

Date:
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لجان الدفعات



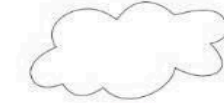
تفريغ فسيولوجي



موضوع المحاضرة: Cardiovascular system



رقم المحاضرة: Lec 8 part 2 /2



إعداد الصيدلانية: Jeneen Alhasan



- Blood يحتوي على
 - white blood cells
 - red blood cells
 - الصفائح
 - البروتينات

THE CARDIOVASCULAR SYSTEM: THE HEART

- The heart contributes to homeostasis by pumping blood through blood vessels to the tissues of the body to deliver oxygen and nutrients and remove wastes.
- The cardiovascular system consists of the blood, the heart, and blood vessels.

- cardio vascular system يحافظ على Balance , homeostasis عن طريقه normal function للجهاز يؤدي فيه الأكسجين و nutrients إلى باقي أنحاء الجسم عن طريقه systemic circulation وتستخدمها الخلايا في cellular process بعدد يرجع الدم محمل بنائي أكسيد الكربون CO₂ واللب يوصل للجزء الأيمن من القلب واللب يؤديه للرئتين وتعمل تبادل بين الأكسجين وغاز أكسيد الكربون فيخرج الدم إلى الجزء الأيسر من القلب محمل بالأكسجين

HISTOLOGY OF CARDIAC MUSCLE TISSUE

- Compared with skeletal muscle fibers, cardiac muscle fibers are shorter in length. They also exhibit branching, which gives individual cardiac muscle fibers a "stair-step" appearance.
- Cardiac muscle fibers connect to neighboring fibers by intercalated discs, which contain desmosomes, which hold the fibers together, and gap junctions, which allow muscle action potentials to conduct from one muscle fiber to its neighbors.
- Gap unit. junctions allow the entire myocardium of the atria or the ventricles to contract as a single, coordinated.

comparison between skeletal muscle and cardiac muscle
 skeletal muscle fiber - يكون طويل
 cardiac muscle fiber - يكون قصير
 contraction - ينقبضونهم نفس

cardiac muscle fiber - يكون
 Branching أكبر يعني عدد تفرعاتها
 يتكون أكبر

cardiac muscle - one nucleus
 skeletal muscle - multi

كل cardiac muscle fiber متصل مع fiber آخر عن طريقه intercalated discs

نوع synapse في
 chemical ← skeletal muscle
 لأنه يحتاج نواقل عصبية
 أما cardiac muscle نوعها electrical

وجود gap junctions في cardiac muscle تساعد على انتقال electrical impulses

cardiac muscle is involuntary controlled

AUTORHYTHMIC FIBERS: THE CONDUCTION SYSTEM

جهاز موجود في القلب →

- ✓ An inherent and rhythmical electrical activity is the reason for the heart's lifelong beat.
- ✓ The **source of this electrical activity** is a network of specialized cardiac muscle fibers called **autorhythmic fibers** because they are **self-excitabile**.
- ✓ **Autorhythmic fibers repeatedly generate action potentials that trigger heart contractions.**

- عملية إنتاج action potential في cardiac muscle عن طريق conduction system يكون في SA node موجودة في right atrium بعدين في AV node بعدين AV bundle بعدين purkinje fiber

← قادرة على إنتاج action potential من تلقاء نفسها

• إذا كان heart rate أقل من 70 منه Brady cardia

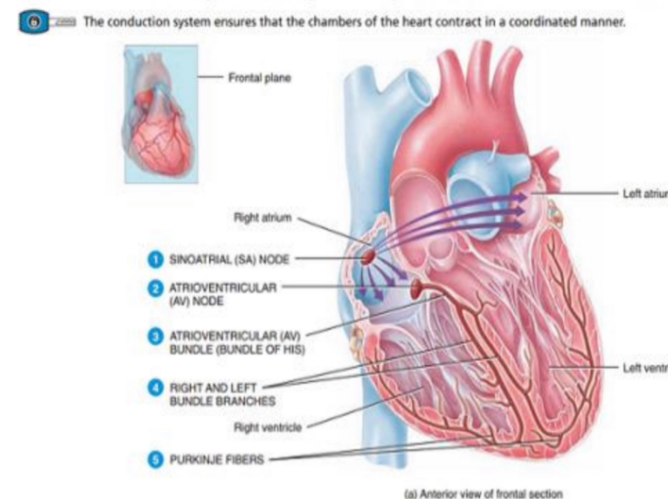
• إذا كان heart rate أعلى من 100 منه tachy cardia

