DOWNLOAD PDF THE CONDUCTION SYSTEM OF THE MAMMLIAN HEART

Chapter 1 : Quiz on the Electrical Conduction System of the Heart | Anatomy & Pathophysiology

The conduction system consists of specialised heart muscle cells, and is situated within the myocardium. There is a skeleton of fibrous tissue that surrounds the conduction system which can be seen on an ECG.

This article has been cited by other articles in PMC. We therefore studied the morphology and function of a wide range of mammalian hearts. From mouse to whale, we found that all hearts show similar structural and functional characteristics. This suggests that the mammalian heart remained well conserved during evolution and in this aspect it differs from other organs and parts of the mammalian body. The archetype of the mammalian heart was apparently so successful that adaptation by natural selection evolution caused by varying habitat demands, as occurred in other organs and many other aspects of mammalian anatomy, bypassed the heart. The structure and function of the heart of placental mammals have thus been strikingly conserved throughout evolution. The changes in the mammalian heart that did take place were mostly adjustments scaling , to compensate for variations in body size and shape. A remarkable scaling effect is, for instance, the difference in atrioventricular AV conduction time, which is vital for optimal cardiac function in all mammals, small and large. This sheds new light on the vital role of the AVN in health and disease. The AVN is master and servant of the heart at the same time and is of salient importance for our understanding of supraventricular arrhythmias in humans, especially AF. The ESB is quite unspecific and thus general when compared with the specialised components it has to support. For instance, one of the functions of an ESB is the routing of messages between system nodes. This routing is independent and unaware of the content of the messages. The function of the heart is likewise independent and unaware of the routing of blood oxygen and of the specialised components of the mammalian body it has to support. Conclusions Evolution seems to have bypassed the heart, which is in contrast to the sometimes similarly looking, but yet quite differently functioning of the other organs of the mammalian body. Since then the number of publications of studies of the electrophysiology, clinical importance and social relevance of AF has exploded. Although an abundant amount of information on the cause and treatment of AF has become available, knowledge of its electrophysiology and of the role of the atria and the atrioventricular node AVN in ventricular rate control is still insufficient to understand all aspects of AF [2 , 3]. Clinically, it is customary to accept the notion of one type of AF but from a more fundamental point of view different causes and different forms may be more realistic and could result in more efficient forms of treatment [4]. Mammalian Heart Conserved Throughout Evolution During the many years of study of form and function of mammalian hearts from mouse to whale we found no fundamental differences between the hearts and circulation of otherwise widely dissimilar species [9]. It became apparent that the heart, when compared with most other organs or parts of the mammalian body, has been rather insensitive to the effect of evolution. It would be useful to present an index of conservation of organs per mammalian species, because each organ has its own morphological and functional parameters. But how to compare the comparison between diastolic and systolic pressures in the four chambers of the hearts of all mammals, with for instance the composition of urine of camels living in the desert versus that of dolphins living in the ocean? With the exception of the heart, all other organs as well as all senses in the bodies of mammalian species seem to display often strong dissimilarity in function. What could be the reason for the mammalian heart to remain so well conserved during evolution while most other organs in mammals and maybe in other classes as well show dramatic changes? Evidently, the archetype of the mammalian heart has been so successful that its original design could not be improved upon [10]. Although impossible to prove, it is almost certain that the contemporary mammalian species inherited their hearts from our common ancestors, the placental mammals, of which the first originated in the Mesozoic, around million years ago. The currently living mammals date back to the end of Cretaceous and beginning of Cenozoic, 65 million years ago [11 , 12]. Evolution shaped all forms of life to warrant survival during the ever ongoing changes in local physical conditions on earth such as climate and geology or in the community of organisms that a given species interacts with. In mammals and not only in mammals this has resulted in a spectacular diversity of ecomorphological specialisation, apparently with the exception of the heart. Small changes, yes, and

functional adjustment to varying body sizes scaling aspects or shape of course, but an amazing overall similarity between the hearts of all mammals seems to be the rule. We may even suggest that: Moreover, with the exception of mitochondrial density which depends on heart size, all cardiac myocytes have the same size and morphology, making it difficult to distinguish the myocytes of one species from another [16 â€” 19]. The same is true for specialised cardiac tissue such as the His bundles responsible for the conduction of the electrical impulse from the atria to the ventricles [20 , 21]. However, being similar is not the same as being identical. There are differences in size of course, and limited differences in the shape of the heart, all depending on the size and shape of the mammal and its habitat. There are also subtle differences among mammals in the shape of the atrial appendages and the extent of trabeculation of the apical components of the ventricles as well minor differences in their conduction system [23 , 24]. Rowlatt concluded after an extensive study of comparative anatomy of the hearts of mammals, thereby focusing on differences rather than on similarities, that: There is no clear conservation on the molecular level; for instance, there are genetically linked immune system differences, among others demonstrated by the rejection of tissues and organs during xenotransplantation [25]. Without an immune system one could exchange similar sized hearts, for instance, of a polar bear with that of a camel. Porcine hearts are already being studied to overcome those immunological problems in humans: Also myosin differences in the myocardium of small versus large mammals can be found, responsible for the rate of force generation during each atrial and ventricular contraction [27]. However, on the macro and micro electron level atria, ventricles, myocardium, conduction system, valves and the coronary system of the heart are for all practical purposes the same in all mammals. Overall similarities of cardiac morphology outweigh the differences among mammalian species. Functional Similarity of the Mammalian Heart Mammalian species live and survive in widely differing habitats, for example polar bears on the North Pole ice and camels in the desert. Despite varying demands on the circulation under those circumstances, their hearts are similar and show identical or nearly identical electrical and mechanical haemodynamic behaviour. The Electrical Function of the Mammalian Heart All contractions of atria and ventricles are preceded by their electrical activation. These activations P and QRS are linked by a varying time interval. This interval variation depends on heart mass or body mass and controls the optimisation of cardiac output under all circumstances.

