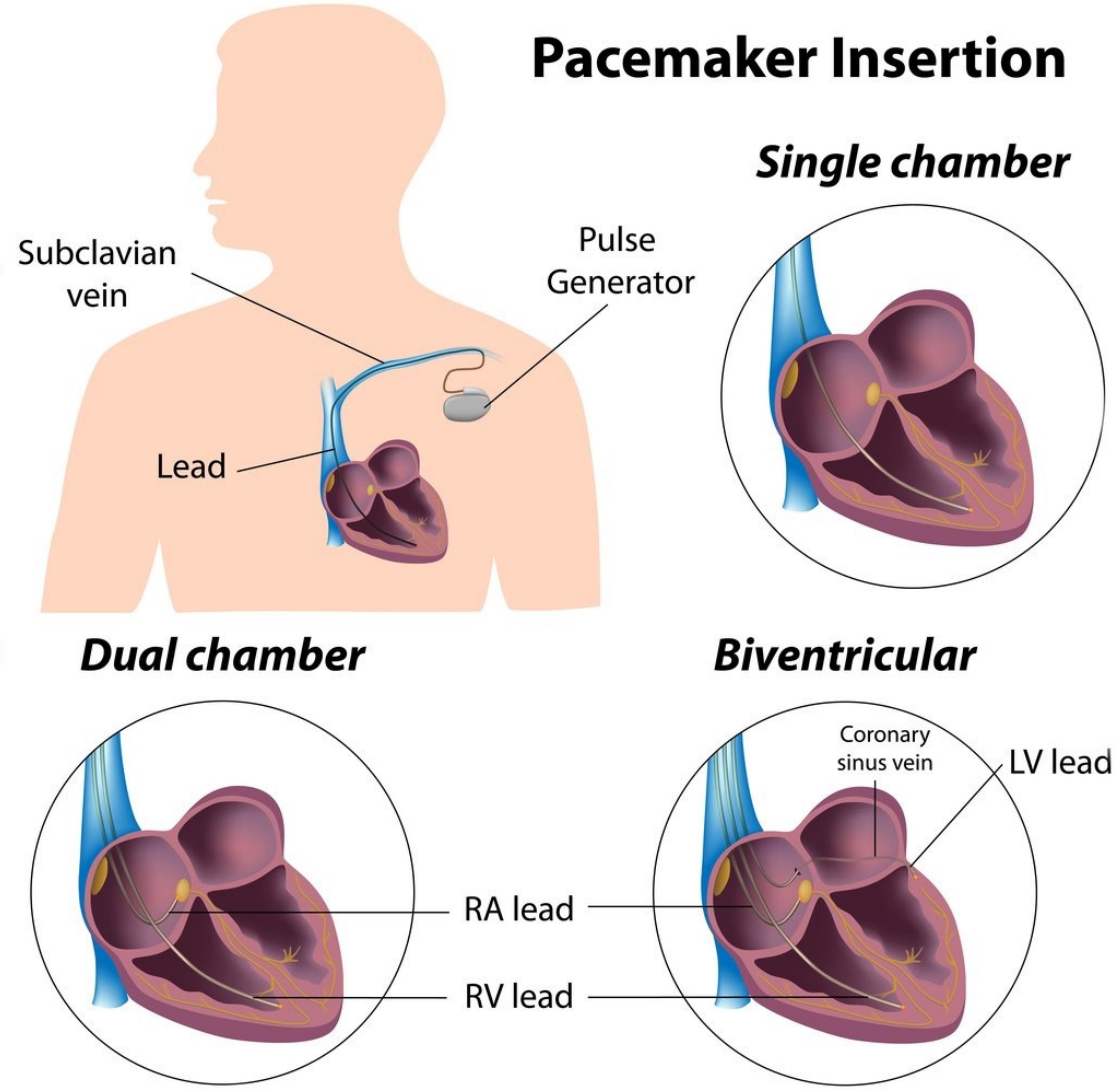
- Pacemakers give a small electrical impulse which initiates a contraction of the heart.
- Most current pacemakers work ‘on demand’; they only fire if you miss beats or the heart is too slow.
- Often now sense if body moving or breathing fast and speed up- ‘rate responsive’.
- Can be single chamber- atrium or ventricle- or dual chamber (both), or biventricular (3 leads, inc. resynchronisation).



Dual-chamber pacemaker.
Marcin Czarniecki, Radiopaedia.org.

Many possible settings and types depending on the problem.