• الدم يرجع من systemic circulation وحقل بقاي الحسيه الكربون إلى الجزء الأيمن من القلب وأول جزء يياخه هذا الدم هو right atrium بعدين في مقام اسمه tricuspid valve يفتح وينزل الدم إلى right ventricle وبعد في مقام يوصل للرئتين اسمه pulmonary valve و CO₂ و يخرج للجزء الأيسر حمل بالأكسجين

AUTORHYTHMIC FIBERS: THE CONDUCTION SYSTEM

1. They act as a pacemaker (electrical excitation that causes contraction of the heart).
2. They form the cardiac conduction system.
3. Cardiac action potentials propagate through the conduction system in the following sequence:
 - **Cardiac excitation normally begins in the sinoatrial (SA) node.**

Figure 20.10 The conduction system of the heart. Autorhythmic fibers in the SA node, located in the right atrial wall (a), act as the heart's pacemaker, initiating cardiac action potentials (b) that cause contraction of the heart's chambers.



• SA node قادرة على إنتاج action potential

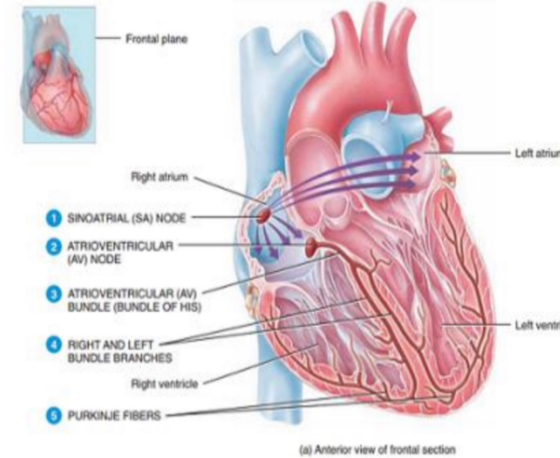
• بعض الناس يكون عندهم مشاكل في SA node أو في AV node ، إذا قم إنتاج action potential بشكل طبيعي عن طريق SA node تكون قيمة heart rate 70 - 100 beat / min لكن إذا كان هناك مشكلة في SA node وتم إنتاج action potential عن طريق AV node لا يتم إنتاج action potential من 70 إلى 100 فتمكن يتم إنتاج heart rate أقل من 70

action potential من 70 إلى 100 فتمكن يتم إنتاج heart rate أقل من 70

AUTORHYTHMIC FIBERS: THE CONDUCTION SYSTEM

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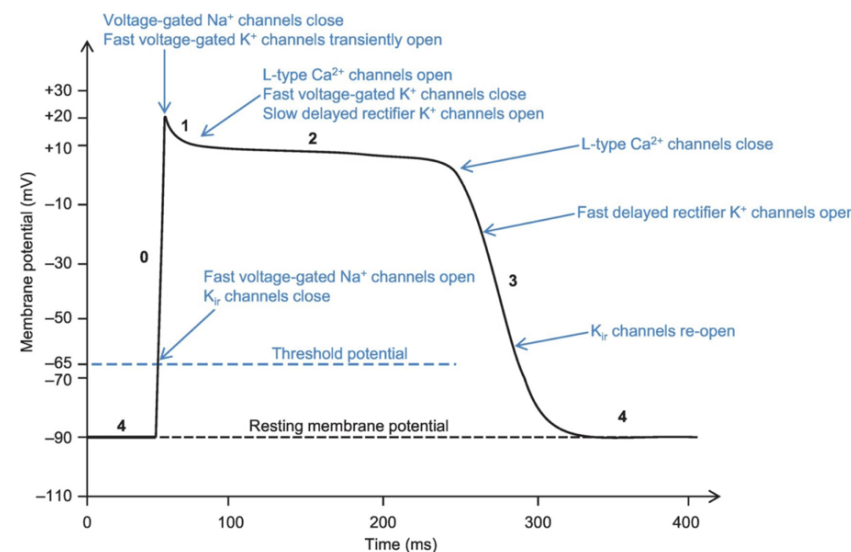
• fibers الخاصة ب SA node يتوزع على جدارين ل atrium

• عملية contraction بتسير بنفس الوقت يعني بنفس الوقت الذي يكون في دم يرجع للجهة اليمنى من القلب يكون في دم يرجع للجهة اليسرى من القلب

