

Macroscopic anatomy of the surface of the heart of albino Wistar rats

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Abstract

Rats have been used in experiments since before Christ and, currently, are the most commonly used animal in scientific research. The literature regarding the heart of these animals is not very detailed and descriptive. The few references that were found are old and detail only one aspect of the heart anatomy of these animals. The objective of this research is to study two macroscopic parameters that are yet to be described regarding the heart of Wistar rats in different phases of their lives. Thirty-six adult male and female rats (*Rattus norvegicus*) weighing 150-770 g were randomly set into 6 experimental groups according to gender and weight. After the excision, each heart was then carefully dissected and removed from the chest. After this process, each heart had their weight measured on a HELMAC HM100 precision scale, and the parameters tape-measured. Once rectified, this tape-measurement allowed the measurement of structures in a single n-dimensional level through an analog precision caliper. The measurements correspond to the perimeter of the atrioventricular groove (PAV) and the distance from the atrioventricular groove to the apex of the heart (DGA). Both these parameters are part of the surface anatomy of the heart and can help to understand the sexual dimorphism and the adaptation that occurs inside the heart when these animals gain weight.

Keywords: heart, anatomy, rats.

1 Introduction

The use of animals as experimental models in scientific research is not new. The first experiments that we know were made in 500 a.C., in southern Italy, by Alcmeon Crotona, who performed dissections in not described species. As from 150 a.C., human dissection was prohibited for ethical reasons, and it gave a boost to experiments using animals of other species. Nowadays, the rat is the most used animal in scientific research.

The use of rats in scientific research is due to facts such as ease of observation and maintenance, possibility of working with a large number of animals, which allows a greater statistics viability, short life cycle, numerous offspring, environmental pattern, use of a single diet, and low ration intake (TIRAPEGUI, CAMPOS and RIBEIRO, 1995).

Specific literature about these animals clearly shows a lack of data about the anatomy of their hearts. One of the most influential references for researchers who use rats as experimental models is *Anatomy of the Rat*, by Eunice Chace Greene (1935). Chapter VII, about the blood system, describes only the paths of veins and arteries in the body of the rat. In a chapter about innards (Chapter IV), there is a brief description of thoracic organs with no detail or measurement. Besides the mentioned literature, there are other books that provide information about the anatomy of the rat; however, the descriptions are merely superficial. Only few articles mention specific information about the hearts of these animals.

Schneider (1938) describes the development of the heart of rats in embryos of different ages, for the documentation of

different stages and characteristics. The first stage observed was twelve days and eleven hours of development. The last observed stage was after sixteen days, when the heart practically reached its adult age. It was observed the presence of two superior venae cavae, on the left and right sides of the rat, which are the result of the development of the terminal segment of the anterior cardinal veins and the duct of Cuvier.

Greene (1935), when describing thoracic veins, calls left and right the two superior venae cavae. They are formed by the confluence of the internal jugular vein and the subclavian vein on the level of the first rib. They go ventrally to the beginning of the subclavian veins and run down (directing the tail) to the right atrium. The right vein is shorter and it opens directly in the posterior portion of the atrium. The left vein runs more to the posterior area of the aortic arch, pulmonary veins, and left bronchial tube, aiming to enter the atrium underneath the inferior vena cava. Seeing that the persistence of two superior venae cavae is a normal condition in rats, there is no formation of left or right brachiocephalic venous trunks and the consequent fusion in the superior vena cava.

Halpern (1957) describes the double blood-supply system in the rat's heart. The same system is found in fish and in some mammals, however, it tends to disappear during the phylogenetic development. The research used a hundred and five animals and concluded that the cardiac muscle of the rat is nourished by the coronary arteries and an extra cardiac system. The existence of such a system helps studies that need a bypass in the blood flow, as the supply of atria

and ventricles are apart, therefore, the supply of sinoatrial and atrioventricular nodes are also independent.

Halpern (1953a) describes the presence of an unforeseen system in mammals. This system is formed by veins that start in the heart and ends in the superior venae cavae. This system is made up of two bigger veins that cross the middle line and end in the inferior vena cava, counter laterally to its source. These veins drain the region in the cone of the right ventricle and the ventral cephalic region of the left ventricle. The author uses the term “extra-coronary cardiac veins” because they start in the heart, but it has no relation to the coronary circulation.