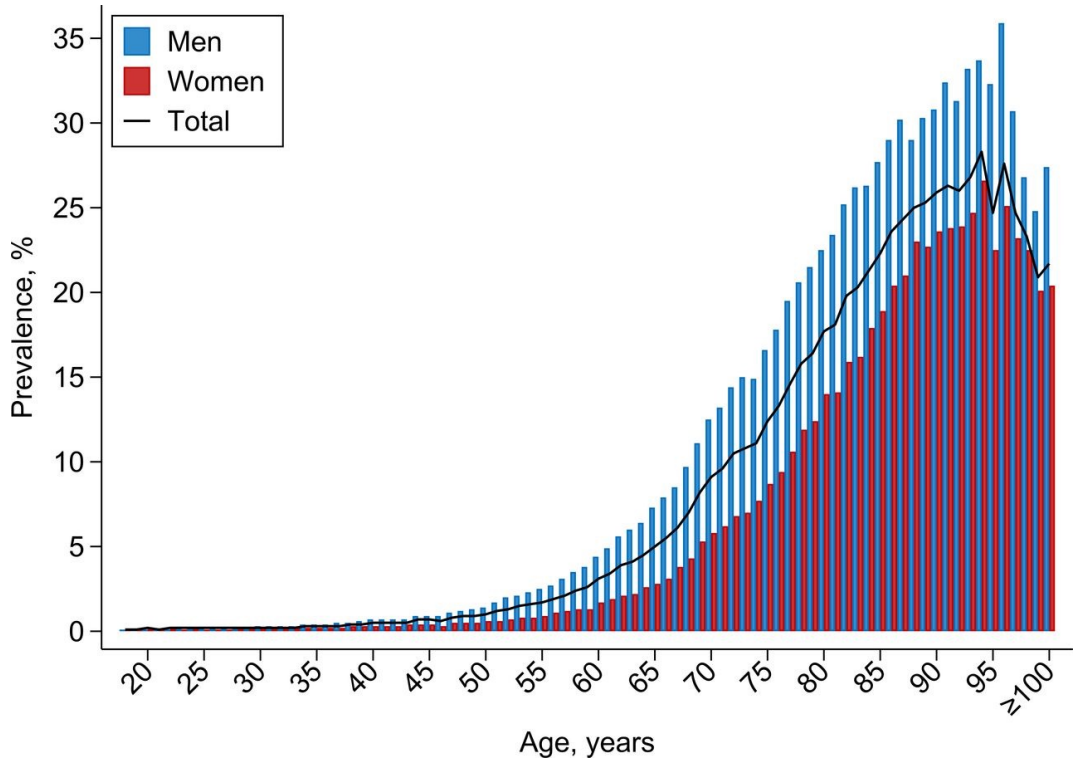
- Single lead right atrium if problem is the SA node only.
- Single lead right ventricle.
- Dual chamber ensures atrium and ventricle contract in sequence. Now commoner in older patients.
- Biventricular (three leads) includes for heart failure.
- Leadless pacemakers.



NHS

Atrial fibrillation (AF). Increasingly common with age.

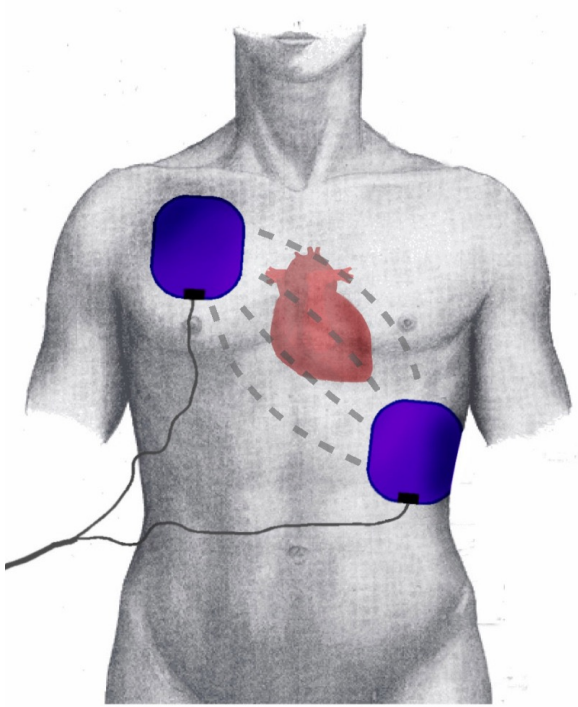
- The atrium is contracting uncontrollably like a twitching bag.
- Ventricle usually contracts irregularly (irregularly irregular).
- Less efficient than normal heartbeat: often breathlessness, heart failure.
- May drive the heart at a very fast, inefficient rate.
- Significantly increased risk of stroke.

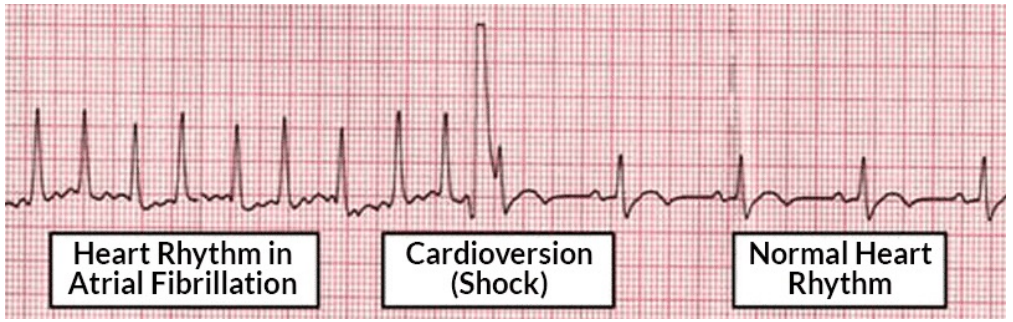


Adapted from Ewingdo; Kjerpeseth et al, Norway, BMJ Heart 2020

Atrial fibrillation may be temporary.

