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Original Research Article

Comparative Morphological and Morphometrical Analysis of Atrio-Ventricular Valves of Human and Porcine

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ABSTRACT

There is increased incidence of valvular heart diseases in recent years due to life style modifications. The mortality rates in valvular diseases are kept in pace using various modalities of treatments. One such lifesaving treatment is valve replacement surgeries. These are done by using mechanical valve prosthesis or tissue grafts. The tissue valves prosthesis, harvested from porcine heart are called as xenograft and are increasingly used in valve repair and replacement surgeries. In the present scenario, there is a smaller number of systematically analysed literatures available on the comparative anatomy of human and porcine heart valves. Hence this study was carried out to acquire knowledge and to put forth some points to future research works on heart valves. In this study, 20 formalin fixed porcine and human hearts were procured from slaughter house and cadavers respectively. The morphology and morphometry of tricuspid valve and mitral valve was observed and analysed using spss software 20 version. All the dependent variables were compared using student t test and independent sample test. The results were tabulated and compared. It was observed that the tricuspid and the mitral valve of the porcine resembles the corresponding human heart valves in morphology and morphometry and their values were coinciding to their maximum. The porcine valve resembles human heart valves in morphology and it can be used in designing valve substitutes in replacement surgeries. Porcine valve can also be used as bio-prosthesis by matching the morphometry and by reducing the geometrical difference to their minimum by using any interventional radiology.

KEY WORDS: Tissue Graft, Porcine, Tricuspid Valve, Mitral Valve, Morphology And Morphometry.

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INTRODUCTION

Heart valve diseases are increasing worldwide due to various pathological causes like rheumatic heart disease, endocarditis, atherosclerosis, exposure to high radiation and aneurysm. These lead to malformation of heart valves like valve prolapse, narrowing of valve, scaring of valves and calcification of heart valves causing either valve incompetence or regurgitation. The heart valve disease progresses to a point that treatment by medicines does not provide symptomatic relief for the patients. In ir-reversible damage, surgery to repair the valve or replacement of valve

becomes the best alternative. In replacement surgeries, the choice is more likely between carbon based mechanical valve or biological tissue valve. In tissue valves prosthesis, the tissue valve is procured as autograft, homograft or xenograft. Xenograft tissue valves are harvested from porcine heart. Post traumatic damage of the tricuspid valve was more frequent than the mitral valve because the valve is placed more anteriorly and being closest to the chest wall [1]. There is an increasing popularity of mitral valve repair in tissue replacement surgeries and there is a current interest on the homograft and heterograft, warranting a new looks at the normal functional anatomy of the systems [2].

This study is conducted to bridge the knowledge gap in the field of valvular anatomy and to enhance the similarity in morphological and morphometrical features of human heart valves and porcine heart valves.

METHODOLOGY

A total number of 20 human heart valves were compared with 20 porcine heart valves. The human and animal ethical committee clearance has been obtained and the study was carried out. The materials used were vernier calliper, blotting paper, surgical silk thread and scissors.

Porcine heart was obtained from slaughter house and was fixed in 10 % formal saline solution. The formalin fixed human heart specimens were procured from the embalmed cadavers, from the department of anatomy in Sri Ramachandra Medical College and Research Institute.

In both the human and porcine hearts, the right atrial wall was removed to expose the tricuspid valve. To obtain the circumference and the length of the attached margin, the surgical silk thread was used on the atrial aspect as illustrated in figure 1 and 2. The height of the leaflet was measured using vernier calliper. The rough zone and clear zone were observed and measured on the atrial aspect using trans-illumination technique as illustrated in figure 3 and 4. The mitral valve of the human and porcine were exposed using the same technique and measurements were taken.

Both the human hearts and porcine hearts weight ranging from 300 gm – 450 gm was used and any deviation from normal were excluded. Total annular circumference of the valve, annular length, height of each leaflet, height of the rough zone and clear zone were observed. All the dependent variables were compared using student t test and independent sample test.

RESULTS AND DISCUSSION

The human tricuspid valve: The human heart is trapezoidal in silhouette with a markedly eccentric apex, reflecting the orthograde posture. In the present study, the outlet component was aligned at right angle to the inlet component which is an important factor for evolution of cardiovascular system [3]. The tricuspid valve orifice was ellipsoid in shape and was larger and thinner. The mean annular circumference of the tricuspid valve was 106.62mm [4]. In the present study the length of the anterior, septal and the posterior leaflets were 31.37mm, 33.03mm and 20 [5]. The height of the posterior leaflet was the smallest of all the three leaflets and presented crescent shape when compared to the septal and anterior leaflet [6]. The leaflet had on its atrial surface, a distinct ridge that followed the rim of the leaflet and distal to that was the rough zone of the leaflet and this was opaque on trans illumination. Between the rough zone and the valvular annulus was the thin membranous clear zone which was clear on trans illumination. The rough zone and clear zone of the anterior was 6.67mm and 8.19mm, the septal leaflet was 6.69mm and 5.53mm and that of the posterior leaflet was 5.69mm and 5.48mm respectively. The rough zone and the clear zone were almost equal in the posterior leaflet. The commissural area had distinct central portion which was clear on transillumination while the periphery merged with the leaflet. The height of the antero-septal, postero-septal and antero-posterior commissures were 5.4mm, 5.65mm and 6.21mm [7].

