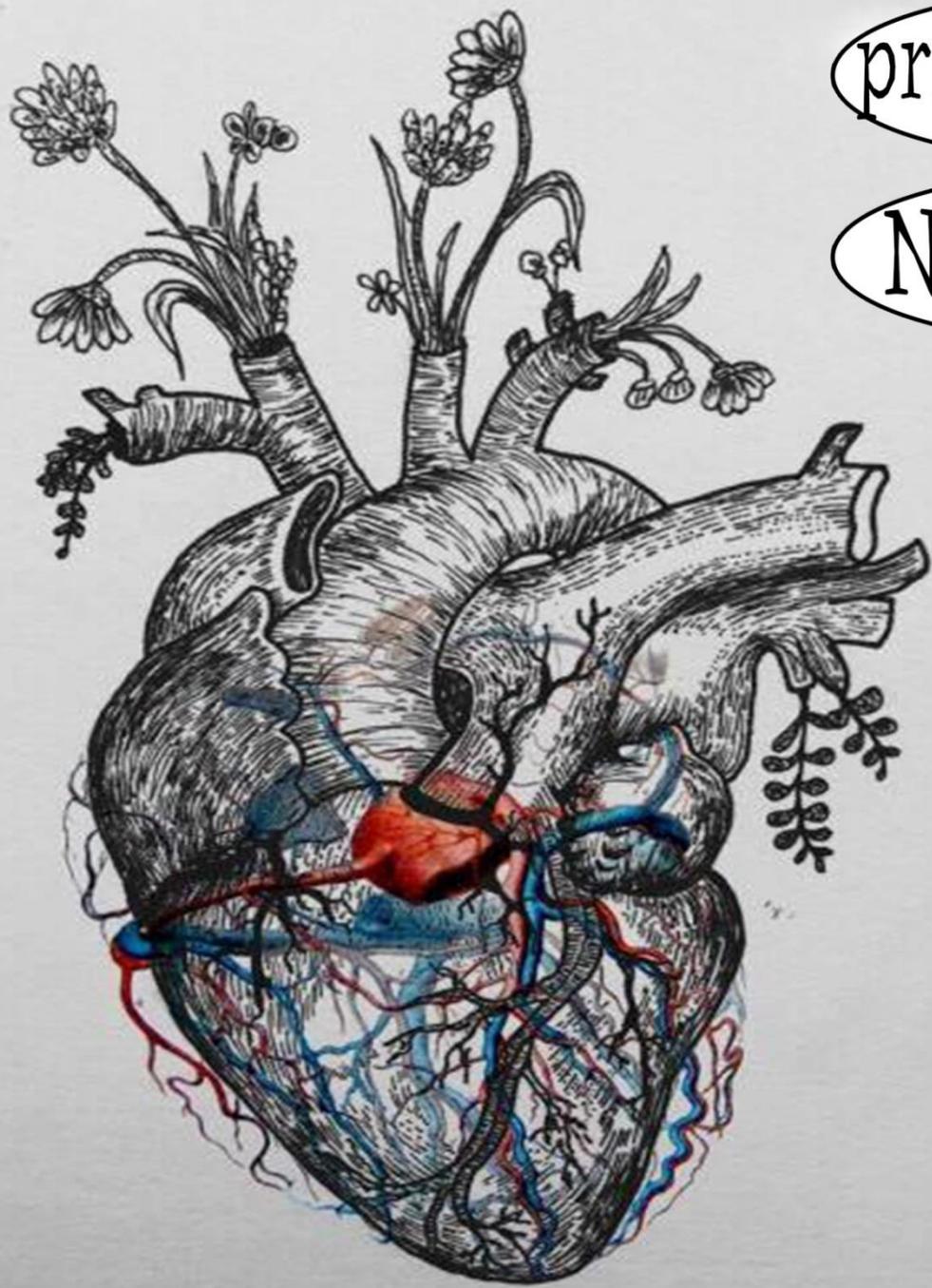


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physiology

lecture

6

Doctor

Mohammed Jaafer

Date

22-3-2016

Done by

Turquoise team



Cardiac Arrhythmias and Their Electrocardiographic Interpretation

Today, we are going to talk about the abnormal excitation.

As we said before, you have the *SA node*, which is the pacemaker for the heart.

The normal sequence of excitation is:

SA node > atria > AV node > AV bundle > Purkinje fibers.

(Normally, there shouldn't be a back flow of AP in the heart).

What are we looking for when we look at the ECG OR measure the pulse?