• في مرحلة depolarization تفتح قنوات الكالسيوم وتفتح قنوات البوتاسيوم وبتطوي عملية contraction لحد ما يعطي كل الدم من right ventricle يعني ينتهي مرحلة depolarization وبتسري repolarization

• في مرحلة repolarization بتسري قنوات الكالسيوم وبتفتح قنوات البوتاسيوم

ACTION POTENTIAL AND CONTRACTION OF CONTRACTILE FIBERS



• action potential في cardiac muscle تختلف كأرقام عن other body cells

• Resting = -90

• threshold = -65

• depolarization = +20

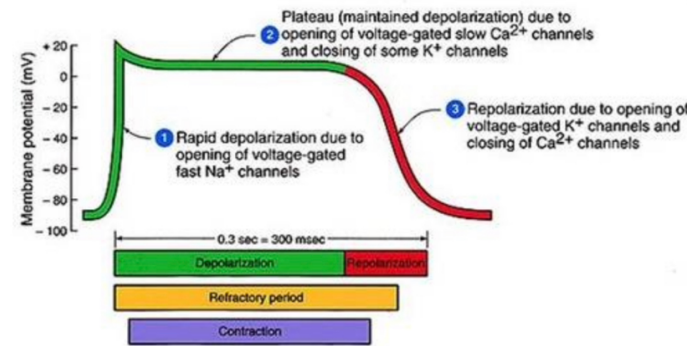
• عملية depolarization التي بتسير بالقلب فترتها أطول

لأنه لما يسير generation of action potential من SA node ، خلال هذا الوقت يكون الدم يعطي في right atrium و ينتقل action potential من SA node إلى AV node ، و gap junction الموجود في AV node صغيرة فال action potential من AV node بطول ، لذلك depolarization بطول

ACTION POTENTIAL AND CONTRACTION OF CONTRACTILE FIBERS

الحفاظ على مرحلة **depolarization** لفترة طويلة حتى أتأكد انه كل الدم عم بجبتي في **Ventricle** بس يجتي ويخلص بلبس **repolarization** اللي بتبكر فيها قنوات الكالسيوم و بتفتح قنوات البوتاسيوم

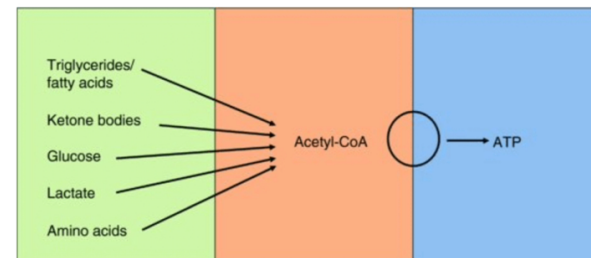
❖ **Plateau:** A period of maintained depolarization. It is due in part to opening of voltage-gated slow calcium ions channels in the sarcolemma. The increased calcium ions concentration in the cytosol ultimately triggers contraction. Several different types of voltage-gated potassium ions channels are also found in the sarcolemma of a contractile fiber (calcium ions inflow just balances potassium ions outflow).



• لما يوصل action potential إلى -120 بهير
after hyperpolarization
سبي ما بهير لفترة طويلة
(ما بطول) لأنه عملين contraction
سريعة جدًا

ATP PRODUCTION IN CARDIAC MUSCLE

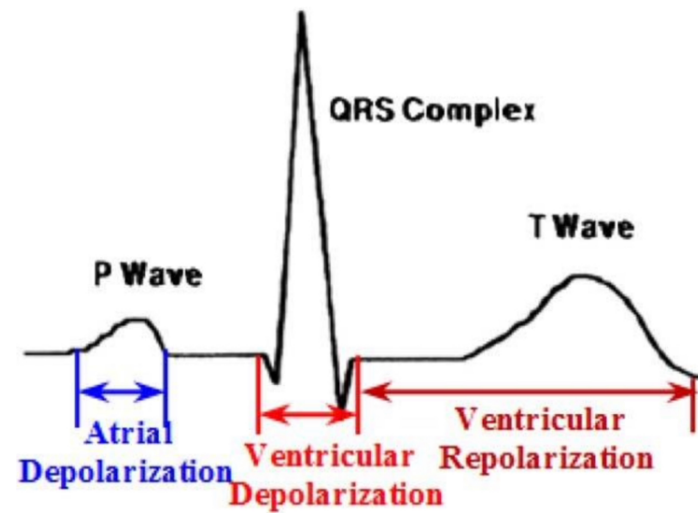
- In contrast to skeletal muscle, cardiac muscle produces little of the ATP it needs by anaerobic cellular respiration.
- Cardiac muscle fibers use several fuels to power mitochondrial ATP production. In a person at rest, the heart's ATP comes mainly from oxidation of fatty acids (60%) and glucose (35%), with smaller contributions from lactic acid, amino acids, and ketone bodies. During exercise, the heart's use of lactic acid, produced by actively contracting skeletal muscles, rises.