- Can be triggered by physiological stress such as sepsis, surgery.
- Alcohol and some drugs including caffeine, cocaine, amphetamines make it more likely.
- Thyroid overactive.
- If an obvious likely cause- stop the cause.
- If no cause but recent onset may be able to shock the heart out of it (DC cardioversion).
- Or drug cardioversion- amiodarone or flecainide.





ACLS.com / Wikimedia

Established (permanent) atrial fibrillation.

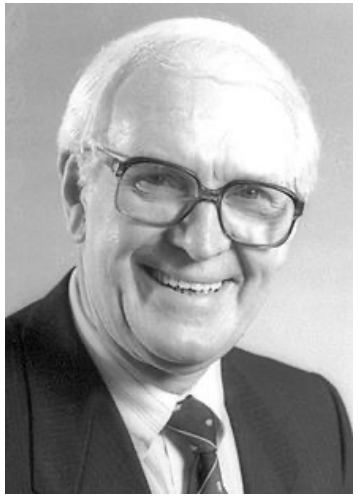
- If need to slow the heart down most commonly:
- Beta blockers.
- Calcium channel blockers.
- Digoxin, originally via work on foxgloves by Dr. William Withering in 1785.

- All lead to a slowing of impulses through the AV node via different routes.

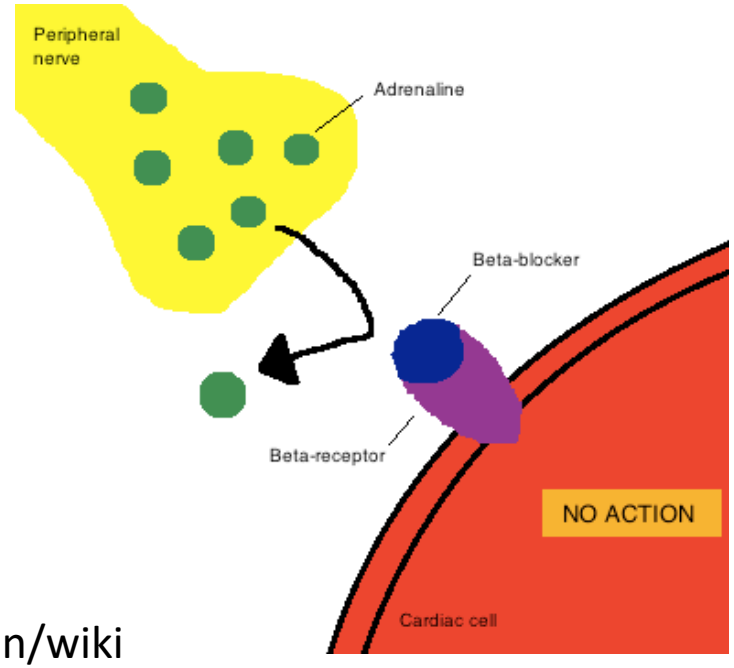
Withering. An account of the foxglove. 1785

Beta (ß) blockers.

- Adrenaline (epinephrine)- key to flight-and-fight response- includes heart going faster.
- Adrenaline stimulates beta receptors on several organs (among other things).
- Beta blockers block this selectively to cause the heart to beat more slowly.
- Previous lecture considered beta blockers used to reduce blood pressure.
- Examples include atenolol.



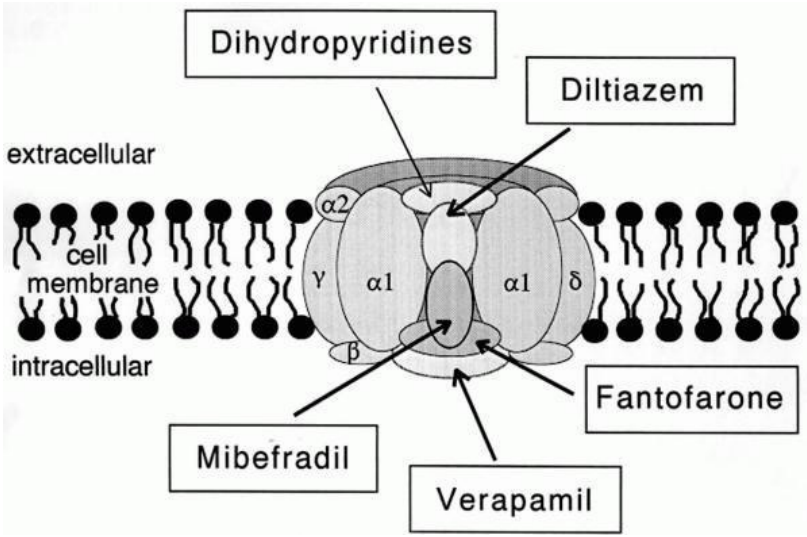
Sir James Black developed propranolol 1964.



Mogsan/wiki

Calcium-channel blockers.