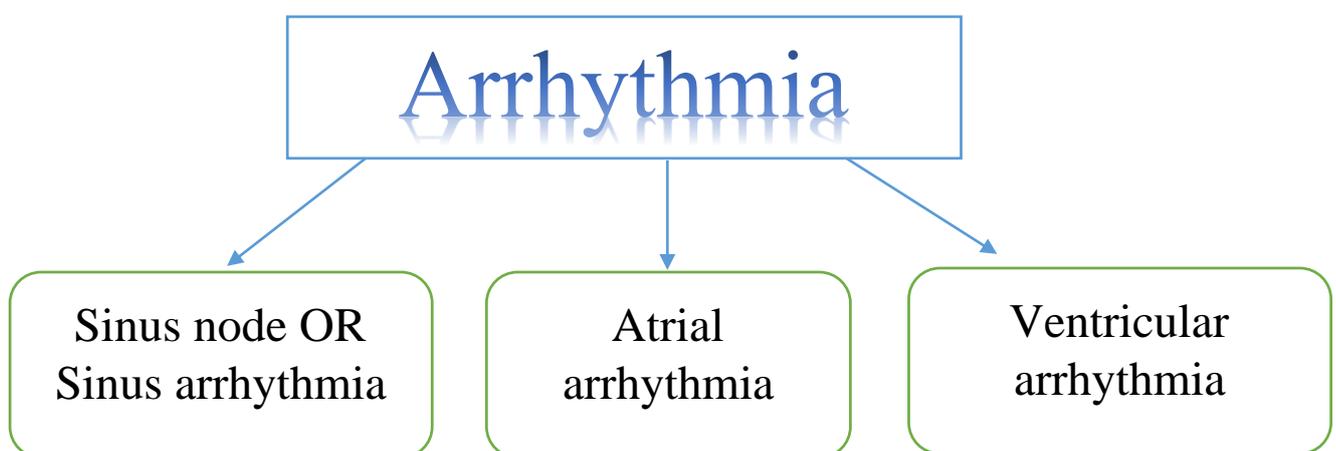
We are looking **for the rate of the heart**: to say whether it is normal or abnormal.

When we say that the rate is regular, this is what we call **SINUS RHYTHM** that means that the rhythm is coming from the SA node.

In the abnormal excitation: The excitation could begin from anywhere in the conductive system, conductive tissues OR EVEN in the ventricular fibers.

If there would be an abnormal beat, it is either one beat or several beats. In this case, there is no more sinus rhythm; we call it abnormal rhythm or **Arrhythmia**.

So simply, Arrhythmia means abnormal rhythm OR abnormal excitation. We can divide arrhythmia into three types:



- In **Sinus node OR Sinus arrhythmia**: There's an abnormality in the SA node. Therefore, the excitation will be abnormal.
- In **Atrial arrhythmia**, the excitation will be in the atrium.
- In **Ventricular arrhythmia**, the excitation will be in the ventricles.

Note: Heart Block: If the excitation is normal in the SA node, and the problem is in the transmission of the AP (blockage in transmission).

SINUS ARRHYTHMIA:

Most of the sinus arrhythmias are **Physiological Responses**, like, tachycardia OR bradycardia.

We can divide it into four main categories:

- 1- Sinus tachycardia (increase in the heart rate).
- 2- Sinus bradycardia (decrease in the heart rate).
- 3- Respiratory arrhythmias: occur after taking a deep inspiration, which will increase the heart rate. Therefore, respiratory arrhythmias would occur when there is an increase in inspiration or a decrease in expiration. Respiratory arrhythmias are manifested in kids or newborn babies. (It is not that clear in the adults).

In all sinus arrhythmia, the AP will start normally in the SA node, with normal ECG, but the rate of excitation will be abnormal (increased or decreased or blocked).

Note: These 3 types are mostly physiological, however, the 4th type is usually pathological.

4- Sick sinus syndrome (SSS):

In this case, there is a problem in the SA node (in the excitation). And this part of the disease can give high rate, slow rate or sinus block, and the patient sometimes loses his consciousness and falls down. In this case, we have to put an artificial pacemaker (and this is the indication for putting artificial pacemaker) {in sinus block, the patient can die if we don't put an artificial pacemaker 😞}.

Atrial arrhythmia:

Any point in the atrium that can generate excitation higher than SA node as IF it becomes the pacemaker. So when there is an active point "a mad area in the atria" for a reason or another that generates more than the SA node → this is atrial arrhythmia (remember that any part of the conductive system has the ability to generate and transmit the impulse).

Note: if this extra excitation arrives at the heart in the refractory period, nothing will happen, but if it come after the refractory period, it will re-stimulate the heart.