• مصادر ATP في skeletal muscle و cardiac muscle
← skeletal muscle ممكن
ما يعتمد على الاكسجين
ولكن cardiac muscle
بحاجة إلى الاكسجين

• نحن بحاجة إلى كميات كبيرة
جداً من ATP في cardiac muscle
ونحتاج إلى مصادر كثيرة

ELECTROCARDIOGRAM



• P wave تفضل

Atrial depolarization

* يمكن يجمع معه بالخبرات في السؤال

Ventricle filling

Atrial systole

وهكذا

ولكن الجواب الأصح هو

Atrial depolarization

• بعد ما تخلص مرحلة Atrial depolarization

بدي أعطي وقت حتى كل

الدم الموجود في Atrium

يطلع لـ ventricle

بعديها بتبليش QRS complex

وتعدين T-wave

• depolarization = contraction = systole

• repolarization = relaxation = diastole

• Atrial depolarization = Atrial contraction = Atrial systole = ventricle filling = ventricle relaxation = ventricle diastole

• الانقباض اللي بصير في ventricle بكون قوته أكبر لأنه right ventricle بده يودّي الدم للرئتين أما left ventricle بده يودي الدم لكل الجسم

• حدار left ventricle بكون very thick

• gap junctions في AV node تكون صغيرة لكن في bundle و purkinje fiber تكون gap junction كبيرة فبكون electrical impulse انتقلوا جدًا كبير

ELECTROCARDIOGRAM

➤ In reading an ECG, the size of the waves can provide clues to abnormalities.

1. **Larger P waves** indicate enlargement of an atrium.
2. An **enlarged Q wave** may indicate a myocardial infarction.
3. An **enlarged R wave** generally indicates enlarged ventricles.
4. The **T wave** is flatter than normal when the heart muscle is receiving insufficient oxygen—as, for example, in coronary artery disease. The T wave may be elevated in hyperkalaemia (high blood K ions level).