Chapter 2 : Conducting System of the Heart - Bundle of His - SA Node - TeachMeAnatomy

The Conduction System of the Mammlian Heart PDF Preface: Sunao Tawara's epoch-making work on the excitation conduction system of the mammalian heart paved the way for the advancement of modern cardiology in the 20th century.

It pumps blood around the body. Mammals have a double circulatory system, so the heart must pump blood to the lung and to the rest of body simultaneously. The Structure of the Heart On the outside, the heart mainly consists of a dark red muscle. It is attached to four very important blood vessels: Internally, the heart is made up of four main cavities: This gets pumped through the pulmonary artery to the lungs where it gets oxygenated, before returning to the heart via the pulmonary vein. This flows through the left atrium into the left ventricle, and then gets pumped to the body via the aorta. It finally returns to the heart through the vena cava, and the process repeats. This is happening inside you right now, about once a second! These valves allow blood to flow downwards when the atria and ventricles relax, but close to prevent blood from flowing back up to the atria when the ventricles are contracting. The ventricles are separated from the aorta and the pulmonary artery by the Semilunar Valves specifically called, respectively, the Aortic and Pulmonary Valves. These prevent blood from flowing in the wrong direction back into the heart. The ventricles walls on the other hand are much thicker. When the ventricles contract, the blood pressure inside becomes very high, and they need to be able to withstand this. Also, the walls of the left ventricle are thicker than those of the right ventricle. This is because the left side of the heart controls the systemic circuit blood to the whole body while the right side controls the pulmonary circuit blood to the lungs. Blood in the systemic circuit needs to be at a high pressure in order to make its way around the whole body and back again. In contrast, the lungs are very close to the heart, and contain very delicate capillaries which would break if subjected to too great a pressure. Hence the systemic circuit requires a greater blood pressure than the pulmonary circuit, and thus the walls of the left ventricle must be thicker than those of the right ventricle. The Cardiac Cycle The cycle of the beating of the heart consists of three main phases: Diastole, Atrial Systole and Ventricular Systole. The heart cycles through each of those phases in order. The atria and ventricles are relaxing, and blood flows from the major veins the vena cava and the pulmonary veins into the atria, then into the ventricles via the open atrioventricular valves. The atrioventricular valves are open because the pressure in the atria is greater than that in the ventricles. The semilunar valves, on the other hand, are closed because the pressure in the ventricles is lower than that in the main arteries leading from the heart. Atrial Systole This is the beginning of the muscle contraction. The atria contract, which pushes more blood into the ventricles. Ventricular Systole During this phase, the ventricles contract, increasing the ventricular pressure. Blood pushes against the atrioventricular valves, since the pressure in the ventricles is now greater than that in the atria, causing them to snap shut, which prevents blood from flowing back into the atria. The pressure in the ventricles continues to increase until it is greater than that in the main arteries leading from the heart. At this point, the semilunar valves are forced open, and blood rushes out of the ventricles out of the heart into the arteries. After the ventricles have finished contracting, the muscles relax, and are pulled back by elastic tissue. Coordination in the Cardiac Cycle There is a need to control and coordinate the cardiac cycle described above. The heart rate needs to change to respond to various factors, such as increased physical activity. Also, the atria and the ventricles have different natural frequencies of contraction. If the contractions where uncoordinated, the atria and the ventricles would contract asynchronously, which would lead to inefficient pumping. Heart muscle is Myogenic: This unusual property means that the heart is able to beat even when not connected to the body. This is located above the right atrium. It generates electrical pulses in a regular fashion, which then spread throughout the heart. The wave of excitation is stopped however by a non-conducting disc of tissue at the base of the atria. This prevents the wave from causing the ventricles to contract too early. The only path to the ventricles is through another node called the Atrioventricular Node. At the atrioventricular node, the electrical pulse is delayed to allow the atria to fully contract. Then the wave travels down the inter-ventricular wall through special conducting tissue known as the Purkyne, towards the apex base and the ventricular muscles.

As the wave reaches the muscles, it initiates the contraction. The wave then moves up the ventricles from the apex causing further contraction. In this manner the contraction of the ventricles starts at the bottom and moves upwards, so that blood is forced upwards into the arteries during ventricular systole. Electrocardiograms An Electrocardiogram ECG is a device that measures the electrical activity of the heart. It consists of several sensors placed around the body connected to a monitor. The sensors detect the electrical signals that spread from the heart through the body to the skin. Written by Sam Adam-Day.

Chapter 3 : Conducting System of Human Heart (With Diagram)

We would like to show you a description here but the site won't allow us.