We have four types:

1) Atrial extra systole:

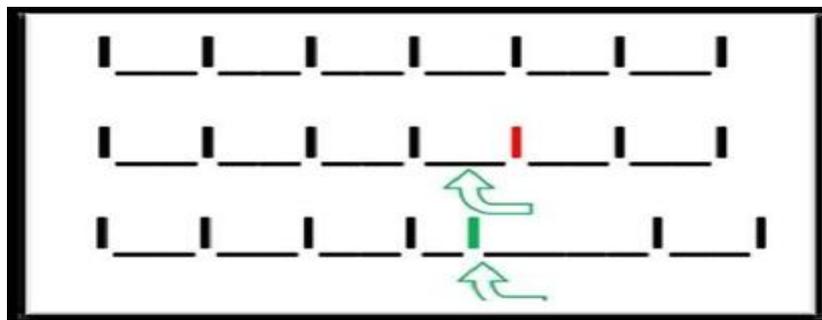
Any focus (point) in the atria can generate an impulse that will give an excitation.

When one extra beat comes before the SA node normal beat, in any point in the atrium (except in the SA node), we will have something that is called **atrial extra systole**.

This extra one beat is called atrial ectopic / atrial extra systole

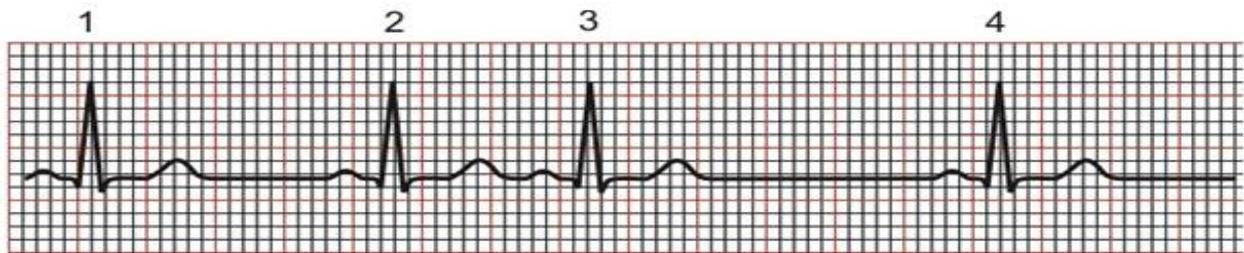
What will happen after that? The patient will tell you that his heart has stopped. **Why?**

Because when there is a beat before the SA node, The SA node will not generate an impulse (the normal impulse), because it's in refractory period.

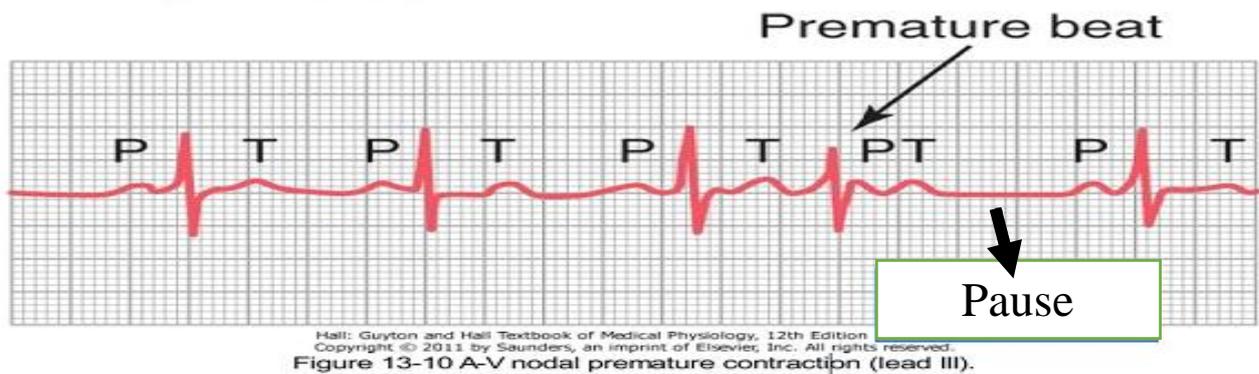


In Other Words; if an extra beat comes in the resting period after a normal beat, the refractory period of the extra beat will cancel the

next normal beat coming from the SA node. (The patient will feel as if his heart has stopped, because a beat is missing and there will be a pause).



This represents a normal sinus beat, except for number 3 which is a premature atrial, after that you have a pause, so it is an extra beat. Note that the distance between 1 and 2 doesn't equal distance between 2 and 3.



Notes: 1) The premature beat, we call it the 'premature atria.' This beat is the extra beat here. 2) All the other beats are normal. (Sinus beats). 3) The pause that is found after the premature beat. 4) This type is also called PAC: premature atrial contraction.

2) Supraventricular Tachycardia/ atrial tachycardia:

When the focus (which gave the one extra beat in the atrial extra systole) generates a rate higher than SA node, it will become the pacemaker. Consequently, we will have what we call it **atrial tachycardia or SVT (supraventricular tachycardia)**.

In SVT; QRS is normal BUT the heart rate is high, the rate will be 150 to 220 (beat/min). Why?

