Original Research Article

Comparison of morphology and morphometry of human pulmonary and porcine pulmonary heart valves

Supadevi S[1], Ramesh Kumar Subramaniam[2*]

[1]Assistant professor, Department of Anatomy, Government Kilpauk Medical College, Chennai, Tamil Nadu, INDIA.
[2]Professor, Department of Anatomy, Sri Ramachandra Medical College, Chennai, Tamil Nadu, INDIA.
Email: supadevi.dr@gmail.com

Abstract

Background: There is an increased interest in the diagnosis and treatment of human valvular heart diseases. When heart valve disease progresses to a point that treatment by medicines does not provide relief from patient symptoms, surgery to repair or replace becomes the best alternative. **Aims and objective:** To compare the morphology and morphometry of human pulmonary and porcine pulmonary heart valves **Material and methods:** Study conducted in Sri Ramachandra medical college and research institute, Chennai during the period of 2014-15.In the present total number of 20 porcine heart valves was compared with 20 human heart valves and their morphology and morphometry was analyzed and compared. Both the human hearts and porcine hearts were weighed and the heart weight ranging from 300 gm – 450 gm was only used in this study. Porcine heart was obtained from slaughter house immediately after the slaughter and the specimen was washed with normal saline and the heart was fixed in 10 % formal saline solution. The formalin fixed specimens of human heart were procured from the embalmed cadavers. The data was entered and they were statistically analyzed using SPSS software 20 version. **Results:** The circumference of the pulmonary valve in human was 68.06mm and that of the porcine was 52.94mm and the p value was significant (p value: 0.000). The attached margin of human and porcine pulmonary valve showed significant difference on both (0.000). The free margin of the pulmonary valve showed insignificant p value (0.152- 0.169).The effective height of human pulmonary valve scallop had significant difference with porcine pulmonary scallops (0.005) and it was more in human pulmonary valve than porcine valve. The height of the scallop was having insignificant difference (0.620- 0.795). **Conclusion:** The porcine valve can be used in replacement surgeries of the human heart valves by matching the morphometry and reducing the geometrical difference to their minimum by using any interventional radiology. The porcine heart valves show excellent features similar to the human heart valves and they can be used in replacement surgeries as good bioprostheses in place of mechanical prosthesis irrespective of their other biochemical and other properties

Key Word: pulmonary heart valves, human heart, porcine heart

[*]**Address for Correspondence:**
Dr. Ramesh Kumar Subramaniam, Professor, Department of Anatomy, Sri Ramachandra Medical College, Chennai, Tamil Nadu, INDIA.
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INTRODUCTION

There is an increased interest in the diagnosis and treatment of human valvular heart diseases[1]. When heart valve disease progresses to a point that treatment by medicines does not provide relief from patient symptoms, surgery to repair or replace becomes the best alternative. If the surgery is not to repair then the choice is more likely between carbon based mechanical valve and biological tissue valve. The valve is chosen depending upon the requirement to improve the quality of life with minimal risk. In tissue valves the homograft or xenograft becomes the best choice. There is an increasing popularity of mitral valve repair and there is a current

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interest on the homograft and hetrograft, warranting a new look at the normal functional anatomy of the systems[2]. Xenograft tissue valves are harvested from porcine heart and porcine bio-prosthesis has been used since 1960. The left atrioventricular valve apparatus of pigs has important application in experimental, clinical and surgical fields. The proven similarity between pig's hearts and human hearts has prioritized their widespread use in heart research[3,4]. Each heart valve is composed of different structures of which each one has its own histo - morphological profile. The aortic valve is considered as the center piece of heart and is considered as the most important valve in respect to the cardiac function and the variation in the anatomy of the human aortic valve has been studied[5,6]. The pulmonary valve is used as the valve substitute for the aortic valve in Ross procedure[7]. Normal data of the tricuspid valve complex and the published work on the tricuspid valve is less[8] compared to the literature available on the detailed anatomy of mitral valve. Although the aortic and the pulmonary valves as well as the mitral and the tricuspid valves show similarities in their architecture, they are individually designed to ensure optimal function with regard to their role in the cardiac cycle. There is less number of studies found to show the morphology of all four human heart valves. Although the xenograft from porcine are best suited for replacement surgery on heart valves and they are used as novel prostheses for their own advantages. There are very less number of studies that has systematically analyzed the comparative anatomy of all four human heart valves with porcine heart valves. Hence this study was carried out to put forth the morphological features of the porcine pulmonary heart valves in comparison with human pulmonary heart valves and their renounced use in heart valve replacement.