Control[edit] Schematic representation of the sinoatrial node and the atrioventricular bundle of His. The location of the SA node is shown in blue. The bundle, represented in red, originates near the orifice of the coronary sinus, undergoes slight enlargement to form the AV node. The AV node tapers down into the bundle of HIS, which passes into the ventricular septum and divides into two bundle branches, the left and right bundles. The ultimate distribution cannot be completely shown in this diagram. Primary SA node [edit] One percent of the cardiomyocytes in the myocardium possess the ability to generate electrical impulses or action potentials spontaneously. A specialized portion of the heart, called the sinoatrial node SA node , is responsible for atrial propagation of this potential. The sinoatrial node SA node is a group of cells positioned on the wall of the right atrium , near the entrance of the superior vena cava. These cells are modified cardiomyocytes. They possess rudimentary contractile filaments, but contract relatively weakly compared to the cardiac contractile cells. Gap junctions allow the passage of positive cations from the depolarization of the pacemaker cell to adjacent contractile cells. This starts the depolarization and eventual action potential in contractile cells. Having cardiomyocytes connected via gap junctions allow all contractile cells of the heart to act in a coordinated fashion and contract as a unit. All the while being in sync with the pacemaker cells; this is the property that allows the pacemaker cells to control contraction in all other cardiomyocytes. Cells in the SA node spontaneously depolarize , ultimately resulting in contraction, approximately times per minute. This native rate is constantly modified by the activity of sympathetic and parasympathetic nerve fibers via the autonomic nervous system , so that the average resting cardiac rate in adult humans is about 70 beats per minute. Secondary AV junction and Bundle of His [edit] If the SA node does not function properly and is unable to control the heart rate, a group of cells further down the heart will become the ectopic pacemaker of the heart. These cells form the Atrioventricular node or AV node , which is an area between the left atrium and the right ventricle within the atrial septum, will take over the pacemaker responsibility. The cells of the AV node normally discharge at about beats per minute, and are called the secondary pacemaker. Further down the electrical conducting system of the heart is the Bundle of His. The left and right branches of this bundle, and the Purkinje fibres , will also produce a spontaneous action potential at a rate of beats per minute, so if the SA and AV node both fail to function, these cells can become pacemakers. It is important to realize that these cells will be initiating action potentials and contraction at a much lower rate than the primary or secondary pacemaker cells. The SA node controls the rate of contraction for the entire heart muscle because its cells have the quickest rate of spontaneous depolarization, thus they initiate action potentials the quickest. The action potential generated by the SA node passes down the electrical conduction system of the heart , and depolarizes the other potential pacemaker cells AV node to initiate action potentials before these other cells have had a chance to generate their own spontaneous action potential, thus they contract and propagate electrical impulses to the pace set by the cells of the SA node. This is the normal conduction of electrical activity in the heart. Generation of action potentials[edit] There are 3 main stages in the generation of an action potential in a pacemaker cell. Since the stages are analogous to contraction of cardiac muscle cells, they have the same naming system. This can lead to some confusion. There is no phase 1 or 2, just phases 0, 3, and 4. Phase 4 - Pacemaker potential[edit] The key to the rhythmic firing of pacemaker cells is that, unlike other neurons in the body, these cells will slowly depolarize by themselves and do not need any outside innervation from the autonomic nervous system to fire action potentials. As in all other cells, the resting potential of a pacemaker cell mV to mV is caused by a continuous outflow or "leak" of potassium ions through ion channel proteins in the membrane that surrounds the cells. However, in pacemaker cells, this potassium permeability efflux decreases as time goes on, causing a slow depolarization. In addition, there is a slow, continuous inward flow of sodium , called the funny current. These two relative ion concentration changes slowly depolarize make more positive the inside membrane potential voltage of the cell, giving these cells their pacemaker potential. When the membrane potential gets depolarized to about mV it has reached threshold cells enter phase 0 ,

allowing an action potential to be generated. Phase 0 - Upstroke[edit] Though much faster than the depolarization of phase 4, the upstroke in a pacemaker cell is slow compared to that in an axon. The SA and AV node do not have fast sodium channels like neurons, and the depolarization is mainly caused by a slow influx of calcium ions. The funny current also increases. Calcium enters the cell via voltage-sensitive calcium channels that open when the threshold is reached. It is important to note that intracellular calcium causes muscular contraction in contractile cells, and is the effector ion. In heart pacemaker cells, phase 0 depends on the activation of L-type calcium channels instead of the activation of voltage-gated fast sodium channels, which are responsible for initiating action potentials in contractile non-pacemaker cells. For this reason, the pacemaker action potential rising phase slope is more gradual than that of the contractile cell image 2. The calcium channels are also inactivated soon after they open. In addition, as sodium channels become inactivated, sodium permeability into the cell is decreased. These ion concentration changes slowly repolarize the cell to resting membrane potential mV. Another important note at this phase is that ionic pumps restore ion concentrations to pre-action potential status. The sodium-calcium exchanger ionic pump works to pump calcium out of the intracellular space, thus effectively relaxing the cell. Restoring these ion concentrations is vital because it enables the cell to reset itself and enables it to repeat the process of spontaneous depolarization leading to activation of an action potential. Clinical significance[edit] Damage to the SA node[edit] If the SA node does not function, or the impulse generated in the SA node is blocked before it travels down the electrical conduction system, a group of cells further down the heart will become its pacemaker. If the AV node also fails, Purkinje fibers are occasionally capable of acting as the default or "escape" pacemaker. The reason Purkinje cells do not normally control the heart rate is that they generate action potentials at a lower frequency than the AV or SA nodes.

Chapter 4 : The Mammalian Heart | A Level Notes

*The Conduction System of the Mammlian Heart: An Anatomico-Histological Study of the Atrioventricular Bundle and the Purkinje Fibers [S. Tawara, Kozo Suma, Munehiro Shimada] on calendrierdelascience.com *FREE* shipping on qualifying offers.*