We said that the AV node has a delay. Because of this delay the AV node cannot transmit all the impulses in the atria to the ventricles, there is a limitation. The maximum rate the AV node can transport to the ventricles is 220. A rate higher than 220 can't cross to the ventricles.

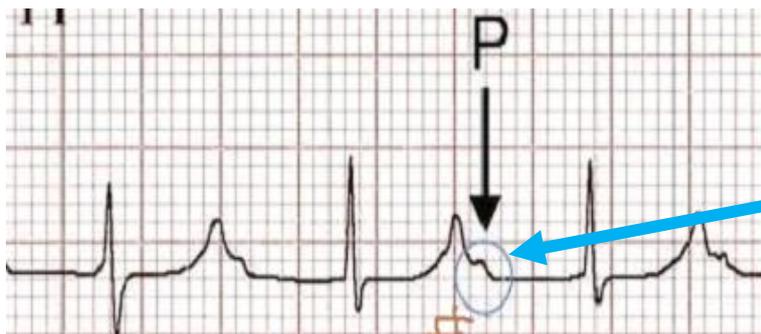
Because of this high rate (150-220 and not higher than 220), the T will come closer to the P (we call it T on P). So when the patient is watching TV or playing xbox at rest, he feels tachycardia for few minutes then it'll stop.

Note: The ECG will be Regular (R-R interval are the same, and the ratio between P, QRS and T is 1:1:1) {BUT the rate is high}.

SVT ECGs:



P.S: This ECG shows tachycardia (due to the high heart rates) in SVT patients.



T ON P

This is also SVT. Here you can notice the T on P (T on P rather separate) and this happen because the rate is very high (there is no time between P and T).

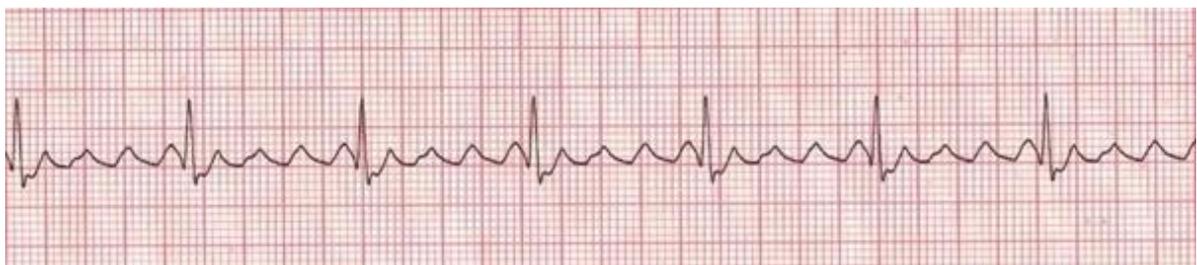
SMILE AND CONTINUE 😊

3) Atrial flutter:

The rate in the focus is more than 220; (250-300). But the point here is that this rate will cross to the ventricle regularly. So, atrial flutter happens in regular case. (R.E.G.U.L.A.R) {the rate in the atria is more than 220, but it is less than 220 in the ventricles}.

In other words, the rate of excitation of the atria will be higher than the ventricles, however, the ventricles' excitation is regular (R-R interval are the same).

In the ECG, we will find that RR interval is regular, but in between we'll have 2 or 3 P waves and 1 QRS (repeated). Three excitation in atrium (3 p) + one in ventricle (1 normal QRS). THEN, three excitation in atrium (3 p) + one in ventricle (1 normal QRS).



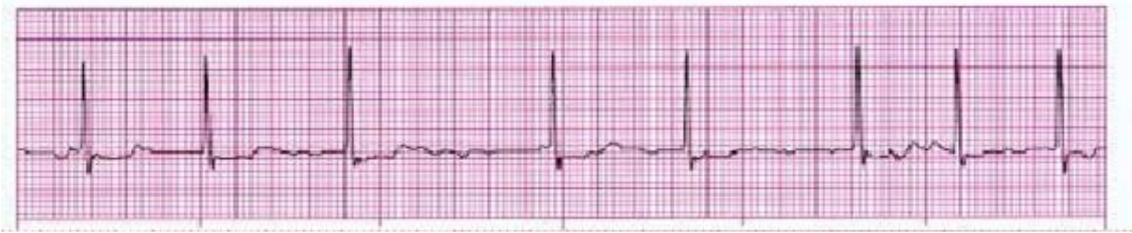
In this ECG, we can notice:

- Repeated P wave in constant frequency (regular). (Here you can notice 3 P then 1 QRS then 1 T repeatedly).
- ECG is abnormal.
- QRS is always normal.
- P waves more than QRS (and it is more than 220 P/minute).
- RR interval is regular.