Human mitral valve: In the present study the human mitral valvular anatomy was observed

and the circumference was 82.3mm. The length of the attached margin of the anterior and posterior cusps were 29.02mm and 38.76mm and it corelated minimum with the study where only leaflets lengths were observed [8]. The mitral valve was biconcave and more of D shaped when observed from the atrial aspect [9]. The annular attachment of the anterior leaflet was half that of the posterior leaflet and the anterior leaflet was almost twice deep as the posterior one [10,11]. At the centre of the anterior leaflet the clear zone was approximately twice the height of the rough zone [12].

Porcine tricuspid valve: The heart of the porcine is valentine shaped due to unguligrade posture. The porcine valve apparatus consists of fibrous ring, cuspids, tendon cords and papillary muscles [13]. In this present study the tricuspid valve leaflets were alone observed for morphology and was not studied as apparatus. The mean circumference of the tricuspid valve was 97.47mm. The height of the anterior leaflet, septal leaflet and the posterior leaflets was 15.84mm, 15.91mm and 14.71mm respectively. The demarcation between the rough zone and clear zone was prominent in porcine heart valves even without trans-illumination. The height of the rough zone and clear zone of the anterior leaflet was 8.94mm, 7.01mm, septal leaflet was 8.05mm, 7.99 mm, and posterior leaflet was 7.21 mm, 7.69mm.

In this study, it was also observed that the ventricular walls were much thicker than the human ventricular wall. The cuspids were also showing varying thickness compared to the human tricuspid valve cusps which were observed well during analysis of rough zone and clear zone on Tran's illumination.

Porcine mitral valve: The mean circumference of the mitral valve was 78.79 mm and the length of the anterior and posterior leaflet was 29.02 mm and 38.76 mm. The height of the anterior and posterior leaflet was 16.26 mm and 12.19 mm. The mean width of the septal cuspid was 25.4 mm, and parietal cuspid was 15.5 mm. The height of the septal cuspid and parietal cuspid was 19.8 mm and 15.2 mm and the septal cuspid was large [14].

The demarcation between the rough zone and clear zone was prominent in porcine heart valves even without trans-illumination. The height of the rough zone and clear zone of the anterior and posterior leaflet was 8.2 mm, 7.92 mm and 7.48 mm and 7.70 mm.

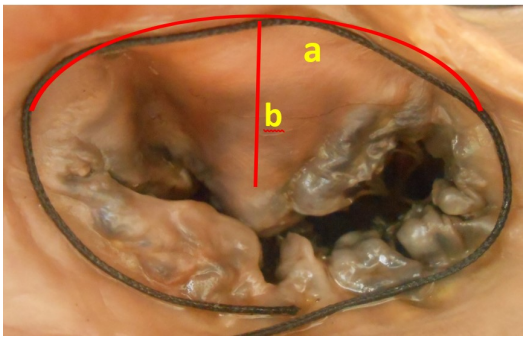

Fig. 1: Human Mitral Valve (Atrial Aspect)

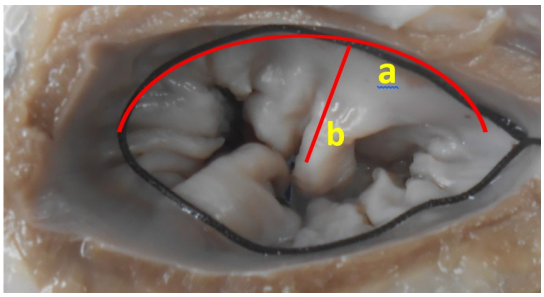

Fig. 2: Porcine Mitral Valve (Atrial Aspect)

In figure 1 & 2
a: attached margin of the mitral valve
b: height of the leaflet from the attached margin to the free margin