سكتان قلبية حادة

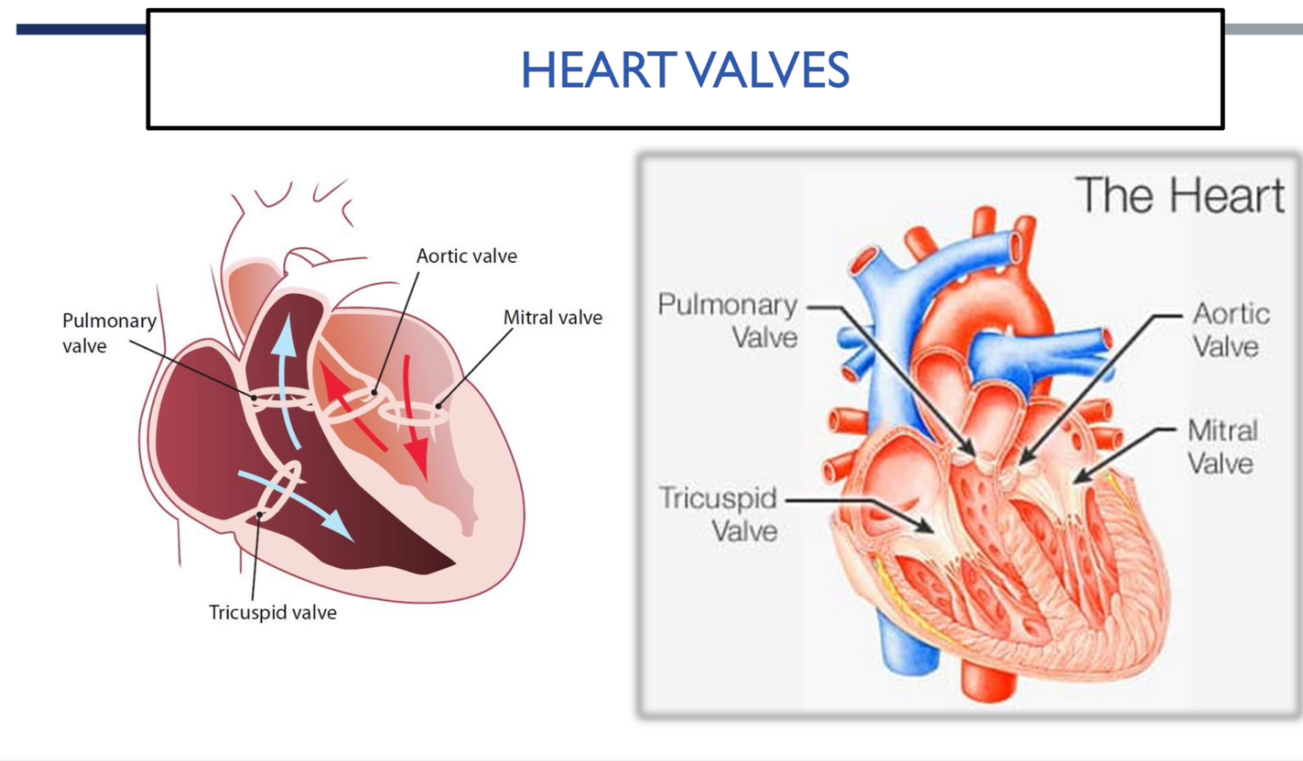
CORRELATION OF ECG WAVES WITH ATRIAL AND VENTRICULAR SYSTOLE

- The term **systole** refers to the phase of contraction.
- The phase of relaxation is **diastole**.
- **The ECG waves predict the timing of atrial and ventricular systole and diastole.**
 - ❖ As the atrial contractile fibers depolarize, the P wave appears in the ECG.
 - ❖ After the P wave begins, the atria contract (atrial systole).
 - ❖ The action potential propagates rapidly again after entering the AV bundle. About 0.2 sec after onset of the P wave, it has propagated through the bundle branches, Purkinje fibers, and the entire ventricular myocardium.
 - ❖ Contraction of ventricular contractile fibers (ventricular systole) begins shortly after the QRS complex appears and continues during the S-T segment.
 - ❖ Repolarization of ventricular contractile fibers produces the T wave in the ECG about after the onset of the P wave.
 - ❖ Shortly after the T wave begins, the ventricles start to relax (ventricular diastole). Ventricular repolarization is complete and ventricular contractile fibers are relaxed.

- other name for mitral valve → **bicuspid valve**

- **tricuspid valve**
٣ فتحات

- **Bicuspid valve**
٢ فتحتين



- ما بين right atrium و tricuspid valve: right ventricle

- ما بين right ventricle و lungs pulmonary valve

- ما بين left atrium و left ventricle mitral valve

- ما بين left ventricle و aorta Aortic valve

- **S₄** دائماً abnormal

- **S₃** ممكن يكون normal او abnormal

- **S₁ and S₂ are very loud**
- **S₃ and S₄ are faint** ضعيفا

- **S₃ و S₄ لهم علاقة**
ب Atrial contraction
يعني يطلعوا قبل S₁

- **S₃ يطلع لما يكون قوّة**
تدفق الدم من atrium إلى ventricle عالية جداً
يعني اول ما حيز atrium contraction

HEART SOUNDS

- Auscultation, the act of listening to sounds within the body, is usually done with a stethoscope.
- During each cardiac cycle, there are four heart sounds, but in a normal heart only the first and second heart sounds (S₁ and S₂) are loud enough to be heard through a stethoscope.
- **The first sound (S₁)**, which can be described as **a lubb sound**, is louder and a bit longer than the second sound. S₁ is caused by blood turbulence associated with **closure of the AV valves** soon after ventricular systole begins.
- **The second sound (S₂)**, which is shorter and not as loud as the first, can be described as a **dupp sound**. S₂ is caused by blood turbulence associated closure of the **semilunar** (aortic and pulmonary) valves at the beginning of ventricular diastole.
- Normally not loud enough to be heard, **S₃** is due to blood turbulence during **rapid ventricular filling**, and **S₄** is due to blood turbulence during **atrial systole**

- **S₁ (lubb sound)**

بيطلع لما يسكر AV valves
يعني الصمام اللي موجود بين
Atrium and ventricle
tricuspid and Bicuspid ←