AIMS AND OBJECTIVE

To compare the morphology and morphometry of human pulmonary and porcine pulmonary heart valves

MATERIAL AND METHODS

The present study was conducted in department of Anatomy of Study conducted in Sri Ramachandra medical college and research institute, Chennai during the period of 2014-15 to Compare the morphology and morphometry of human pulmonary and porcine pulmonary heart valves. For this purpose total number of 20 porcine heart valves was compared with 20 human heart valves and their morphology and morphometry was analyzed and compared. Both the human hearts and porcine hearts were weighed and the heart weight ranging from 300 gm – 450 gm was only used in this study.

Acquisition of porcine heart valves: Porcine heart was obtained from slaughter house immediately after the slaughter and the specimen was washed with normal saline and the blood clots were removed from the external surface of the heart and from the great vessels as much as possible. Then the heart was fixed in 10 % formal saline solution. They were brought to the department for the structural analysis of the valves. The ascending component of the aorta and pulmonary trunk was cut above the arterial valves.

Acquisition of human heart valves: The formalin fixed specimens were procured from the embalmed cadavers, from the Department of Anatomy in Sri Ramachandra Medical College and Research Institute.

METHODOLOGY

The pulmonary valve was opened in between the right anterior and posterior and extended till the right ventricle. The attached margin of the scallop was measured using silk thread along the attached margin of the scallop and the free margin was measured in the same way. The effective height of the scallop was the height from the lowest point of the attached margin (nadir) to the free margin of the cusp and measured using the verniercaliper. This does not measure the length of the cusp. The height of the scallop was measured using verniercaliper from the nadir to the point on the circumference. The aortic valve circumference was measured at the sino-tubular junction, which can be observed as a ridge above the aortic valve scallops. Then the valve was opened along the commissure between the right and left coronary scallop. The attached margin, free margin, effective height and height of the scallop were measured in the same manner as the pulmonary valve. The height of the ostium was measured from the inner aspect of the attached margin to the opening of the coronary vessel using verniercaliper. Since the hearts were preserved in formalin and there was possibility of some tissue shrinkage to occur, all the measurement was made to nearest millimeter by a metric scale. The observations were made and the results were tabulated.

Statistical analysis: The data was entered and they were statistically analyzed using SPSS software 20 version. All the dependent variables were compared using student t test and independent sample test.

RESULTS

Table 1: Mean value of the attached margin and free margin of the pulmonary valve (Human and Porcine)

	Group	N	Mean	Std. Deviation	Std. Error Mean
circumference of human pulmonary valve	Human	20	68.0600	11.02420	2.46509
	Porcine	20	52.9445	6.35430	1.42087
attatched margin of right anterior scallop	Human	20	36.5245	3.30760	.73960
	Porcine	20	31.4800	4.15526	.92914
attatched margin of left anterior scallop	Human	20	37.9385	4.30828	.96336
	Porcine	20	31.9195	3.55781	.79555
attatched margin of posterior scallop	Human	20	39.3670	6.39333	1.42959
	Porcine	20	31.4610	4.01511	.89781
free margin of right anterior scallop	Human	20	23.0305	4.43366	.99140
	Porcine	20	23.6660	3.78186	.84565
free margin of left anterior scallop	Human	20	25.1855	5.48651	1.22682
	Porcine	20	23.0200	3.70304	.82803
free margin of posterior scallop	Human	20	23.7485	4.66890	1.04400
	Porcine	20	22.7540	4.05642	.90704

It was seen that the circumference of the pulmonary valve in human was 68.06mm and that of the porcine was 52.94mm and the p value was significant (p value: 0.000). The circumference of pulmonary valve was more in porcine than the human heart valves. The attached margin of human and porcine pulmonary valve showed significant difference on both (0.000). The free margin of the pulmonary valve showed insignificant p value (0.152- 0.169). All the parameters regarding the pulmonary were more in human pulmonary valve than porcine pulmonary valve.