4) Atrial fibrillation:

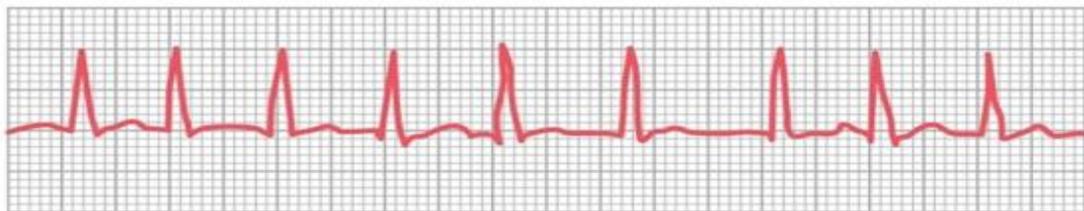
The heart rate is more than 250 beat/min (sometimes the doctor says it's more than 350 beat/min and other times more than 250). More than one focus will generate impulse leading to many impulses that can cross through the AV node in irregular way. For example, three excitation (3 p) in atrium + one in ventricle (1 normal QRS); THEN five excitation (5p) in atrium + one in ventricle (1 normal QRS) {NOT REGULAR OR irregular}.

Related ECGs:



- P is repeated in different frequencies (irregular) {abnormal ECG} in atrial fibrillation.
- QRS is always normal.
- In atrial fibrillation, the P wave will be **very shallow and sometime absent**, you can see too many P waves, and R-R interval is **irregular**. (Note that the R-R interval is regular in atrial flutter).

Irregularity of Ventricular Rhythm during Atrial Fibrillation



Hall: Guyton and Hall Textbook of Medical Physiology, 12th Edition
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Figure 13-19 Atrial fibrillation (lead I). The waves that can be seen are ventricular QRS and T waves.



P is repeated in different frequencies (irregular)
{abnormal ECG}

QRS is always normal

Atrial fibrillation is the most:

1. Common arrhythmia.
2. Common arrhythmia that develops in a normal heart.

Note: the only type of atrial arrhythmia with irregular R-R interval is the atrial fibrillation.

Patients of atrial fibrillation can live up to 20 years!

Atrial fibrillation (irregular) is a highly risk arrhythmia. The rate here is very high, the blood in the atria will stay there because there is no time for pumping, leading to a clot. And after atrial fibrillation is over, this clot will pass in the blood resulting in a cerebrovascular accident {CVA} (leading to paralysis).

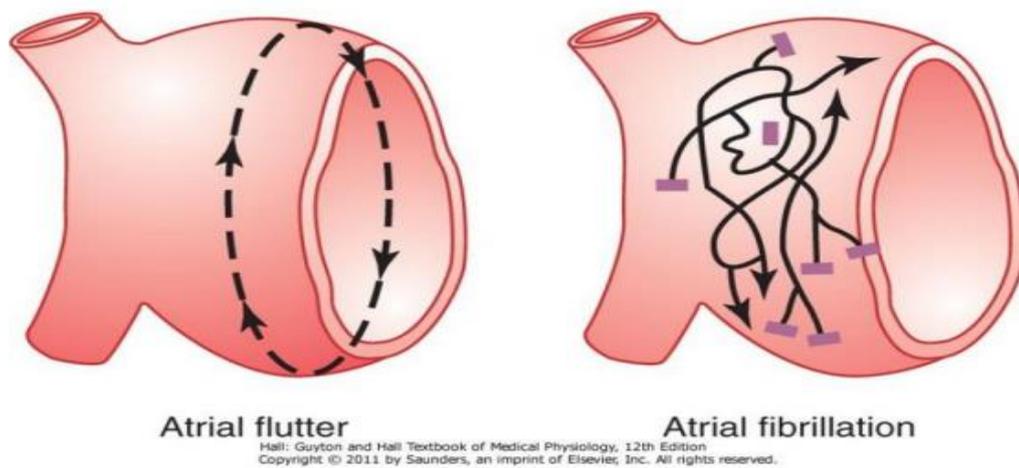
SO it's vital to give atrial fibrillation patients an anticoagulant to prevent the formation of the clot.

Note: the doctor made some sounds in the record at 22:22 that represent different types of atrial arrhythmia, you can listen to them.

The doctor said that in the exam he will not bring an ECG and ask us what this is for diagnosis.

Type of atrial arrhythmia	Number of Beat/ min	R-R interval	P wave
PAC	-----	Irregular	
SVT	150-220	Regular	T on P P = QRS
Atrial flutter	More than 220	Regular	More than QRS
Atrial fibrillation	More than 220	Irregular	Very shallow and more than QRS

Between 5% - 10% of the population will develop atrial fibrillation after the age of 5!!



Because there are too many points that can generate AP in atrial fibrillation, there will be too many P wave, and these P waves will be shallow.

You can see here how atrial flutter and how atrial fibrillation can develop. In flutter the beats are more than 220 but going in one pathway (starting and ending at the same point), but in atrial fibrillation there are so many points that generate excitation at the same time so some of them cross to the AV node while other can't if the AV node is in refractory period.

