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Morfological Comparisons of the Heart of Mammals and Humans

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Abstract: Currently, animal studies are fundamental to the development of new therapies aimed at improving the quality of life of patients with cardiovascular disease. In addition, early testing of cardiac device prototypes is typically conducted using animal models with and without cardiovascular disease. that the animal model to be tested is similar in anatomy and physiology to the human model. Unfortunately, detailed information linking the anatomy of the human heart to that of the most common large mammalian models is still lacking.

Keywords: animals, heart, human, topography, comparison.

All large mammalian hearts are enclosed by the pericardium, which creates the pericardial cavity surrounding the heart. The pericardium is fixed to the great arteries at the base of the heart and is attached to the sternum and diaphragm in all mammals, although the degree of these attachments to the diaphragm varies between species. Specifically, the attachment to the central tendinous aponeurosis of the diaphragm is firm and broad in humans and pigs, the phrenopericardial ligament is the only pericardial attachment in dogs, and the caudal portion of the pericardium is attached via the strong sternopericadial ligament in sheep [American Heart Association. (2001)]. The pericardium consists of three layers: the serous visceral pericardium (epicardium), the serous parietal pericardium, and the fibrous pericardium. The serous parietal pericardium lines the inner surface of the fibrous pericardium, and the serous visceral pericardium lines the outer surface of the heart. The pericardial cavity is found between the outer two layers and contains the pericardial fluid. The pericardium is considered to serve many functions, including: [Hoeg, J.M. (1997] prevention of heart dilation; [Kelly, D.P. 1994] protection of the heart from infection and adhesions to surrounding tissues;[Marwick, C. 1997] maintenance of the heart in a fixed position in the thorax; and [Ridker, P.M. 1999] regulation of the interrelations between the stroke volumes of the two ventricles [Gura, T. (2001]. However, it should be noted that the pericardium is not essential for survival because humans with congenital absence of the pericardium and pericardiectomized animals or humans can survive for many years [Roses, A.D. 2002]. Although the basic structure of the pericardium is the same, there are important differences between species. For instance, pericardial wall thickness increases with increasing heart size. Nevertheless, humans are the notable exception to this rule, having a much thicker pericardium than animals with similar heart sizes[Seidman, C.E. and Seidman, J.G. 1991]. Specifically, the pericardium of the human heart varies in thickness between 1 and 3.5 mm [Hoeg, J.M. (1997]; the average thicknesses of the pericardia of various animal species were found to be considerably thinner (sheep hearts 0.32 Ѓ} 0.01 mm; pig hearts 0.20 Ѓ} 0.01 mm; dog hearts 0.19 Ѓ} 0.01 mm) [Gura, T. 2001]. The left and right ventricles of the large mammals used for cardiovascular research contain essentially the same components that are structurally very similar to human hearts: an inlet region, an apical region, and an outlet region. The ventricles can be considered the major outflow pumping chambers of the heart and as expected, their walls are significantly more muscular in nature than those of the atria. Importantly, the left ventricular walls are also notably more muscular than those of the right ventricle because the left ventricle must generate enough pressure to overcome the resistance of the systemic circulation, which is much greater than the resistance of the pulmonary circulation (normally more than four times greater). The walls of both ventricles near the apex have interanastomosing muscular ridges and columns termed the trabeculae carneae that serve to strengthen the walls and increase the force exerted during contraction [Cheng, C.F 2003]. However, large mammalian hearts reportedly do not have the same degree of trabeculations located in the ventricles compared to normal adult human hearts, and the trabeculations in animal hearts are commonly much coarser than those of human hearts [Lander, E.S 2001].

Reptiles have a smaller body compared to mammals. Thus, it is possible that the structure of the heart and blood cells of animals corresponds to their energy needs. Thus, the lizard heart is designed in such a way that it allows the mixing of oxygenated and deoxygenated blood, resulting in the presence of nucleated red blood cells, as opposed to non-nuclear mammalian red blood cells. This supports the advancement of mammals over reptiles in an evolutionary direction. [ORHERUATA, RA 2018].