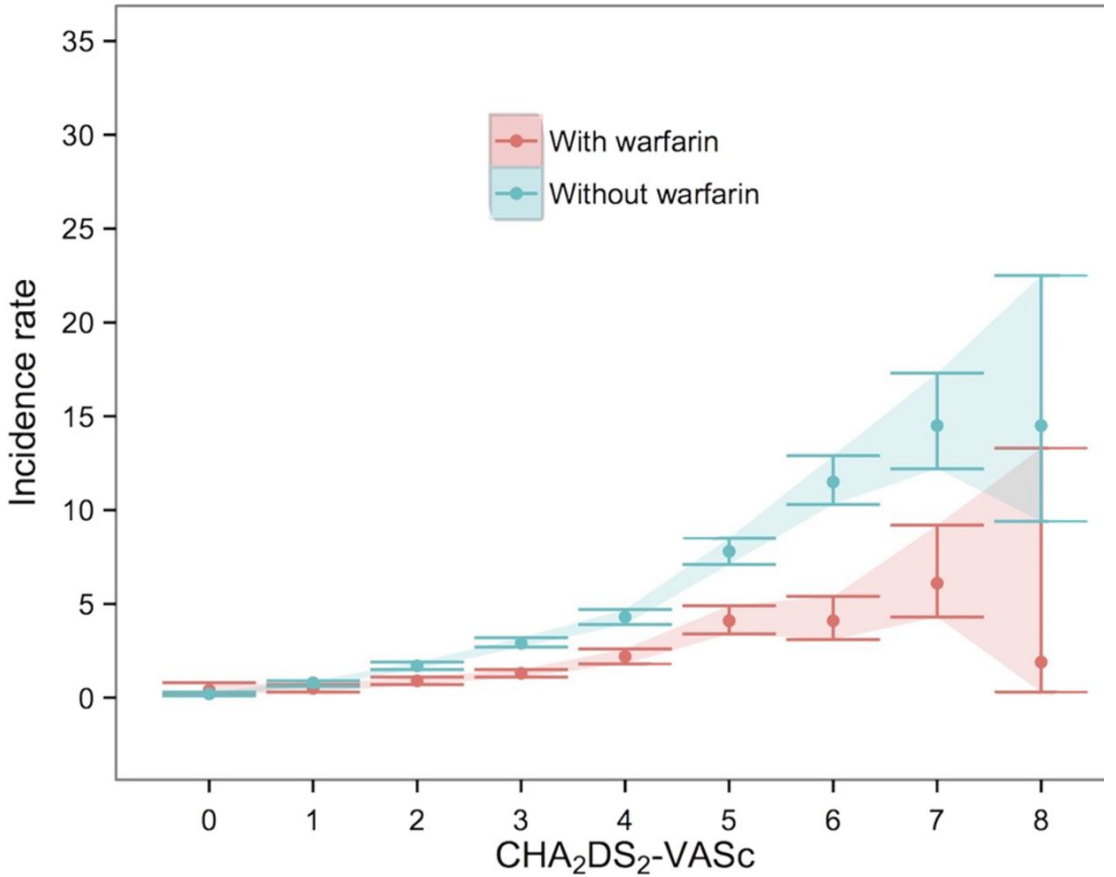
- The body uses calcium channels to signal and initiate action by many cells.
- In previous lecture Ca channel blockers optimised to reduce blood pressure.
- Some are optimised for slowing the heart: diltiazem and verapamil.



Vet vijayraj / wiki

A patient who has prolonged or permanent atrial fibrillation is likely to need anticoagulation (blood thinning).

- AF associated with higher risk of stroke.
- If other risk factors this is even higher. Various scoring systems.
- Except in young patients without other risk factors usually need anticoagulation unless high bleeding risk.
- Significantly reduces stroke risk.
- Directly acting oral anticoagulants. (DOAC); examples apixaban, rivaroxaban.
- Older alternative warfarin.



CHA2DS2-VASc score and risk of stroke by warfarin use. Allen V et al BMJ Heart 2017.

Cardiac (catheter) ablation for atrial fibrillation.