Overview of Cardiac Conduction The sinoatrial node is located in the upper part of the right atrium in the healthy heart, and serves as the natural pacemaker Figure 1. These nodal cells manifest spontaneous depolarizations and are thus responsible for generating the normal cardiac rhythm; such a heart rate can also be described as intrinsic or automatic. Importantly, the frequency of this earliest cardiac depolarization is well modulated by both sympathetic and parasympathetic efferent innervation. Although the atrial rhythms normally emanate from the sinoatrial node, variations in the initiation site of atrial depolarization have been documented outside of the histological nodal tissues, particularly when high atrial rates are elicited, and may include paranodal tissue []. In general, although it typically cannot be seen grossly, the location of the sinoatrial node is on the roof of the right atrium at the approximate junction of the superior vena cava, the right atrial appendage, and the sulcus terminalis. In the adult human, the node is approximately 1 mm below the epicardium, mm long, and up to 5 mm thick [1,16]. The conduction system of the heart. Normal excitation originates in the sinoatrial SA node, then propagates through both atria internodal tracts shown as dashed lines. The atrial depolarization spreads to the atrioventricular AV node, passes through the bundle of His not labeled , and then to the Purkinje fibers which make up the left and right bundle branches; subsequently all ventricular muscle becomes activated. After initial sinoatrial nodal excitation, depolarization spreads throughout the atria. The exact mechanisms involved in the spread of impulses excitation from the sinoatrial node across the atria are still today, somewhat controversial [1,17]. However, it is generally accepted that: It is believed by many that there are three preferential anatomic conduction pathways from the sinoatrial node to the atrioventricular node [1,18]. In general, these can be considered as the shortest electrical routes between the nodes. Note that there are microscopically identifiable structures, appearing to be preferentially oriented fibers, that provide a direct node-to-node pathway. In some hearts, pale staining Purkinje-like fibers have also been reported in these regions. In addition to excitation along these preferential conduction pathways, general excitation spreads from cell to cell throughout the entire atrial myocardium via the specialized connections between cells, the gap junctions, that typically exist between all myocardial cell types see below. It then follows that towards the end of atrial depolarization, the excitation reaches the atrioventricular node via the aforementioned atrial routes, with the final result being excitation of the atrioventricular node. Further, these routes are known as the slow or fast pathways, which are considered to be functionally and anatomically distinct. The slow pathway typically crosses the isthmus between the coronary sinus and the tricuspid annulus; it has a longer conduction time, but a shorter effective refractory period. The fast pathway is commonly a superior route, emanating from the interatrial septum, and has a faster conduction rate but, in turn, a longer effective refractory period. Though the primary function of the atrioventricular node may seem simple, that is to relay conduction between the atria and ventricles, its structure is very complex [1]. As a means to describe these complexities, mathematical arrays and finite element analysis models have been constructed to elucidate the underlying structure-function relationship of the node [19]. In general, the atrioventricular node is located in the so-called floor of the right atrium, over the muscular part of the interventricular septum, inferior to the membranous septum: Following atrioventricular nodal excitation, the slow pathway conducts impulses to the His bundle, indicated by a longer interval between atrial and His activation. Currently, there is interest in the ability to place pacing leads to preferentially activate the bundle of His; in such approaches, ultrasound or other imaging modalities are used to map the electrical characteristic His potentials to position the pacing leads [20]. After leaving the bundle of His, the normal wave of cardiac depolarization spreads first to both the left and right bundle branches; these pathways rapidly and simultaneously carry depolarization to the apical regions of both the left and right ventricles see Figure 1. Finally, the signal broadly travels through the remainder of the Purkinje fibers and ventricular myocardial depolarization spreads. In certain pathological

conditions, direct accessory connections from the atrioventricular node and the penetrating portion of the bundle of His to the ventricular myocardium have been described [21]. Yet, the function and prevalence of these connections, termed Mahaim fibers, is poorly understood. A rare bundle of Kent, an additional aberrant pathway when present, exists between the atria and ventricles and is associated with the clinical manifestation of ventricular tachycardias also known as Wolff-Parkinson-White syndrome. Therapeutically, this accessory pathway is electrically identified and then commonly ablated as a curative procedure. The left bundle branch splits into fascicles as it travels down the left side of the ventricular septum just below the endocardium. Its fascicles extend for a distance of 5 to 15 mm, fanning out over the left ventricle. Importantly, typically about midway to the apex of the left ventricle, the left bundle separates into two major divisions, the anterior and posterior branches or fascicles. These divisions extend to the base of each papillary muscle as well as the adjacent myocardium. In contrast, the right bundle branch continues inferiorly, as if it were a continuation of the bundle of His, traveling along the right side of the muscular interventricular septum. This bundle branch runs proximally, just beneath the endocardium, and its course runs slightly inferior to the septal papillary muscle of the tricuspid valve before dividing into fibers that spread throughout the right ventricle. The complex network of conducting fibers that extends from either the right or left bundle branches is composed of the rapid conduction cells known as Purkinje fibers. Purkinje fibers in both the right and left ventricles act as preferential conduction pathways to provide rapid activation, so to coordinate the excitation pattern within the various regions of the ventricular myocardium. Most of these fibers travel within the trabeculations of the right and left ventricles, as well as within the myocardium itself. Due to tremendous variability in the degree and morphology of the trabeculations existing both within and between species, it is likely that variations in the left ventricular conduction patterns also exist. It should be noted that one of the most common and easily recognized conduction pathways found in mammalian hearts is the moderator band, which contains Purkinje fibers from the right bundle branch see: Furthermore, in many human hearts, within both the right and left ventricles, one can identify conduction bands that are white in appearance e. In , Aschoff and Monckeberg provided three criteria for considering a myocardial cell as a specialized conduction cell, including: It is noteworthy that only the cells within the bundle of His, left and right bundle branches, and Purkinje fibers satisfy all three criteria. Yet, with major advances in histo-molecular techniques, it is likely that new criterion will follow that better define the uniqueness of specialized conduction structures. Normal excitation originates in the sinoatrial SA node then propagates through both atria. The table shows conduction velocities and intrinsic pacemaker rates of various structures within the cardiac conduction pathway. The structures are listed in the order of activation during a normal cardiac contraction, beginning with the sinoatrial node. Note that the intrinsic pacemaker rate is slower in structures further along the activation pathway. For example, the atrioventricular nodal rate is slower than the sinoatrial nodal rate. If the sinoatrial node becomes inactive, the atrioventricular nodal rate will then determine the ventricular rate. Tabulation adapted from Katz AM. Physiology of the Heart, third edition. Lippincott, Williams, and Wilkins, The University of Minnesota is an equal opportunity educator and employer.

Chapter 5 : The Conduction System of the Mammlian Heart PDF

The conducting system of the heart consists of cardiac muscle cells and conducting fibers (not nervous tissue) that are specialized for initiating impulses and conducting them rapidly through the heart (see the image below). They initiate the normal cardiac cycle and coordinate the contractions of.