The study of literature sources shows that there are three types of cardiomyocytes: contractile (atypical), which form the main part and have a well-developed contractile apparatus, which occupies most of their sarcoplasm; atypical cardiomyocytes - have the ability to generate and quickly conduct electrical impulses. They form nodes and bundles of the conduction system of the heart. They are characterized by weak development of the contractile apparatus, light sarcoplasm and large nuclei; secretory (endocrine) cardiomyocytes are located in the atria (especially the right) and are characterized by a process form and a weak development of the contractile apparatus. In their sarcoplasm, near the poles of the nucleus, there are dense granules surrounded by a membrane with a diameter of 200-300 nm, containing the hormone atrial natriuretic factor (peptid) -PNF. This hormone causes increased loss of sodium and water in the urine (natriuresis and diuresis), vasodilation, and lowering blood pressure, inhibition of the secretion of aldosterone, cortisol and vasopressin. All cardiomyocytes initially have the ability to produce PNP during embryonic development; in the future (already after birth), it sharply decreases in the cells of the ventricles, remaining in the atrial cardiomyocytes. When the heart muscle is overloaded, the ability to synthesize PNP can be restored in ventricular cardiomyocytes. [Загоруйко, Г. Е 2017, Y. Kanzaki 2012].

All large mammalian hearts have a very similar conduction system with the following main components: sinoatrial node, atrioventricular node, bundle of His, right and left main bundle branches, and Purkinje fibers. Interspecies variations are well recognized, especially regarding the finer details of the arrangement of the transitional and compact components of the atrioventricular node[Ballas, C.B 2002].

	Location of the AV node	AV node and His bundle junction	*Length of the His bundle*	*Route of the His bundle*
Human	Located at the base of the atrial septum, anterior to the coronary sinus, and just above the tricuspid tricuspid valve.	End of the AV node and the beginning of the His bundle are nearly impossible to distinguish	Total length of the unbranched portion is 2–3 mm. Penetrating bundle is 0.25–0.75 mm long Bundle bifurcates just after emerg ing from the central fibrous body	Bundle lies just beneath the mem branous septum at the crest of the interventricular septum
Pig	Lies on the right side of the crest of the ventricular septum and is	No explicit information found	Penetrating bundle is very short in comparison to humans	Climbs to the right side of the sum mit of the ventricular septum where it enters the central

	lower on the septum than in humans			fibrous body. The bifurcation occurs more proximally than in humans.
Dog	Same as in humans.	Consists of internodal tracts of myocardial fibers.	Penetrating bundle is 1–1.5 mm long, significantly longer than the human penetrating bundle	His bundle runs forward and down ward through the fibrous base of the heart, just beneath the endocardium There are at least three discrete His bundle branches of myocardium that join the atrial end of the AV node via a proximal His bundle branch
Sheep	Located at the base of the atrial septum, anterior to the coronary sinus, just above the tricuspid valve and at the junction of the middle and posterior one-third of the os cordis	Junction is characterized by fingerlike projections, where the two types of tissue overlap size and staining qualities of the initial Purkinje cells of the His bundle make it easy to distin guish between the end of the AV node and the beginning of the His bundle.	Portion of the bundle passing through the central fibrous body is 1 mm. Bundle extends 4–6 mm beyond the central fibrous body before it bifurcates.	Unbranched bundle must pass beneath the os cordis to reach the right side of the ventricular septum His bundle then remains relatively deep within the confines of the Ventricular myocardium. Branching occurs more anteriorly in sheep than in humans.

Thus, the analysis of the cited literature data indicates that the size and shape of the heart in different species of mammals depends on the conditions in which animals are kept, the apparatus of movement, their body type, age, and sex. At the same time, the literature provides a relatively small amount of material on the topography of the heart, the relative and absolute mass of the heart, as well as the size and shape of the auricles in humans and animals.

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