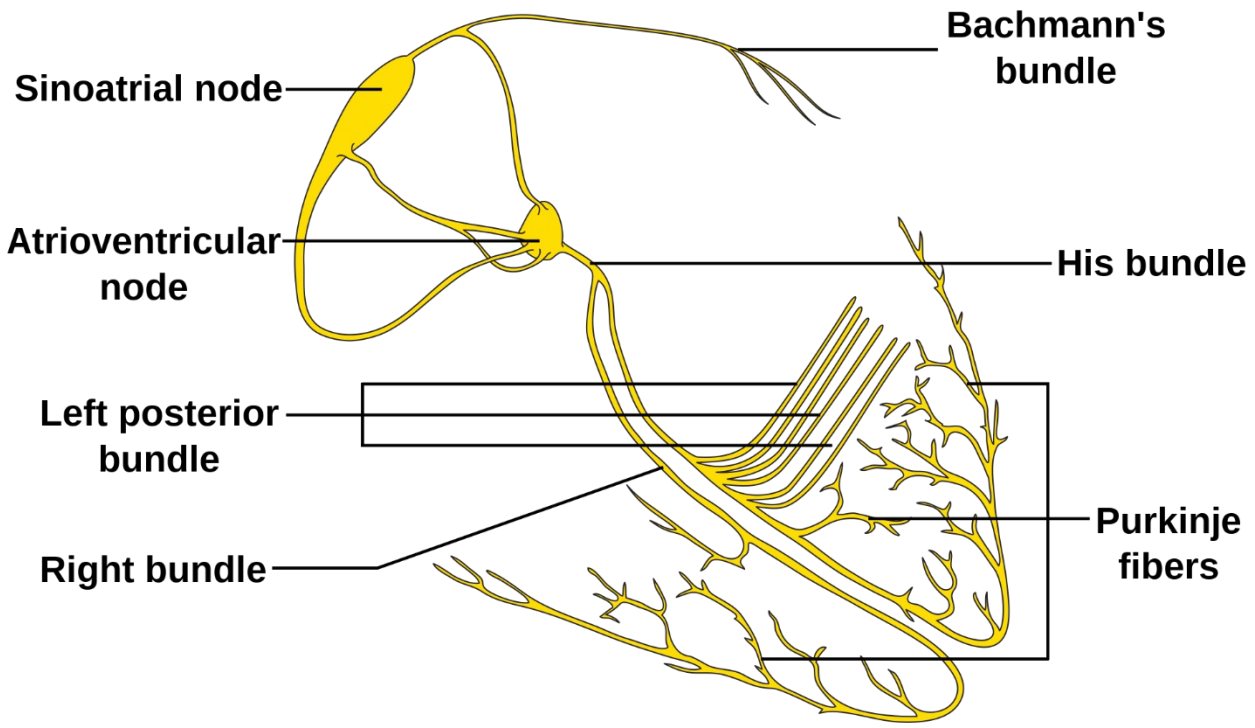
- In some people it is possible permanently to stop atrial fibrillation by cardiac ablation.
- Usually if not controlled with drugs.
- Performed via catheters fed usually from the groin up into the heart.
- If there is an area of the heart that is causing the atrial fibrillation it is detected then burned (scarring) by radiofrequency device.
- May need pacemaker afterwards.

NHS Papworth Hospital.

Intermittent (paroxysmal) atrial fibrillation.

- Some people have intermittent atrial fibrillation.
- In some this is controlled by drugs taken continuously, making it less likely.
- In some by ‘pill in the pocket’.
- Or ablation.
- May need anticoagulation.

Heart beating too fast: tachycardia.

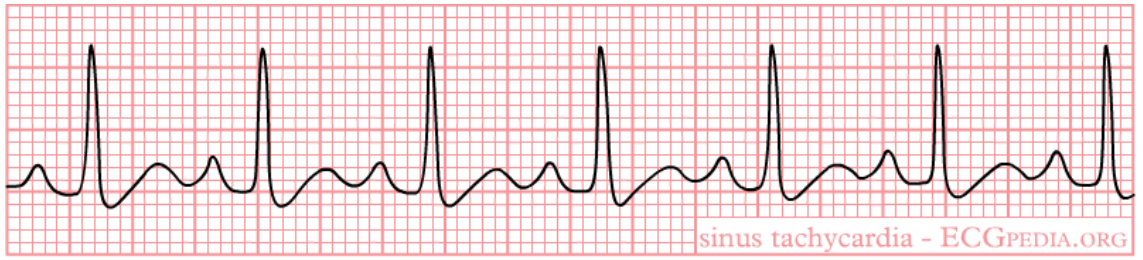


Madhero88; Angelito7

Sinus tachycardia. The heart is not the problem.

- Sinus tachycardia when the heart is going fast, but it is a normal p-wave and then ventricular contraction. Includes:
- Exercise (normal).
- Stress.
- Sepsis/infection.
- Shock/blood loss.
- Hyperthyroidism.

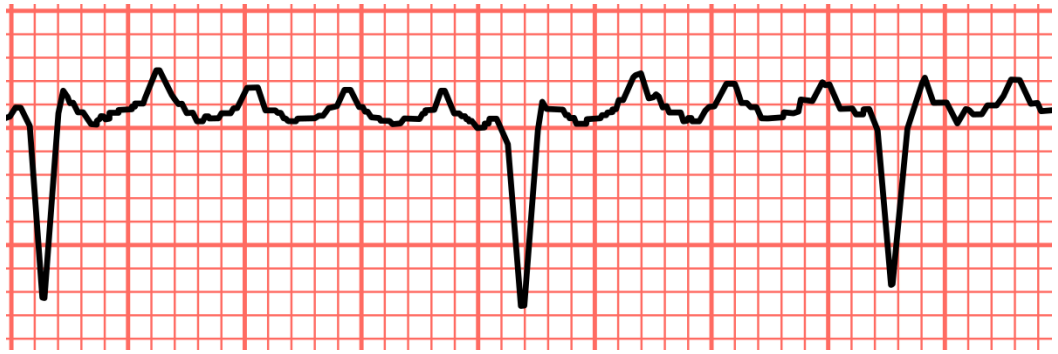
Treat the cause.



CardioNetworks

Atrial flutter.