Conduction System of the Heart What makes the heart beat? Your heart continues beating every moment of the day and night, even without you being aware of it. It may change its rate and rhythm for a few moments when you exercise or when you are excited, but it soon goes back to its regular pace without your conscious control. The cycle of contraction and relaxation of the heart muscle is generated by electrical impulses that are controlled by the conduction system of the heart, which may be influenced by factors such as temperature, exercise, and hormonal changes. This conduction system is composed of a group of special cells found in the walls of the heart muscle, which send the electrical impulses and cause the heart muscle to contract. It is made up of these elements: It initiates an impulse that causes depolarization and generates the action potential, an electrical event, which spreads out through the two upper chambers atria and to the AV node. It sets the pace of the beating of the heart. The AV Atrioventricular node This group of cells is found between the atria and ventricles. It transmits electrical impulses from the atria, where the action potential is briefly delayed as they contract, to the AV bundle. The AV bundle Bundle of His The electrical connection between the atria and the lower chambers of the heart the ventricles is through the AV bundle. It allows the movement of the action potential from the septum in the atria to the septum dividing the ventricles, and connects the AV node to the ventricular Bundle Branches. Purkinje fibres These fibers begin at the interventricular septum down to the apex of your heart, and continue through the ventricular muscles myocardium. From an electrical event action potential , a mechanical event muscle contraction occurs when the contractile cells act in a coordinated fashion, resulting in a heartbeat. How Does the Conduction System Work? The conduction system of the heart works this way: Pacemaker Impulse Generation The SA node is known a natural pacemaker because it sets the pace of the heartbeat. It is where cardiac muscle contraction begins, from an impulse which causes the right and left atria to contract and push blood into the ventricles. Purkinje Fibers Impulse Conduction Then the action potential spreads through the Purkinje fibers, which causes the left and right ventricles to contract. The strong contraction of the ventricles causes the pumping of the blood from the right ventricle to the lungs, and from the left ventricle to the rest of the body. After the ventricles contract, they relax and get filled with more blood from the atria as an electrical impulse from the SA node begins the cardiac cycle again. Heart and ECG Comparison Ventricular contraction begins at the lower portion apex of your heart and moves upward and forces blood toward the large arteries, which are located above or superior to the ventricle. The P wave signals atrial depolarization, which corresponds to atrial contraction. The QRS complex signals ventricular depolarization, which corresponds to ventricular contraction. The T wave indicates ventricular repolarization, which corresponds to ventricular relaxation. This may occur when: The sinus SA node changes its rate or rhythm. The conduction system of the heart is interrupted. Certain parts of the heart tissue take over the SA node and becomes another "pacemaker. You may need an ECG evaluation to monitor the rhythm of your heart. An abnormal electrical rhythm may or may not need treatment, which can include medications or surgery. Watch this video to learn more about cardiac conduction system and its relationship with ECG.

Chapter 6 : Blood Circulation in Mammalian Heart | calendrierdelascience.com

J.D. Steimle, I.P. Moskowitz, in Current Topics in Developmental Biology, 6 TBX5 in Cardiac Conduction System Development. The cardiac conduction system is a highly specialized network of cardiomyocytes within the heart that generate and transmit electrical impulses throughout the heart to coordinate contraction.

Introduction The intrinsic conduction system of the heart is comprised of several specialized subpopulations of cells that either spontaneously generate electrical activity pacemaker cells , or preferentially conduct this excitation throughout the four chambers of the heart in a coordinated fashion. This tutorial will discuss details of this anatomy, as well as physiologic properties of the system. The cardiac action potential underlies signaling within the heart, and various heart cell myocyte populations elicit characteristic waveforms. The active sensing or recording of these action potentials is important in both research and clinical studies. This cellular network has become known as the "conduction system" [1]. The orderly contractions of the atria and ventricles are regulated by the organized transmission of electrical impulses that pass through these modified cardiac muscle cells; these specialize cells are interposed within the contractile myocardium. More specifically, this intrinsic conduction system is thought to be comprised of the following subpopulations of cells: Normally, following an initiating activation or depolarization within a pacemaker cell, this electrical excitation spreads throughout the heart in a rapid and highly coordinated fashion. This system functionally controls the timing of activities between the atrial and ventricular chambers, allowing for optimized hemodynamic performance. Interestingly, a common global architecture of this conduction system is present in mammals: In , Johannes E. In addition, Gaskell also identified the presence of a slow ventricular activation rate to disassociation with that of the atria [4]. The first description of the mammalian sinoatrial node was reported by Sir Arthur Keith and Martin Flack in , in the Journal of Anatomy and Physiology. Nevertheless it should be noted that still today, novel findings about the functionality of this node are being identified. The elucidation of the electrical connection from the atrioventricular node through the cardiac skeleton to the ventricular portion of the conduction system, known as the bundle of His, is attributed to Wilhelm His Jr. Importantly, Tawara later verified the existence of this bundle in [7]. Due to difficulty in distinguishing the atrioventricular nodal tissue from the surrounding tissue, he also defined the beginning of the bundle of His as the point at which these specialized atrioventricular nodal cells enter the central fibrous body which delineates the atria from the ventricles. Tawara is also credited with being the first person to clearly identify the specialized conduction tissues modified myocytes that span from the atrial septum to the ventricular apex, including the right and left bundle branches and Purkinje fibers. Further, based on detailed anatomical and histological studies of the hearts of animals and stillborn human fetuses, Koch also observed that the last part of the heart to lose activity when the whole organ dies, is the pacemaker region ultimum moriens. He postulated that the cardiac region near the opening of the wall of the coronary sinus was thus the true pacemaker of the heart [8,9]; note that the atrioventricular node will elicit an escape rhythm when the sinoatrial node in the right atrium fails. The University of Minnesota is an equal opportunity educator and employer.

Chapter 7 : Cardiac pacemaker - Wikipedia

Disorders of the heart's conduction system can cause problems with the heart's ability to function effectively. These problems are typically the result of a blockage that diminishes the rate of speed at which impulses are conducted.