Note: the arrhythmia doesn't happen all the time, it will come to the patient for few minute and disappear for some time (maybe hours or days) {it will happen every day, every week, every month, etc.} (In some cases, it can be continues).

Drink some water, take a deep breathe, smile, and continue ☺

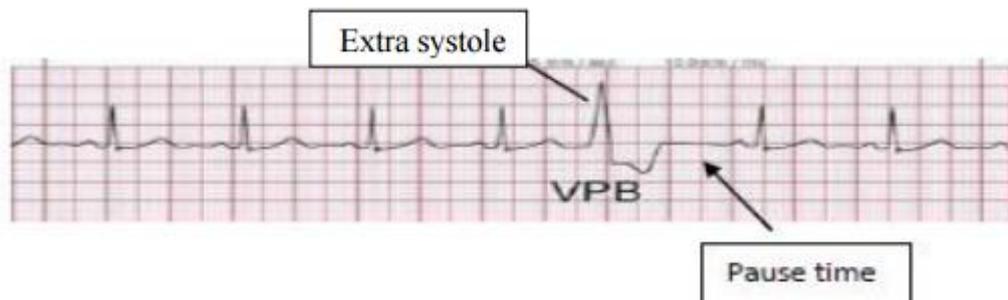
Ventricular arrhythmia:

This type of arrhythmia occurs in the ventricles.

The main difference between the atrial arrhythmia and the ventricular arrhythmia is the QRS interval. QRS in the atrial Arrhythmia is **normal** because the excitation is in a normal pathway (Atria>AV node>Ventricles), while in ventricular arrhythmia, the excitation is abnormal. So for that reason, the QRS interval appears **widened** in Ventricular arrhythmia.

*It has different types:

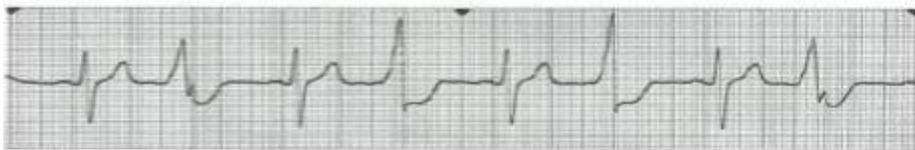
1. Premature ventricular contraction (PVC) or ventricular extra systole: There's one extra systole in the ventricles + it is only one point to give you the extra systole.



Note the pause after the extra systole.

Note: the QRS looks abnormal because it arises from the ventricles not from the SA node, so it's abnormal.

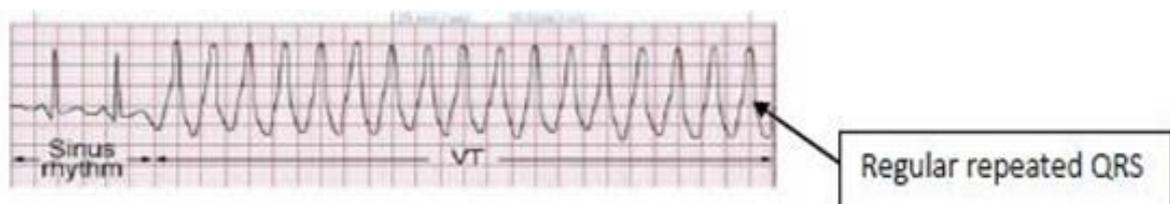
2. Bigeminal: one normal beat coming from the SA node, followed up by an abnormal beat from the ventricle. So one normal, one abnormal (repeat).



3. Trigeminal: Here are two normal beats followed up by one abnormal.



4. Ventricular tachycardia: when this extra systole repeats its self-several times in regular way (it's the second most dangerous type of arrhythmias).



It is extremely important to monitor the ECG of a ventricular tachycardia patient, where we must put him/her in the CCU (coronary care unit). Because if there would be ventricular tachycardia, the patient will die immediately. So, we have to rush to do something.

5. Ventricular fibrillation: it occurs when the beat repeats itself in an irregular fashion, and it is the most **dangerous** type of arrhythmia where the patient dies within few seconds.

When the patient has ventricular tachycardia, he will (almost always) develop ventricular fibrillation and he will die within few seconds (you can't see a patient in the street with VF !!).

However, patients of atrial fibrillation can live up to 20 years!

This is the ECG for Ventricular fibrillation. And as the doctor mentioned it is a bizarre shaped, and it will last for few seconds only, then the patient will die (heart arrest or asystole).



The doctor kept repeating: the most common type of arrhythmia is: **atrial fibrillation**, the irregular type of arrhythmia is: **atrial fibrillation**.

In ventricular tachycardia, we don't see P wave or T wave because its amplitude is very small in comparison with QRS.