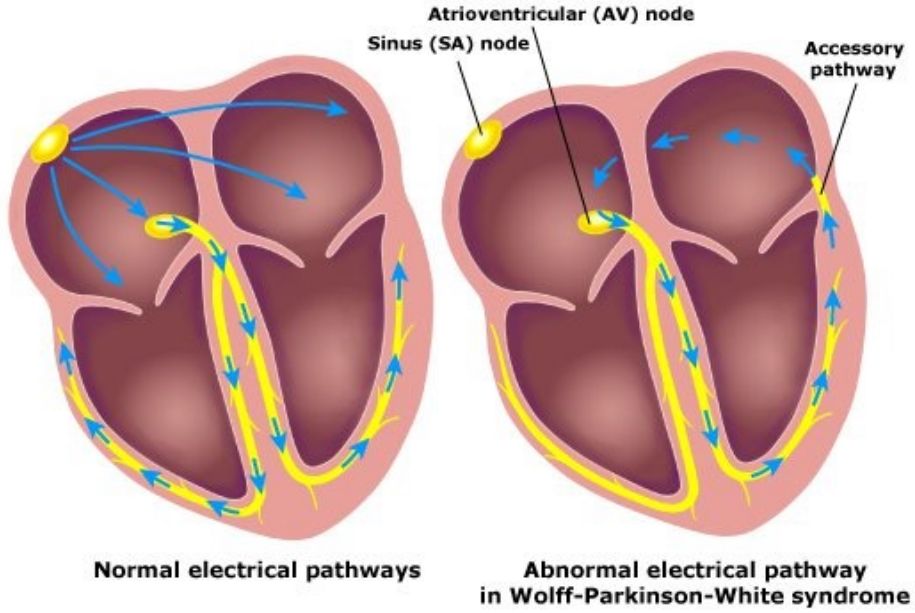
- The atrium is contracting at 280-300 beats per minute.
- Can have 1:1 (around 300bpm), or 2:1 block at the AV node leading to a ventricular rate of around 150.
- Or a 3:1, 4:1, 5:1 block. ‘Saw tooth’ rhythm.
- Usually easier to terminate than atrial fibrillation.
- Ablation often effective.



Ewingdo (1:1) James Heilman5:1/4:1

Supraventricular tachycardia (SVT).

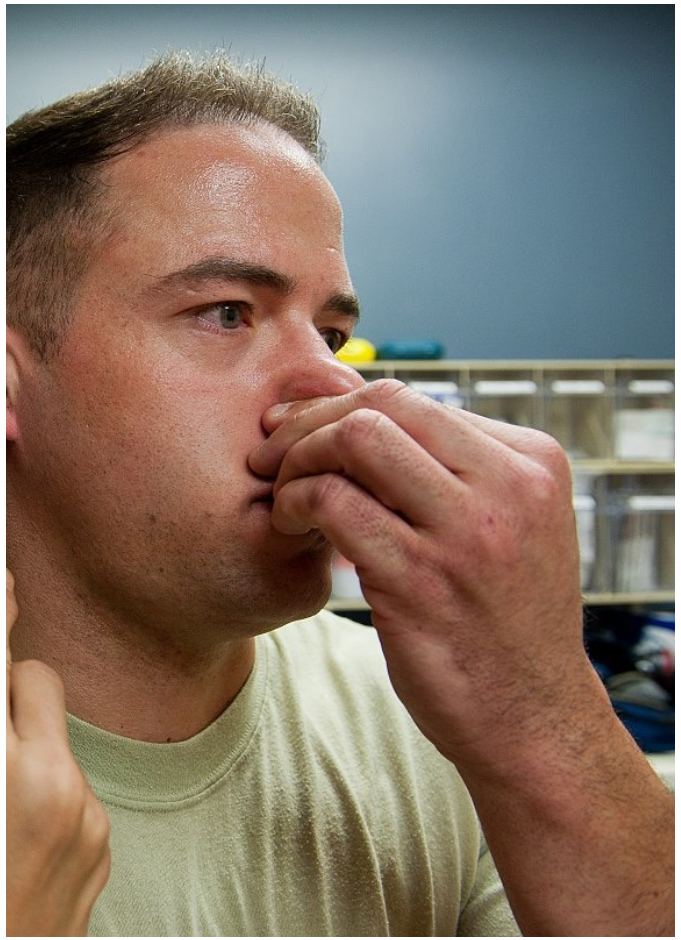
- If the tachycardia comes from above the AV node (atrium) or the AV node supraventricular.
- Usually a narrow complex ECG: narrow complex tachycardia. Include:
- Abnormal firing of a heart muscle cell: automaticity.
- Re-entry.
- Wolf-Parkinson-White (WPW).



Queens University re-entrant ECG; Tom Lück WPW

Treatment of supraventricular tachycardia.