The left and right bundle branches The Purkinje fibres Image: The cardiac conduction system The SA node is the natural pacemaker of the heart. The SA node releases electrical stimuli at a regular rate, the rate is dictated by the needs of the body. Each stimulus passes through the myocardial cells of the atria creating a wave of contraction which spreads rapidly through both atria. As an analogy, imagine a picture made up of dominoes. One domino is pushed over causing a wave of collapsing dominoes spreading out across the picture until all dominoes are down. The heart is made up of around half a billion cells, In the picture above you can see the difference in muscle mass of the various chambers. The majority of the cells make up the ventricular walls. The rapidity of atrial contraction is such that around million myocardial cells contract in less than one third of a second. So fast that it appears instantaneous. The electrical stimulus from the SA node eventually reaches the AV node and is delayed briefly so that the contracting atria have enough time to pump all the blood into the ventricles. Once the atria are empty of blood the valves between the atria and ventricles close. At this point the atria begin to refill and the electrical stimulus passes through the AV node and Bundle of His into the Bundle branches and Purkinje fibres. Imagine the bundle branches as motorways, if you like, with the Purkinje fibres as A and B roads that spread widely across the ventricles. In this way all the cells in the ventricles receive an electrical stimulus causing them to contract. Using the same domino analogy, around million myocardial cells that make up the ventricles contract in less than one third of a second. As the ventricles contract, the right ventricle pumps blood to the lungs where carbon dioxide is released and oxygen is absorbed, whilst the left ventricle pumps blood into the aorta from where it passes into the coronary and arterial circulation. At this point the ventricles are empty, the atria are full and the valves between them are closed. The SA node is about to release another electrical stimulus and the process is about to repeat itself. However, there is a 3rd section to this process. The SA node and AV node contain only one stimulus. Therefore every time the nodes release a stimulus they must recharge before they can do it again. Imagine you are washing your car and have a bucket of water to rinse off the soap. You throw the bucket of water over the car but find you need another one. The bucket does not magically refill. You have to pause to fill it. In the case of the heart, the SA node recharges whilst the atria are refilling, and the AV node recharges when the ventricles are refilling. In this way there is no need for a pause in heart function. Again, this process takes less than one third of a second. The times given for the 3 different stages are based on a heart rate of 60 bpm , or 1 beat per second. The term used for the release discharge of an electrical stimulus is "depolarisation", and the term for recharging is "repolarisation". So, the 3 stages of a single heart beat are: Atrial depolarisation Ventricular depolarisation Atrial and ventricular repolarisation. As the atria repolarise during ventricular contraction, there is no wave representing atrial repolarisation as it is buried in the QRS.

Chapter 8 : Electrical conduction system of the heart - WikiVisually

Mammalian Heart/Human Heart. The SA node or sinoatrial node is the pacemaker. Automaticity and rhythmicity are the properties responsible for this.

Back to Top The aorta or the great artery arising from the left ventricle takes the oxygenated blood to the body organs through a number of arteries. From these organs, the deoxygenated blood is collected by the superior and inferior vena cava and brought back to the right auricle. The right auricle pumps the deoxygenated blood into the right ventricle. Pulmonary Circulation Back to Top The deoxygenated blood from the right ventricle is taken by the pulmonary artery to the lungs for oxygenation. The blood after oxygenation is returned to the left auricle of the heart by the pulmonary vein. From the left auricle the blood flows to the left ventricle. Diagram of human circulation Back to Top The cardiac muscles of the heart have the property of excitability and conductivity. When these muscles are stimulated, they get excited and initiate waves of electric potential called cardiac impulses, which are conducted along the special cardiac muscle fibres on the wall of the heart chambers. Origin and Conduction of Heart Beat The impulse originates from the SA node which lies on the right wall of the right auricle below the opening of the vena cava. It is also called pacemaker as it determines the rate of heart beat. The impulse originated from the sinu-auricular node is picked up and propagated by a special system of tissues present in the heart. The conducting system includes the following components. It functions as a relay station and it transmits the impulses to other parts of the heart through the bundle of His. When the SA node fails to function, it acts as a resume pace maker as it can also initiate the cardiac impulse. The bundle of His originates from the AV node as a bundle of tissue. Immediately after its origin it divides into 2 branches. These branches run along the inner border of each ventricle and reach the tip of the ventricle and then runs upwards along the outer margin of the ventricle. The bundle of His and its branches produce minute branches called Purkinje fibres on the wall of the ventricles. During a heart beat, the auricles contract first and the ventricles contract later. This is because there is no muscular continuity between the auricles and the ventricles. The auricles receive the impulses directly from the SA node. The impulses reach the AV node about 0. So the ventricles always contract after the auricles. Regulation of Heart Beat Neurons connecting the heart to the cardiovascular system The heart beat is controlled by the nervous system, hormones, temperature and pH.

Chapter 9 : Cardiac conduction system - Health Video: MedlinePlus Medical Encyclopedia

Cardiology Teaching Package. A Beginners Guide to Normal Heart Function, Sinus Rhythm & Common Cardiac Arrhythmias. Cardiac Conduction System. Going back to the analogy of the central heating system, the pump, pipes and radiators are of no use unless connected to a power supply.