Table 2: Comparison of Mean value of the attached margin and free margin of the pulmonary valve (Human and Porcine)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
circumference of human pulmonary valve	Equal variances assumed	6.804	.013	5.313	38	.000	15.11550	2.84526	9.35557	20.87543
	Equal variances not assumed			5.313	30.370	.000	15.11550	2.84526	9.30767	20.92333
attatched margin of right anterior scallop	Equal variances assumed	.314	.579	4.248	38	.000	5.04450	1.18757	2.64039	7.44861
	Equal variances not assumed			4.248	36.180	.000	5.04450	1.18757	2.63641	7.45259
attatched margin of left anterior scallop	Equal variances assumed	.828	.368	4.818	38	.000	6.01900	1.24939	3.48975	8.54825
	Equal variances not assumed			4.818	36.688	.000	6.01900	1.24939	3.48678	8.55122
attatched margin of posterior scallop	Equal variances assumed	1.626	.210	4.683	38	.000	7.90600	1.68813	4.48856	11.32344
	Equal variances not assumed			4.683	31.970	.000	7.90600	1.68813	4.46726	11.34474
free margin of right anterior scallop	Equal variances assumed	1.811	.186	-.488	38	.629	-.63550	1.30307	-3.27343	2.00243
	Equal variances not assumed			-.488	37.078	.629	-.63550	1.30307	-3.27558	2.00458
free margin of left anterior scallop	Equal variances assumed	1.312	.259	1.463	38	.152	2.16550	1.48011	-.83082	5.16182
	Equal variances not assumed			1.463	33.336	.153	2.16550	1.48011	-.84465	5.17565
free margin of posterior scallop	Equal variances assumed	.361	.551	.719	38	.476	.99450	1.38299	-1.80522	3.79422
	Equal variances not assumed			.719	37.273	.477	.99450	1.38299	-1.80701	3.79601

Table 3: Mean value of the effective height of pulmonary scallop (Human and Porcine)

	Group	N	Mean	Std. Deviation	Std. Error Mean
effective height of right anterior scallop	Human	20	9.8380	1.78411	.39894
	Porcine	20	8.6325	2.34381	.52409
effective height of left anterior scallop	Human	20	10.6265	1.78815	.39984
	Porcine	20	8.5625	2.53733	.56736
effective height of posterior scallop	Human	20	10.6540	1.63654	.36594
	Porcine	20	8.6880	1.79524	.40143
height of right anterior scallop	Human	20	12.7120	1.37639	.30777
	Porcine	20	12.8700	2.32200	.51922
height of left anterior scallop	Human	20	13.7245	1.36599	.30545
	Porcine	20	12.7140	1.95593	.43736
height of posterior scallop	Human	20	13.0140	1.98645	.44418
	Porcine	20	12.6785	2.24611	.50225

It was observed that the effective height of human pulmonary valve scallop had significant difference with porcine pulmonary scallops (0.005) and it was more in human pulmonary valve than porcine valve. The height of the scallop was having insignificant difference (0.620- 0.795).