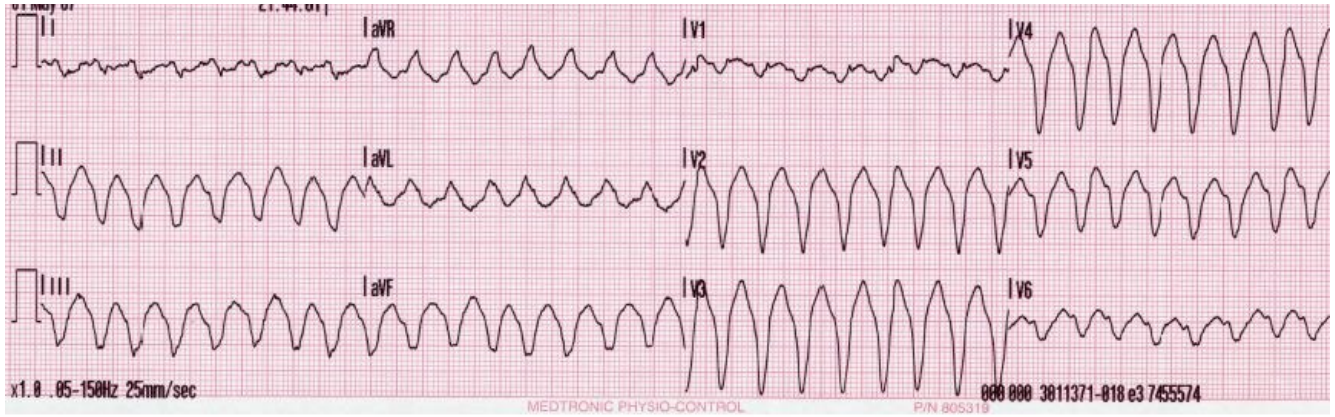
- Often temporary (but may recur).
- Parasympathetic system, eg blow against resistance (Valsalva) and release reduces AV conduction.
- Drugs to produce a temporary AV block.
- DC cardioversion (shock).
- Longer term drugs to slow transmission in the heart.
- Ablation.



USAF

Ventricular tachycardia (VT).

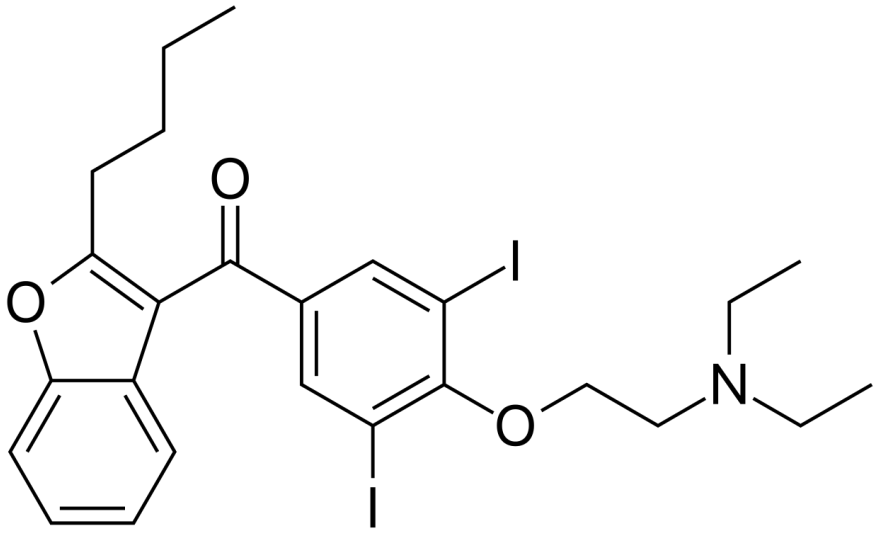
- Ventricular tachycardia from below the AV node.
- Broad complex tachycardia.
- Usually more severe than SVT. Generally a medical emergency.
- May be life-threatening.



Glenlarson

Treatment of ventricular tachycardia (VT).

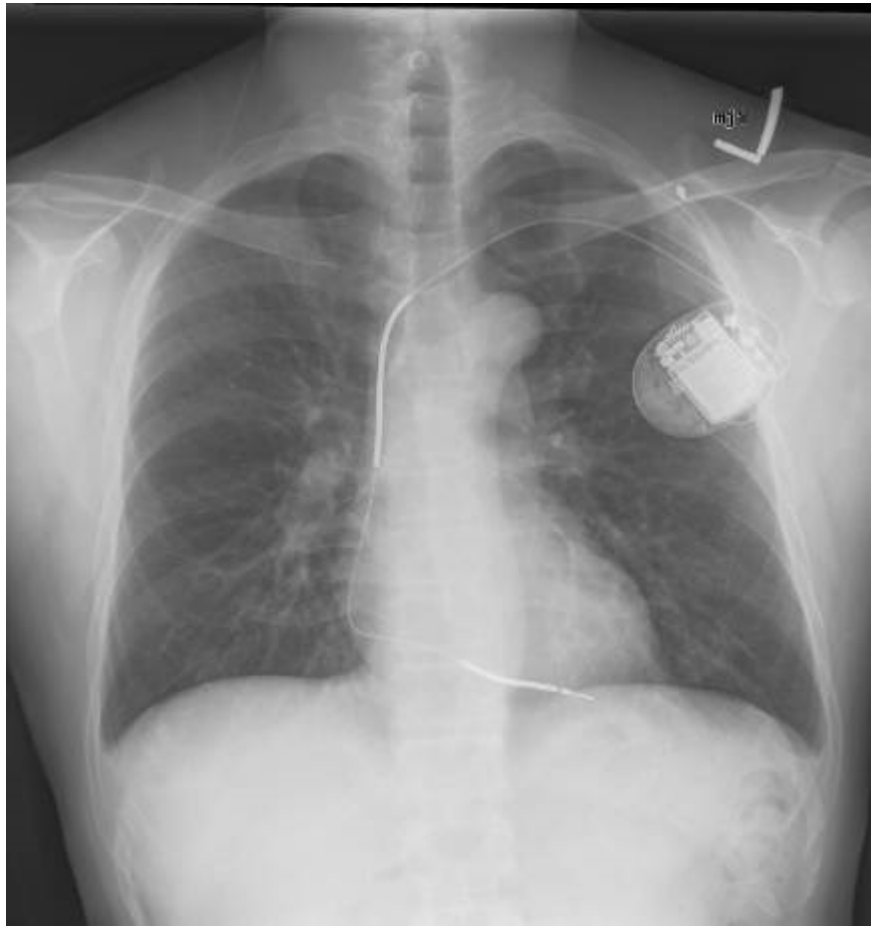
- Drugs which work on the AV node not relevant or dangerous.
- Amiodarone.
- DC cardioversion (shock) early if low blood pressure or other major risk.