Anatomical terminology â€" Anatomical terminology is a form of scientific terminology used by anatomists, zoologists, and health professionals such as doctors. Anatomical terminology uses many terms, suffixes, and prefixes deriving from Ancient Greek. These terms can be confusing to those unfamiliar with them, but can be more precise reducing ambiguity, also, since these anatomical terms are not used in everyday conversation, their meanings are less likely to change, and less likely to be misinterpreted. By using precise anatomical terminology such ambiguity is eliminated, an international standard for anatomical terminology, Terminologia Anatomica has been created. Anatomical terminology has quite regular morphology, the prefixes and suffixes are used to add meanings to different roots. The root of a term refers to an organ, tissue. For example, in the disorder hypertension, the prefix hyper- means high or over, the roots, prefixes and suffixes are often derived from Greek or Latin, and often quite dissimilar from their English-language variants. Latin names of such as musculus biceps brachii can be split up and refer to, musculus for muscle, biceps for two-headed. The first word tells us what we are speaking about, the second describes it, when describing the position of anatomical structures, structures may be described according to the anatomical landmark they are near. These landmarks may include structures, such as the umbilicus or sternum, or anatomical lines, the cephalon or cephalic region refers to the head. This area is differentiated into the cranium, facies, frons, oculus, auris, bucca, nausus, oris. The neck area is called the cervicis or cervical region, examples of structures named according to this include the frontalis muscle, submental lymph nodes, buccal membrane and orbicularis oculi muscle. Sometimes, unique terminology is used to reduce confusion in different parts of the body, for example, different terms are used when it comes to the skull in compliance with its embryonic origin and its tilted position compared to in other animals. Here, Rostral refers to proximity to the front of the nose, similarly, in the arms, different terminology is often used in the arms, in part to reduce ambiguity as what is the front, back, inner and outer surfaces. For this reason, the terms below are used, Radial referring to the radius bone, ulnar referring to the ulna bone, medially positioned when in the standard anatomical position. Other terms are used to describe the movement and actions of the hands and feet. International morphological terminology is used by the colleges of medicine and dentistry and it facilitates communication and exchanges between scientists from different countries of the world and it is used daily in the fields of research, teaching and medical care. The international morphological terminology refers to morphological sciences as a biological sciences branch, in this field, the form and structure are examined as well as the changes or developments in the organism 2. Cardiac muscle â€" Cardiac muscle is an involuntary, striated muscle that is found in the walls and histological foundation of the heart, specifically the myocardium. Cardiac muscle is one of three types of muscle, the others being skeletal and smooth muscle. These three types of all form in the process of myogenesis. The cells that constitute cardiac muscle, called cardiomyocytes or myocardiocytes, predominantly contain only one nucleus, the myocardium is the muscle tissue of the heart, and forms a thick middle layer between the outer epicardium layer and the inner endocardium layer. This complex mechanism illustrates systole of the heart, Cardiac muscle cells, unlike most other tissues in the body, rely on an available blood and electrical supply to deliver oxygen and nutrients and remove waste products such as carbon dioxide. The coronary arteries help fulfill this function, Cardiac muscle has cross striations formed by rotating segments of thick and thin protein filaments. Like skeletal muscle, the structural proteins of cardiac muscle are myosin and actin. However, in contrast to skeletal muscle, cardiac muscle cells are typically branch-like instead of linear, another histological difference between cardiac muscle and skeletal muscle is that the T-tubules in the cardiac muscle are bigger and wider and track laterally to the Z-discs. There are fewer T-tubules in comparison with skeletal muscle, the diad is a structure in the cardiac myocyte located at the sarcomere Z-line. This way, the wave of depolarization can be coupled to calcium-mediated cardiac muscle

contraction via the sliding filament mechanism, Cardiac muscle forms these instead of the triads formed between the sarcoplasmic reticulum in skeletal muscle and T-tubules. T-tubules play critical role in excitation-contraction coupling, recently, the action potentials of T-tubules were recorded optically by Guixue Bu et al. There is a syncytium and a ventricular syncytium that are connected by cardiac connection fibres. Electrical resistance through intercalated discs is very low, thus allowing free diffusion of ions, the ease of ion movement along cardiac muscle fibers axes is such that action potentials are able to travel from one cardiac muscle cell to the next, facing only slight resistance. Each syncytium obeys the all or none law, intercalated discs are complex adhering structures that connect the single cardiomyocytes to an electrochemical syncytium. The discs are responsible mainly for force transmission during muscle contraction, intercalated discs consist of three different types of cell-cell junctions, the actin filament anchoring adherens junctions, the intermediate filament anchoring desmosomes, and gap junctions. They allow action potentials to spread between cells by permitting the passage of ions between cells, producing depolarization of the heart muscle 3. Thorax â€" The thorax or chest is a part of the anatomy of humans and various other animals located between the neck and the abdomen. The thorax includes the thoracic cavity and the thoracic wall and it contains organs including the heart, lungs, and thymus gland, as well as muscles and various other internal structures. Many diseases may affect the chest, and one of the most common symptoms is chest pain, in humans and other hominids, the thorax is the chest region of the body between the neck and the abdomen, along with its internal organs and other contents. It is mostly protected and supported by the rib cage, spine, arteries and veins are also contained â€", bones. The area exposed by open-necked shirts, the V of the chest is sometimes the location of a skin disease polymorphous light eruption. In the human body, the region of the thorax between the neck and diaphragm in the front of the body is called the chest, the corresponding area in an animal can also be referred to as the chest. The shape of the chest does not correspond to part of the thoracic skeleton that encloses the heart. All the breadth of the shoulders is due to the girdle, and contains the axillae. Level with this line the second ribs join the sternum, at the lower part of the sternum, where the seventh or last true ribs join it, the ensiform cartilage begins, and above this there is often a depression known as the pit of the stomach. The bones of the thorax, called the thoracic skeleton is a component of the axial skeleton and it consists of the ribs and sternum. The ribs of the thorax are numbered in ascending order from The anatomy of the chest can also be described through the use of anatomical landmarks, the female nipple is surrounded for half an inch by a more or less pigmented disc, the areola. The apex of a heart is in the fifth left intercostal space. Different types of diseases or conditions that affect the chest include pleurisy, flail chest, atelectasis, and these conditions can be hereditary or caused by birth defects or trauma. Any condition that lowers the ability to breathe deeply or to cough is considered a chest disease or condition. The major pathophysiologies encountered in blunt chest trauma involve derangements in the flow of air, blood, sepsis due to leakage of alimentary tract contents, as in esophageal perforations, also must be considered. Blunt trauma commonly results in chest wall injuries, the pain associated with these injuries can make breathing difficult, and this may compromise ventilation 4. Depolarization â€" In biology, depolarization is a change within a cell, during which the cell undergoes a shift in electric charge distribution, resulting in less negative charge inside the cell. Depolarization is essential to the function of cells, communication between cells, and the overall physiology of an organism. Most cells in higher organisms maintain an environment that is negatively charged relative to the cells exterior. This difference in charge is called the membrane potential. In the process of depolarization, the internal charge of the cell temporarily becomes more positive. This shift from a negative to a more positive membrane potential occurs during several processes, during an action potential, the depolarization is so large that the potential difference across the cell membrane briefly reverses polarity, with the inside of the cell becoming positively charged. The change in charge typically occurs due to an influx of ions into a cell. The opposite of a depolarization is called a hyperpolarization, usage of the term depolarization in biology differs from its use in physics. In physics it refers instead to situations in which any form of polarity changes to a value of zero, the process of depolarization is entirely dependent upon the intrinsic electrical nature of most cells. When a cell is at rest, the cell maintains what is known as a resting potential, the resting potential generated by nearly all cells results in the interior of the cell having a negative charge compared to the exterior of the cell. To