Causes of arrhythmia:

Atrial arrhythmia can develop in either normal or dilated (diseased caused mainly by valvular disease) heart. While ventricular arrhythmia can never develop in the normal heart unless it is a side effects of some drugs.

Mostly, atrial arrhythmia will develop in normal heart, but not the ventricular arrhythmia.

People who consume drugs may develop ventricular arrhythmia in normal heart.

Ventricular arrhythmia mostly develop in patients with Myocardial infarction, dilated cardiomyopathy, heart failure, in infection like: (myocarditis), hypertension or ischemia (angina).

Now if someone sleeps in the night and he didn't wake up (☹), he mostly developed ventricular fibrillation, as a side effect of a drug, or he took an over dose of a drug (so, some drugs cause ventricular arrhythmia and will lead to death after taking a high dose or after a normal dose).

Most of anti-arrhythmic drugs cause arrhythmia (they will develop arrhythmia as a side effect!).

The causes (or precipitating factors) of atrial arrhythmia are:

- | | |
|-------------------|---------------------|
| 1. Heavy smokers. | 4. Alcohol. |
| 2. Stress. | 5. Anxiety. |
| 3. Hypertension. | 6. Hyperthyroidism. |

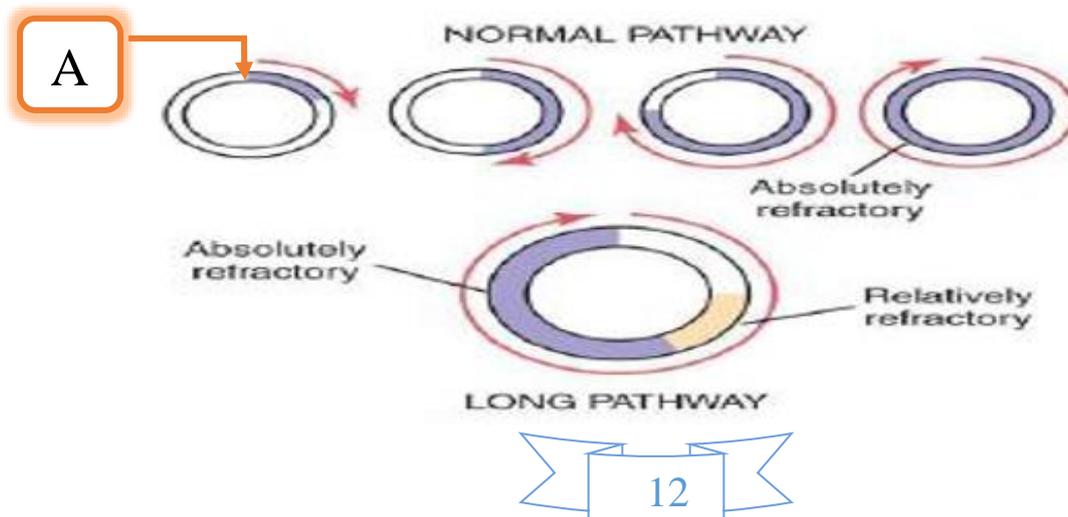
Remember:
Ventricular
arrhythmia
is caused by:

The main cause of arrhythmia is: valvular heart disease (like mitral heart disease).

Remember: the most common heart disease is mitral heart disease.

Mechanism Of arrhythmia:

Imagine this a strip of cardiac muscle (the figure). The impulse will start at point A and it will rotate back to the original point (point A). Then, what will happen?



If the point A is in the refractory period, the impulse will die out. But if it's out the refractory period it will stimulate it again.

This is called re-entry phenomena, where the impulse will keep stimulating again and again, as long as point A is out of the refractory period (the same impulse will keep stimulating the heart).

So how will point A be out of the refractory period? By three mechanisms:

1. Dilation of the heart muscle (as a result of heart failure or cardiomyopathy). Dilation will lead to increase the surface (or the distance) of the heart, so the impulse will need more time to go back to A → A will be out of refractory Period.
2. Slow conduction, decreasing the excitation velocity (Either Parasympathetic stimulation or low Potassium). So, it will take time to start excitation.
3. Shortening action potential, so the refractory period will be short, and A will be out of RP very fast (this happen in sympathetic stimulation or with digoxin toxicity).

So all of these factors lead to re-entry phenomena.

Re-entry phenomena can happen in the atria or ventricles.

Now, how can we diagnose a patient with arrhythmia? Simply, By ECG.

But the problem is that the patient will come to you and say he felt tachycardia, palpation, ... and by the time he is in the hospital he will be normal, so we will put a Holter monitor, this device will record the ECG for 1 day, 2 days, 3 days and so on.

And we ask the patient to press on the device any time he feels abnormal, and it will record the ECG at that time.

The most common complication of arrhythmia is Heart failure, and the most dangerous complication is atrial fibrillation (because the heart rate is very high → shallow atrial contraction → blood will stay in atria → coagulation → cerebrovascular accident).