Table 4: Comparison of Mean value of the effective height of pulmonary scallop (Human and Porcine)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
effective height of right anterior scallop	Equal variances assumed	1.931	.173	1.830	38	.075	1.20550	.65865	-.12788	2.53888
	Equal variances not assumed			1.830	35.484	.076	1.20550	.65865	-.13099	2.54199
effective height of left anterior scallop	Equal variances assumed	2.296	.138	2.974	38	.005	2.06400	.69410	.65887	3.46913
	Equal variances not assumed			2.974	34.139	.005	2.06400	.69410	.65363	3.47437
effective height of posterior scallop	Equal variances assumed	.000	.982	3.619	38	.001	1.96600	.54319	.86637	3.06563
	Equal variances not assumed			3.619	37.679	.001	1.96600	.54319	.86606	3.06594
height of right anterior scallop	Equal variances assumed	10.156	.003	-.262	38	.795	-.15800	.60358	-1.37988	1.06388
	Equal variances not assumed			-.262	30.885	.795	-.15800	.60358	-1.38919	1.07319
height of left anterior scallop	Equal variances assumed	6.463	.015	1.894	38	.066	1.01050	.53346	-.06943	2.09043
	Equal variances not assumed			1.894	33.972	.067	1.01050	.53346	-.07365	2.09465
height of posterior scallop	Equal variances assumed	.775	.384	.500	38	.620	.33550	.67048	-1.02183	1.69283
	Equal variances not assumed			.500	37.441	.620	.33550	.67048	-1.02249	1.69349

Figure 1: Human Pulmonary Valve

Figure 2 : Porcine Pulmonary Valve

DISCUSSION

The present study was conducted with the aim to compare the morphology and morphometry of human pulmonary and porcine pulmonary heart valves. For this purpose total 20 cases of Human and porcine pulmonary heart valves were compared. In the present study the circumference of the pulmonary valve at the level of junction of the cusps with the arterial wall was 68.06mm. The attached margin and free margin of the right posterior, left posterior and anterior was 36.52 mm, 37.93 mm, 39.36 mm, 23.03 mm, 25.18 mm and 23.74 mm. Height of the scallops was also observed and it was 12.17 mm for anterior, 13.72 mm for the left posterior and 13.01mm for the right posterior. The circumference of the pulmonary valve in human was 68.06mm and that of the porcine was 52.94mm and the difference observed was statistically significant (p value: 0.000). The circumference of pulmonary valve was more in porcine than the human heart valves. The attached margin of human and porcine pulmonary valve showed significant difference on both (0.000). The free margin of the pulmonary valve showed insignificant p value (0.152-0.169). All the parameters regarding the pulmonary were more in human pulmonary valve than porcine pulmonary valve. Michael G. Bateman, *et al.*,[9] observed the mean annular diameter of pulmonary valve as 25.4 mm. It was seen that the free margin and attached margin length of all the three leaflets were observed. The pulmonary valve is used in place of aortic valve in replacement surgeries. The valve has three scallops as of the aortic but they are referred as the right anterior, left anterior and posterior. The mean circumference of the pulmonary valve was 52.94 mm. Length of the attached margin of the 3 scallop was 31.46 mm- 31.91 mm. The length of the free margin was 22.75 mm- 23.66 mm. Effective height of the leaflet was 3.56 mm- 8.68 mm. The height of the scallop was 12.67 mm-12.87 mm. The valve almost resembles the aortic valve in circumference, height of the scallop, effective height, attached margin and free margin. Martin Misfield and Hans-Hinrich Sievers[10] studied the pulmonary valve in accordance with aortic valve and

observed that the root of the pulmonary valve does not have a circular form and the root was not a well defined fibrous structure. They also observed that the nodule of arantii was less frequent when compared to the aortic leaflets. They have also studied the valves microscopic structure and the neuronal innervations of the leaflets.

CONCLUSION

Human pulmonary valve does not correlate with porcine pulmonary valve in morphometry, but the features were similar in both the human and porcine heart valves. And the above said features were compared to their maximum without any inter observer variation. Thus the porcine valve can be used in replacement surgeries of the human heart valves by matching the morphometry and reducing the geometrical difference to their minimum by using any interventional radiology. The porcine heart valves show excellent features similar to the human heart valves and they can be used in replacement surgeries as good bioprostheses in place of mechanical prosthesis irrespective of their other biochemical and other properties

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