maintain this electrical imbalance, microscopic positively and negatively charged particles called ions are transported across the plasma membrane. The resting potential must be established within a cell before the cell can be depolarized, there are many mechanisms by which a cell can establish a resting potential, however there is a typical pattern of generating this resting potential that many cells follow. The cell uses ion channels, ion pumps, and voltage gated ion channels to generate a negative resting potential within the cell, however, the process of generating the resting potential within the cell also creates an environment outside of the cell that favors depolarization. The sodium potassium pump is largely responsible for the optimization of conditions on both the interior and the exterior of the cell for depolarization, additionally, despite the high concentration of positively-charged potassium ions, most cells contain internal components, which accumulate to establish a negative inner-charge. After a cell has established a potential, that cell has the capacity to undergo depolarization. During depolarization, the charge within the cell rapidly shifts from negative to positive, for this rapid change to take place within the interior of the cell, several events must occur along the plasma membrane of the cell as well. While the sodium potassium pump continues to work, the voltage gated ion channels that had closed while the cell was at resting potential have been opened by an electrical stimulus. As the sodium rushes back into the cell the positive sodium ions raise the charge inside the cell from negative to positive, once the interior of the cell becomes positively charged, depolarization of the cell is complete 5. Muscle contraction â€" Muscle contraction is the activation of tension-generating sites within muscle fibers. The termination of muscle contraction is followed by muscle relaxation, which is a return of the fibers to their low tension-generating state. Muscle contractions can be described based on two variables, length and tension, a muscle contraction is described as isometric if the muscle tension changes but the muscle length remains the same. In contrast, a muscle contraction is isotonic if muscle length changes, if the muscle length shortens, the contraction is concentric, if the muscle length lengthens, the contraction is eccentric. In natural movements that underlie locomotor activity, muscle contractions are multifaceted as they are able to produce changes in length, therefore, neither length nor tension is likely to remain the same in muscles that contract during locomotor activity. In vertebrates, skeletal muscle contractions are neurogenic as they require synaptic input from neurons to produce muscle contractions. A single motor neuron is able to innervate multiple muscle fibers, once innervated, the protein filaments within each skeletal muscle fiber slide past each other to produce a contraction, which is explained by the sliding filament theory. The contraction produced can be described as a twitch, summation, or tetanus, in skeletal muscles, muscle tension is at its greatest when the muscle is stretched to an intermediate length as described by the length-tension relationship. Unlike skeletal muscle, the contractions of smooth and cardiac muscles are myogenic, the mechanisms of contraction in these muscle tissues are similar to those in skeletal muscle tissues. Muscle contractions can be described based on two variables, force and length, force itself can be differentiated as either tension or load. Muscle tension is the force exerted by the muscle on an object whereas a load is the force exerted by an object on the muscle, when muscle tension changes without any corresponding changes in muscle length, the muscle contraction is described as isometric. If the muscle length changes while muscle tension remains the same, in an isotonic contraction, the muscle length can either shorten to produce a concentric contraction or lengthen to produce an eccentric contraction. Furthermore, if the muscle length shortens, the contraction is concentric, but if the muscle length lengthens, then the contraction is eccentric. In natural movements that underlie locomotor activity, muscle contractions are multifaceted as they are able to produce changes in length, therefore, neither length nor tension is likely to remain constant when the muscle is active during locomotor activity. An isometric contraction of a muscle generates tension without changing length, an example can be found when the muscles of the hand and forearm grip an object, the joints of the hand do not move, but muscles generate sufficient force to prevent the object from being dropped. In isotonic contraction, the tension in the muscle remains constant despite a change in muscle length and this occurs when a muscles force of contraction matches the total load on the muscle. In concentric contraction, muscle tension is sufficient to overcome the load, and this occurs when the force generated by the muscle exceeds the load opposing its contraction. During a concentric contraction, a muscle is stimulated to contract according to the sliding filament theory and this occurs throughout the length of the muscle, generating a force at the origin and insertion, causing the muscle

to shorten and changing the angle of the joint 6. Cardiac output â€" Cardiac output, is a term used in cardiac physiology that describes the volume of blood being pumped by the heart, in particular by a left or right ventricle, per unit time. The factors affecting stroke volume and heart rate also affect cardiac output, the figure to the right illustrates this dependency and lists some of these factors. A detailed hierarchical illustration is provided in a subsequent figure, there are many methods of measuring CO, both invasively and non-invasively, each with its own advantages and drawbacks. No standard or reference measurement against which all of these methods can be compared exists, the function of the heart is to drive blood through the circulatory system in a cycle that delivers oxygen, nutrients and chemicals to the bodys cells and removes cellular waste. This is detailed in equation below, there are a number of clinical methods to measure cardiac output, ranging from direct intracardiac catheterisation to non-invasive measurement of the arterial pulse. Each method has advantages and drawbacks, relative comparison is limited by the absence of a widely accepted gold standard measurement. Cardiac output should therefore be measured at evenly spaced points over a cycle or averaged over several cycles. Invasive methods are accepted, but there is increasing evidence that these methods are neither accurate nor effective in guiding therapy. Consequently, the focus on development of methods is growing. This method uses ultrasound and the Doppler effect to measure cardiac output, the blood velocity through the heart causes a Doppler shift in the frequency of the returning ultrasound waves. Echocardiography is a method of quantifying cardiac output using ultrasound. Two-dimensional ultrasound and Doppler measurements are used together to calculate cardiac output, the result is then multiplied by the heart rate to obtain cardiac output.