2 Materials and Methods

The experiments were made in accordance to the Ethical Principles for Experimental Animals (COBAO) and the research was approved by the Animal Experimentation Committee (CETEA) of the Faculty of Medicine of Ribeirão Preto, University of São Paulo (Protocol 0347/2005).

Thirty-six adult male and female rats (*Rattus norvegicus*) weighing between 150-770 g were used in the procedures. The animals were divided into six groups according to gender and weight (Table 1).

2.1 Experimental procedures

General anesthesia was administrated and the animals were attached to the surgical table in the supine position, then a bilateral thoracotomy was made. After visualizing the thoracic organs, the animal was perfused by 0.9% aqueous sodium chloride which was, in a stopper, heated to ambient temperature. Afterwards, it was diluted to 10% in aqueous formaldehyde solution (CH₂O). The heart was removed and immersed, for forty-eight hours, in aqueous formaldehyde solution, diluted to 10%. After the forty-eight hours, the hearts were dissected using a standard method and weighed in the HELMAC HM100 precision scale. Two measurements were performed: the measurement the coronary groove perimeter (atrioventricular), and the measurement of the distance from the coronary groove to the apex of the heart.

2.2 Morphometrical analysis

A nylon line was used supporting the surface of each heart. The measurements of the atrioventricular groove perimeter (PAV) (Figure 1), and the distance from the atrioventricular groove to the apex of the heart (DGA) (Figure 2) were performed. The tape was rectified and measured with an analog MAUb caliper.

2.3 Statistical analysis

To achieve the objective, the analysis of variance (ANOVA), according to the PROC GLM procedure of SAS software version 9 was used, for the purpose of comparing

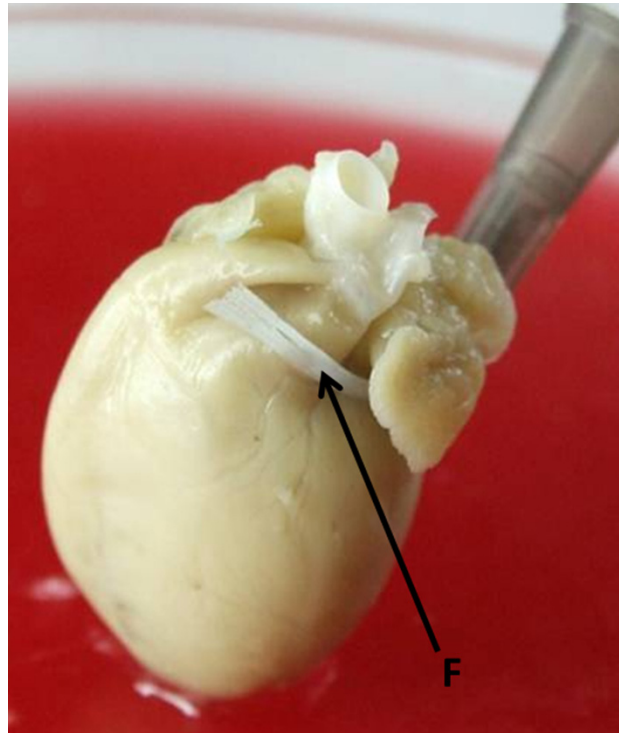


Figure 1. Inferior view: The heart of Albino Wistar rats, with the nylon line (F) positioned to measure the atrioventricular groove perimeter (3x).

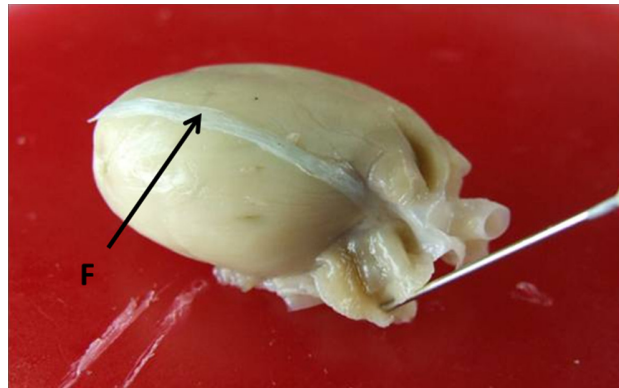


Figure 2. Anterolateral view of the heart of albino Wistar rats, with the nylon line (F) positioned to measure the distance from the atrioventricular groove to the vertex of the heart.