- **S₂ يطلع لما تسكر الصمامات**
اللي بعد ventricles

pulmonary and aortic ←
these two types of valves are called
Semilunar valves

- **S₄ يطلع قبل S₁ مباشرة**
- **الترتيب S₂ S₁ S₄... S₃**

- sympathetic يعمل central dilation
ويعمل peripheral constriction

- peripheral constriction عند يزيد كمية الدم التي راجع من general circulation و يقلل كمية الدم التي رايح على organs

CARDIAC OUTPUT

- **Cardiac output (CO)** is the volume of blood ejected from the left ventricle (or the right ventricle) into the aorta (or pulmonary trunk) each minute. Cardiac output equals **the stroke volume (SV)**, the volume of blood ejected by the ventricle during each contraction, **multiplied by the heart rate (HR)**, the number of heartbeats per minute:

$$CO \text{ (mL/min)} = SV \text{ (mL/beat)} \times HR \text{ (beats/min)}$$

- **Cardiac reserve** is the difference between a person's maximum cardiac output and cardiac output at rest. The average person has a cardiac reserve of four or five times the resting value.

- cardiac output وخرجان القلب يعني كم مل يطلع من القلب في الدقيقة

- sympathetic يزيد من cardiac output عن طريق زيادة heart rate يعني بشجع epinephrine and norepinephrine على خروج الكالسيوم بكميات أكبر ف depolarization بطول مدة أكبر أما Ach مع parasympathetic يقلل من heart rate فيقلل من cardiac output

- venous retain كم كمية الدم التي رجعت من systemic circulation Back to the heart

- كمية الدم التي راجع تعبر right atrium اسمها preload يعني قبل ما يعبر

- كل ما كانت كمية الدم التي راجعة من systemic circulation أكبر كلما كان preload أكبر كلما كان end-diastolic volume أكبر كلما كان stroke volume أكبر cardiac output أكبر

PRELOAD: EFFECT OF STRETCHING

- Within limits, the more the heart fills with blood during diastole, the greater the force of contraction during systole. This relationship is known as the Frank-Starling law of the heart.
- The preload is proportional to the end-diastolic volume (EDV), (the volume of blood that fills the ventricles at the end of diastole). Normally, the greater the EDV, the more forceful the next contraction.
- $\text{preload} \rightarrow \text{stroke volume} \rightarrow \text{after load}$
- Two key factors determine EDV: (1) the duration of ventricular diastole and (2) venous return, the volume of blood returning to the right ventricle.

↖ vein

- end diastolic volume يعني الدم الذي يملئ نهاية diastole ، يعني الكمية النهائية التي عبت ب right atrium مثلًا نهاية diastole

- end systolic volume آخر دم قبل بعد ما انتهى systole

- $\text{end diastolic volume} - \text{end systolic volume of left ventricle} = \text{stroke volume}$

- stroke volume كمية الدم التي طلعت (مل) بكل Beat

AFTERLOAD

- Ejection of blood from the heart begins when pressure in the right ventricle exceeds the pressure in the pulmonary trunk, and when the pressure in the left ventricle exceeds the pressure in the aorta.
- At that point, the higher pressure in the ventricles causes blood to push the semilunar valves open. The pressure that must be overcome before a semilunar valve can open is termed the **afterload**.
- Conditions that can increase afterload include hypertension (elevated blood pressure) and narrowing of arteries by atherosclerosis.

- after load $\Rightarrow$ pressure of blood
لا يطع من left ventricle او right ventricle

- اذا كانت كمية الدم التي طالعة كبيرة يعني pressure عالي

- Blood pressure and Blood flow
علاقة طردية

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- cardiac reserve = cardiac output - cardiac output at rest
القلب الدم المخزن في

- كلما زاد venous return يزيد preload
afterload يزيد
stroke volume ويزيد pressure
عندئذ cardiac output

REGULATION OF STROKE VOLUME

- A healthy heart will pump out the blood that entered its chambers during the previous diastole.
- Three factors regulate stroke volume and ensure that the left and right ventricles pump equal volumes of blood: (1) preload, the degree of stretch on the heart before it contracts; (2) contractility, the forcefulness of contraction of individual ventricular muscle fibers; and (3) afterload, the pressure that must be exceeded before ejection of blood from the ventricles can occur.