And our last topic ☺

Heart Block/Conduction block:

Here the excitation is **normal**, but the transmission or conduction of the impulse from the atria to the ventricles is greatly affected (**abnormal**).

The transmission occurs in the AV node. So, the AV node is either: **diseased** or a **dead tissue**. If it is diseased, the transmission will be much **slower** (1st and 2nd degree heart block), so the excitation will pass but it will take more time.

While in dead tissue there is no transmission of the excitation to the ventricles, so the atria and the ventricle will excite their self independently (3rd degree heart block or complete heart block).

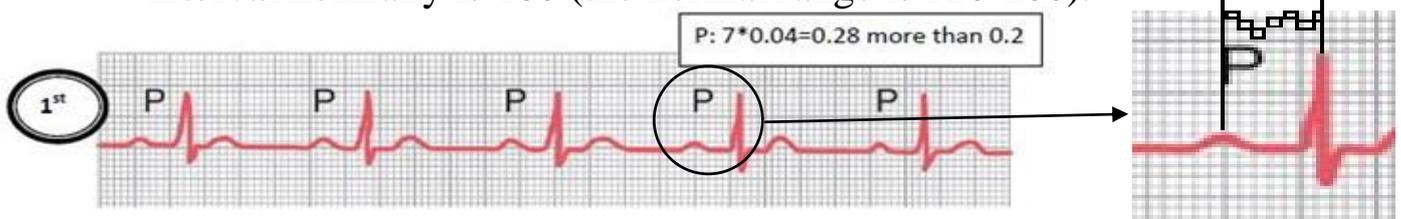
So, we have three classes of heart block:

- A) 1st degree.
- B) 2nd degree.
- C) 3rd degree (complete heart block).

In 3rd degree the heart rate will be less than 40, so we need artificial pacemaker. Remember: the other use of artificial pacemaker is in the SSS (sick sinus syndrome).

The 1st degree heart block:

It's simply the prolongation of the PR period (PR>200). The PR interval normally is 160 (the normal range is 120-200).



Remember: each small square equals .04 second, so if there is more than 5 small squares between P wave and R → 1st degree.

In the last figure the distance between P and R was almost 7 small squares → more than 5 → 1st degree heart block.

The 2^{ed} degree heart block:

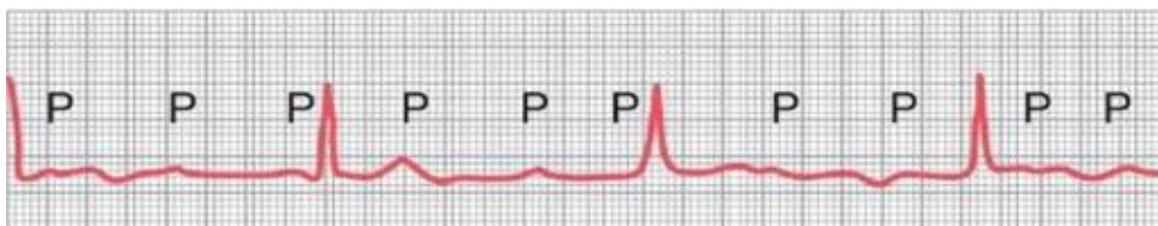
It is the progressive increase of the PR interval. PR wave is normal, then slightly increases till one beat is missing. Example, at first it would be 160 then becomes 180, then 200, then 220, and then 240, then one beat is missing then start all over again from 160.



The 3rd degree heart block (complete heart block):

In this degree there's no connection (relation) between the ventricle and the atrium. In this case the ventricular rate is very low (30-35) and is irregular.

The heart rate is less than 40. So here the patient will feel dizzy because of decreased blood flow to the brain due to low cardiac output. This is an indication for an artificial pacemaker.



WE NEED AN ARTIFICIAL PACEMAKER IN CASE OF:

Sick sinus syndrome & complete heart block.

Treatment:

The treatment of arrhythmia is done either pharmacologically (antiarrhythmic drugs) or nonpharmacologically (no medicine).

Non-pharmacological treatment is done either by:

- 1) Valsalva maneuver: when you expire against closed epiglottis (as if you are in the bathroom), so you generate pressure in the chest to stimulate the parasympathetic.
- 2) Ask the patient to put his hands in ice.
- 3) Press hard press on the eyeballs.
- 4) Do carotid massage (but be careful to do the massage only at one side; not both).
- 5) Put ice in front of the head.

You should explain those non-pharmacological treatments to the patients in order to terminate arrhythmia at home. But he/she should be administrated to the hospital to take further useful pharmacological Treatment (these treatment is used mainly for patient with SVT or atrial fibrillation).

And now you finish the sheet and feel like



DONE BY: أحمد عبيد

فرقة فريوار