Table 1. Experimental groups. (*) age according to a growing curve for albino Wistar rats developed in the Bioterium at USP, Ribeirão Preto - SP.

Groups	Males	Females
150-249 g / 35-49 days of age*	Group I-M 6 animals	Group I-F 6 animals
250-350 g / 56-77 days of age*	Group II-M 6 animals	Group II-F 6 animals
above 351 g / age greater than 98 days*	Group III-M 6 animals	Group III-F 6 animals

the average between the groups. The values of $p \leq 0,05$ were employed.

3 Results

The Figure 3A and B show the variables of the atrioventricular groove perimeter (PAV), and the distance from the atrioventricular groove to the vertex of the heart in three different groups and in both genders.

For the PAV variable within the groups, both for males and females, no results were statistically significant between groups I and III and between groups II and III. Between

groups I and II, there was no statistical difference. The results of the DGA variable, by comparison within the intragroups, were not statistically significant. By comparison within the intergroup, between females and males, the results are similar: there is no statistical significance between groups I and II. The significance lies in the comparison between group II and III and between groups I and III (Table 2).

4 Discussion

During every phase of the experiments, the animals maintained normal behavior, typical of the species, without

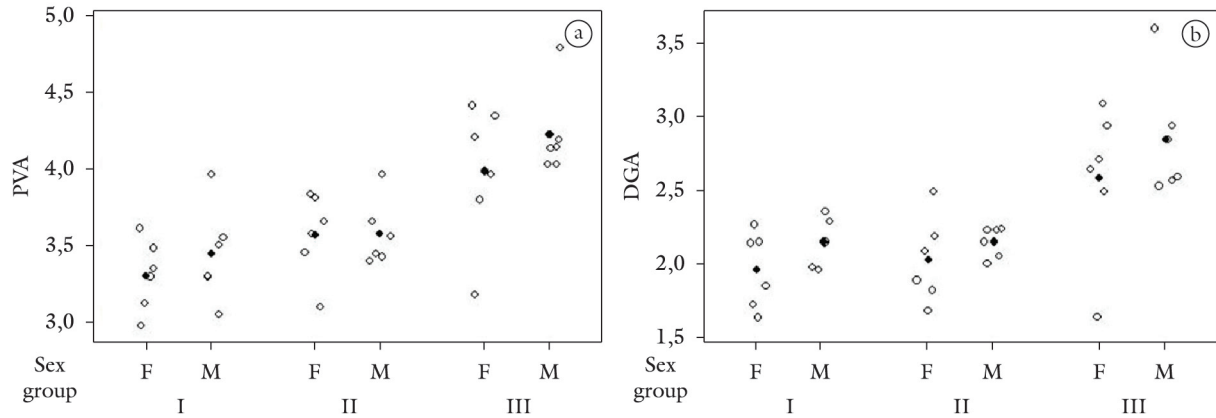


Figure 3. Variable dispersion: A. atrioventricular groove perimeter (PAV) and B. the distance from the atrioventricular groove to the vertex of the heart (DGA). The bold dots represent the average value (mm).

Table 2. The results obtained, in millimeters, for the atrioventricular groove perimeter (PAV), and the distance from the atrioventricular groove to the vertex of the heart (DGA) in comparison within intragroups and intergroups. (a) respective average value to groups within the comparison, (b) calculate the difference between the average values within the respective groups. (*) Statistically significant.

Variables	Comparisons	Average ^(a)	Average ^(a)	Estimate ^(b)	p-value
PAV	Groups				
	Group I: F X M	3.31	3.45	0.14	0.43
	Group II: F X M	3.58	3.58	0.00	0.99
	Group III: F X M	3.99	4.22	0.23	0.20
	Female				
	Group I vs Group II	3.31	3.58	0.27	0.14
	Group I vs Group III	3.31	3.99	0.68	< 0.01*
	Group II vs Group III	3.58	3.99	0.41	0.03*
	Male				
	Group I vs Group II	3.45	3.58	0.13	0.47
Group I vs Group III	3.45	4.22	0.77	< 0.01*	
Group II vs Group III	3.58	4.22	0.64	< 0.01*	
DGA	Groups				
	Group I: F X M	1.96	2.15	0.19	0.32
	Group II: F X M	2.03	2.15	0.12	0.51
	Group III: F X M	2.59	2.85	0.27	0.16
	Female				
	Group I vs Group II	1.96	2.03	0.07	0.72
	Group I vs Group III	1.96	2.59	0.63	< 0.01*
	Group II vs Group III	2.03	2.59	0.56	< 0.01*
	Male				
	Group I vs Group II	2.15	2.15	0.00	0.99
Group I vs Group III	2.15	2.85	0.70	< 0.01*	
Group II vs Group III	2.15	2.85	0.70	< 0.01*	