• كلما كان الكالسيوم أكثر يكون contraction أكبر وبالتالي stroke volume يكون أكبر

• كلما كان preload أكبر stroke volume أكبر

CONTRACTILITY

- ❑ **Myocardial contractility**, the strength of contraction at any given preload.
- ❑ Substances that increase contractility are **positive inotropic agents** (promote calcium ions inflow during cardiac action potentials), those that decrease contractility are **negative inotropic agents** (reducing calcium ions inflow).

• أي شيء يزيد الكالسيوم اسمه positive inotropic agent

• الذي يقلل من الكالسيوم اسمه negative inotropic agent

④

- كيف الجسم يده يعرف انه ضغط الدم قليل او عالي ؟
- في شريان طالع من left ventricle اسمه Aorta وفي شريان يتفرع من نفس المنطقة تبع Aorta في طبقات Blood vessels فيها sensory receptors فلما يطغى الدم من left ventricle بكمية عالية بحس activation لهذه sensory receptors

REGULATION OF HEART RATE

Autonomic Regulation of Heart Rate:

- ❖ **Nervous system regulation of the heart originates in the cardiovascular center in the medulla oblongata.** The cardiovascular center then directs appropriate output by increasing or decreasing the frequency of nerve impulses in both the sympathetic and parasympathetic branches of the ANS.
- ❖ **Proprioceptors** that are monitoring the position of limbs and muscles send nerve impulses at an increased frequency to the cardiovascular center.
- ❖ Proprioceptor input is a major stimulus for the quick rise in heart rate that occurs at the onset of physical activity.
- ❖ **Other sensory receptors** that provide input to the cardiovascular center include **chemoreceptors**, which monitor chemical changes in the blood, and **baroreceptors**, which monitor the stretching of major arteries and veins caused by the pressure of the blood flowing through them. Important baroreceptors located in the arch of the aorta and in the carotid arteries.

②

- main two sensory receptors
اللي موجودين على Aorta و carotid
① Baroreceptors
② chemoreceptors

- لا يطغى كمية الدم من left ventricle كبير بحس activation لـ baroreceptors

Baroreceptors and chemoreceptors are next to each other على السطح تبع Aorta و carotid

- لا يطغى Blood pressure كبير بحس activation لهذه sensory receptors و نوعها ionotropic receptors يعني بتكون ion channels ملزقة بـ Baroreceptors و chemoreceptors

- Baroreceptor ← sensitive لقيمة Blood pressure

- اذا كان ضغط الدم عالي بحس توسع للشريان فتخزن Baroreceptor وتفتح ion channels و Baroreceptor يكون متصل مع 2 nerves (10, 11) vagus , accelerator nerve

- لا يكون الضغط عالي يتم انتاج action potential عن طريق فتح ion channels اللي بتكون موجودة بجانب Baroreceptors وانتقال هذا action potential عن طريق vagus nerve

- cerebral cortex فيه cardiovascular center ، في هذا center واحد يعمل activation لـ عمل القلب و واحد يعمل inhibition لعمل القلب فواحد منهم generation of action potential و واحد اسمه cardiovascular stimulatory center فواحد عنده الضغط عالي و صار activation لـ cardiovascular inhibitory center يعني يعمل activation لـ parasympathetic ، لكن واحد عنده قليل بحس shrinkage او constriction و تخزن Baroreceptors و بتفتح ion channels و بحس generation of action potential عن طريق cardiac accelerator nerve بيودي action potential لـ cardiac stimulatory center عنان يزيد sympathetic

- Baroreceptors تخزن اذا الضغط عالي أو قليل لكن chemoreceptors تخزن حسب نسبة الأكسجين و CO₂ ، المفروض CO₂ بيجي من أنسجة الجسم بتك مع H₂O و بعطينا H₂CO₃ و اللي لبرجع يتحلل و بعطينا H⁺ + HCO₃⁻ فلما تكون نسبة CO₂ عالية ← نسبة H₂CO₃ عالية ← نسبة H⁺ عالية ← نسبة الحموضة acidity عالية فالـ chemoreceptor بتخزن لـ acidity و تكون نسبة الدم الـ pH cardiac output قليلة و نسبة الأكسجين قليلة يعني نسبة CO₂ عالية

REGULATION OF HEART RATE

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* تَحَلُّلَة

• نسبة O_2 قليلة لها مصطلح **hypoxia**

• نسبة CO_2 عالية لها مصطلح **hypercapnia**

• نسبة H^+ عالية لها مصطلح **acidosis**

← **chemoreceptors** تتحقق لنسبة H^+
التي ينتج من تحيئة O_2 و CO_2 الموجودة بالدم