Amiodarone. Wiki.

Pacemakers and implantable defibrillators in tachycardia.

- ‘Block and pace’: use drugs to slow the heart, and a pacemaker to kick in if it goes too slowly.
- Ablate and pace.
- Implantable cardioverter defibrillator. Can be intravenous or subcutaneous.



.

Gregory Marcus. Intravenous defibrillator.

Cardiac arrest.

- Usually sudden especially after a heart attack. Collapse, no pulse.

- (Sometimes) shockable rhythms, including:
- Ventricular fibrillation (VF).
- Pulseless VT.

Scottish Ambulance Service / JER 5150

CPR.

- An essential first aid skill.
- Chest compressions pump enough blood around the body and brain to keep them viable (for a while).
- 100-120 a minute.
- Use whilst waiting for help- phone 999 first.
- CPR alone can be used with minimal training. Rescue breaths usually need basic first aid training.

St John Ambulance.

External defibrillators.

- Cardiac arrest teams in hospitals and paramedics trained to use both drugs and defibrillators.

- Automatic defibrillators available in many public sites. They both diagnose and administer a shock.

London Ambulance Service.

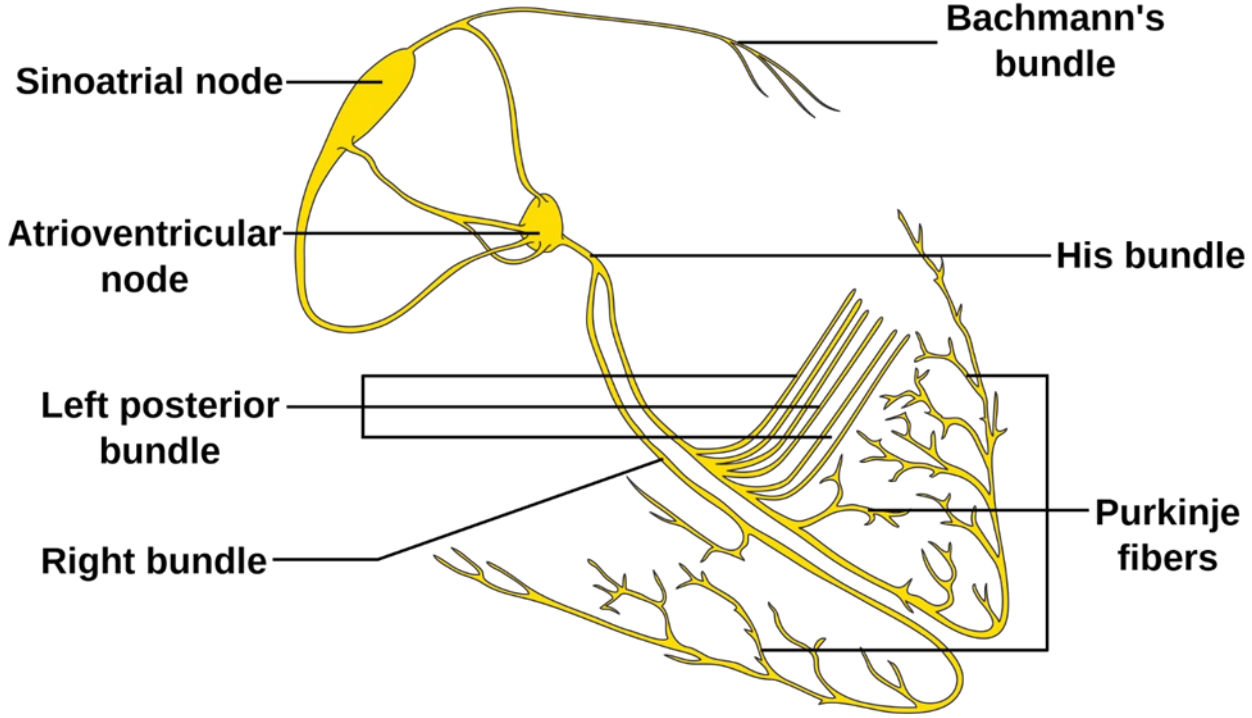
Prevention of arrythmia- keeping the heart young.

- Some medical drugs make arrythmia more likely.
- Alcohol, some recreational drugs.

- Generally things that are good for the heart reduce the risk of arrhythmia.
- Include stopping smoking, exercise, reducing hypertension and cholesterol.

Paul Holloway. Parkrun.

Bradycardia and tachycardia .



Jer 5150, Queens University

Madhero88; Angelito7