developing any observable and/or detectable pathological process throughout the experiment that could compromise the establishment of morphometric parameters of the heart in these animals. These two variables were described together so as to help to understand and define patterns to the dimensions in the anatomy of the surface of the heart of albino Wistar rats. The atrioventricular groove (coronary) delimits externally the separation between the atria and ventricles.

The measurement of this parameter (PAV) through a simple and accurate method, as the one used in this experiment, allowed the measurement of the perimeter of the atrioventricular septum. When these results were compared within the intragroups, there was no possibility of finding significant differences. However, in the analyses within the intergroup, not only for males but also for females, there was statistical difference between groups I and III, with the increase of the average values throughout the development. When group I was compared with group II, not only with males but also with females, no significant difference was found.

The measure of the DGA was used as a guide for the maximum length of the left ventricle of the heart. In this study, the absolute values of these variables showed a tendency for a smaller left ventricle in the females in the three experimental groups. The average values of this parameter were always increasing. The increase of these values meets the demands for a systolic volume that is compatible with the gain of body weight these animals have during their life cycle since the objective was to present the morphometry of the heart without there being any external factor associated.

However, the references about the anatomy of Wistar-albino rats are sparse and old; no need of description of normal standards for the study of changes in the morphology of the heart of these animals may have a point of reference for possible changes. The study of physical activity, for example, shows that several morphological and physiological effects are promoted on the cardiovascular system, such as tachycardia, increased systolic volume and increased ejection fraction (RERYCH, SCHOLZ, SABISTON et al., 1980). These last two parameters mentioned are related to the increase in the mass of right ventricle (RV) and left ventricle (LV). Exercised animals compared to sedentary RV hypertrophy show an increase from 21 to 31% by weight and RV increase of 7% to 12% by weight of LV (ANTWERP, BEGHI, LEVICKY et al., 1982; ANTWERP, LEVICKY, BEGHI et al., 1983; ANVERSA, BEGHI, LEVICKY et al., 1985).

Elliott, Faraday and Grunberg (2003) describes the deleterious effects on the cardiovascular system by analyzing the daily stress in mild cardiac morphology and blood volume in rats. Length heart, heart weight, width of the left ventricular cavity, the width of the right ventricle, the thickness of the side wall anterior wall thickness, posterior wall thickness and interventricular septum thickness were measured. The results suggest that exposure to stress can alter the morphology heart and blood volume, and that there are differences between males and females in their responses to stress with respect to cardiac morphology and blood volume. Reinforce previous findings that males and females may have different cardiovascular responses to stress (VILLABLANCA, 1996; BARRETT-CONNOR, 1997).

Studies in humans with induced stress have also documented the increase in left ventricular mass (DEVEREUX and ROMAN, 1993; MANUCK, 1994). The atrioventricular groove externally delimits the separation between the atria and ventricles. The measurement of this parameter (VAP) by a simple and accurate method as used in this experiment allowed the calculation of the diameter of the atrioventricular septum, ie the perimeter of the valve rings. This study found an increase in the average of these values throughout development, but without statistically significant difference when males and females were compared.

Moise (2011) in her study evaluated ventricular remodeling and valve rings in dilated cardiomyopathy obtaining measures of the perimeters of the rings in atrioventricular groove. It was observed that the left atrioventricular ring dilates not, contrary to the right, through a mechanism that can display peculiarities arising from structural differences and blood pressure in both ventricles.

5 Conclusion

By the presented analysis of both parameters, it is proved that there is a sexual dimorphism related to the anatomy of the surface of the heart of Albino Wistar rats. The female hearts are shorter, less stretched, smaller and lighter. The measurements of the DGA variable showed a tendency in the females, shorter in length, to a progressive increase throughout the period of development of the analyzed animals.

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