REGULATION OF HEART RATE

■ Autonomic Regulation of Heart Rate:

- ❖ **Through the sympathetic cardiac accelerator nerves:** In SA (and AV) node fibers, **norepinephrine** speeds the rate of spontaneous depolarization so that these pacemakers fire impulses more rapidly and heart rate increases; in contractile fibers throughout the atria and ventricles, **norepinephrine** enhances calcium ions entry through the voltage-gated slow calcium ions channels, thereby **increasing contractility**.
- ❖ **Through Parasympathetic nerve impulses reach the heart via the right and left vagus (X) nerves:** Vagal axons terminate in the SA node, AV node, and atrial myocardium. They release **acetylcholine**, which decreases heart rate by slowing the rate of spontaneous depolarization in autorhythmic fibers. As only a few vagal fibers innervate ventricular muscle, changes in **parasympathetic activity have little effect on contractility of the ventricles**.

• عندما تزيد تحيئة الكالسيوم
فبتزيد **contraction**
وبتزيد **depolarization**

• **proprioceptors** موجودة على
skeletal muscles لكننا نعتبر
↓ **sensory receptor**
Blood pressure

CHEMICAL REGULATION OF HEART RATE

1. epinephrine and norepinephrine
heart rate ← **تزيد**
2. acetyl choline
heart rate ← **تقلل**
3. renine angiotensin aldosterone system kidneys **موجود** بال

1. **Hormones** Epinephrine and norepinephrine (from the adrenal medullae) enhance the heart's pumping effectiveness. These hormones affect cardiac muscle fibers in much the same way as does norepinephrine released by cardiac accelerator nerves—they increase both heart rate and contractility. One sign of hyperthyroidism (excessive thyroid hormone) is tachycardia, an elevated resting heart rate.
2. **Cations**.: Given that differences between intracellular and extracellular concentrations of several cations (for example, sodium and potassium ions) are crucial for the production of action potentials in all nerve and muscle fibers. Elevated blood levels of potassium ions or sodium ions decrease heart rate and contractility. **Excess sodium ions** blocks calcium inflow during cardiac action potentials, thereby decreasing the force of contraction, whereas **excess potassium ions** blocks generation of action potentials. A moderate **increase in interstitial (and thus intracellular) calcium ions level** speeds heart rate and strengthens the heartbeat.

• **hyperthyroidism** مثل واحد عنده
هو هرمون موجود بالغدة الدرقية
إذا كان هذا الهرمون نسبته عالية يكون
heart rate نسبته عالية
لأنه لما تكون عمل الغدة الدرقية عالية
تكون عملية الأيض عالية فال heart rate
يكون عالي

• **cations** ← كالسيوم كلما كان الكالسيوم
عالي ← heart rate يزيد
← بوتاسيوم كلما كان عالي
heart rate يقل
← Sodium كلما كان عالي
قنوات الكالسيوم ما بتفتح
يعني heart rate يقل

OTHER FACTORS IN HEART RATE REGULATION

- Age, gender, physical fitness, and body temperature also influence resting heart rate.
- **A physically fit person may even exhibit bradycardia, a resting heart rate under 50 beats/min.**
- During surgical repair of certain heart abnormalities, it is helpful to slow a patient's heart rate by **hypothermia**, in which the person's body is deliberately cooled to a low core temperature.

• **heart rate** تكون 70 - 100

الحرارة تكون عالية فال heart rate
تكون قليلة

HELP FOR FAILING HEARTS

- **Cardiac transplantation** is the replacement of a severely damaged heart with a normal heart from a brain-dead or recently deceased donor.
- **Cardiac transplants are performed on patients with end-stage heart failure or severe coronary artery disease.**

• الناس اللي بتعير قلوبهم أمراض
في **conduction pathway**
والقلب بطل يشتغل عندهم
أدّا فيه ينظروا يعلوا عملية زراعة
قلب

→ **Atrium** في
و **ventricle** عكن يحس
فيها تخشات وتكرها ، اذا
كان التكبير واصل 70%
فهذا قلبه محب يشتغل اول
خيار يكون عملية قلب مفتوح

لكن اذا ما نويبت فبنتم اللجوء ل **cardiac transplantation** زراعة القلب