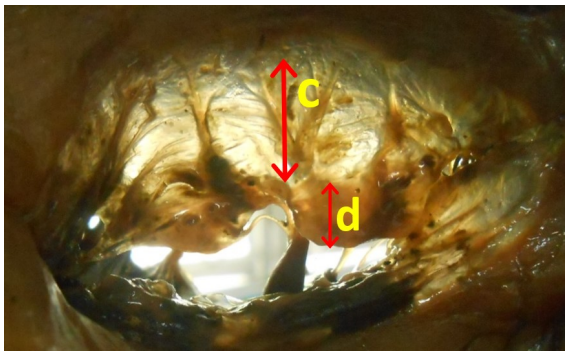

Fig. 3: Human Mitral Valve (Atrial Aspect)

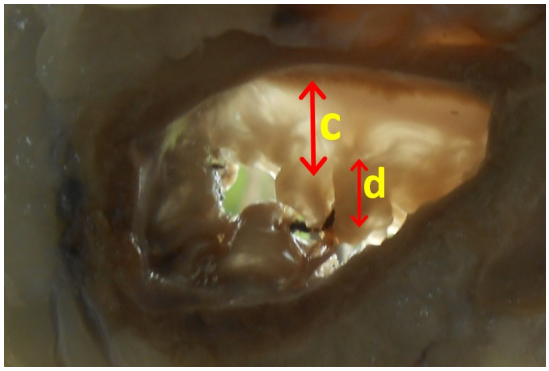

Fig. 4: Human Mitral Valve (Atrial Aspect)

Fig 3 & 4 c: height of the rough zone
d: height of the clear zone

Table 1: Mean value of the length and height of the tricuspid valve leaflet (human and porcine).

Measurements	Group	N	Mean	Std. Deviation	Std. Error Mean
Circumference of tricuspid valve	Human	20	106.6265	11079620	2.63771
	Porcine	20	97.4715	23.01495	5014630
Attached margin of anterior leaflet	Human	20	31.37	9046533	2011651
	porcine	20	31.444	11045097	2056052
Attached margin of the septal leaflet	Human	20	33.034	60.9353	1.55078
	porcine	20	37.5395	10.01145	2.23863
Attached margin of posterior leaflet	Human	20	20.0835	6.38712	1.4282
	porcine	20	24.0635	8.49637	1089985
Height of anterior leaflet	Human	20	15.838	4.68021	1.04653
	porcine	20	15.834	4.76454	1.06538
Height of septal leaflet	Human	20	12.258	4.40123	0.98414
	porcine	20	15.9165	5.28593	1.18197
Height of posterior leaflet	Human	20	11.791	2.97372	0.66494
	porcine	20	14.717	5.6783	1.26971

Table 2: The mean value of the rough zone and clear zone of the tricuspid valve leaflets (human and porcine).

Measurements	Group	No	Mean	Std. deviations	Std.Error mean
Rough zone of the anterior leaflet	Human	20	6.671	2.56482	0.57351
	Porcine	20	8.942	4.02945	0.90101
Rough zone of the septal leaflet	Human	20	6.692	2.01844	0.054134
	Porcine	20	8.051	2.65211	0.059303
Rough zone of the posterior leaflet	Human	20	5.694	3.13948	0.70201
	Porcine	20	7.2195	3.12.26	0.69771
Clear zone of the anterior leaflet	Human	20	8.194	3.72521	0.83298
	Porcine	20	7.0155	2.40804	0.53845
Clear zone of the septal leaflet	Human	20	5.536	3.00598	0.67216
	Porcine	20	7.992	2.8785	0.64365
Clear zone of the posterior leaflet	Human	20	5.4825	2.90022	0.64851
	Porcine	20	7.693	3.09536	0.69214

Table 3: Height, Length, Rough Zone and Clear Zone of the Mitral Valve of Human and Porcine.

Measurements	Group	N	Mean	Std. Deviation	Std. Error Mean
Circumference of mitral valve	Human	20	82.319	18.31201	4.09469
	Porcine	20	78.7945	23.81411	5.325
Attached margin of anterior leaflet	Human	20	29.02	6.4138	1.43417
	porcine	20	31.553	11.3409	2.5359
Attached margin of posterior leaflet	Human	20	38.7625	11.16654	2.49692
	porcine	20	40.0045	10.55644	2.36049
Height of anterior leaflet	Human	20	16.2655	3.06329	0.68497
	porcine	20	15.634	3.60834	0.80685
Height of posterior leaflet	Human	20	12.196	4.01588	0.89798
	porcine	20	14.813	3.87642	0.86679
Rough zone of the anterior leaflet	Human	20	6.5605	1.94076	0.43397
	Porcine	20	8.279	2.61481	0.58469
Rough zone of the posterior leaflet	Human	20	6.1215	2.39543	0.53566
	Porcine	20	7.485	2.22066	0.449655
Clear zone of the anterior leaflet	Human	20	9.7625	3.25097	0.72694
	Porcine	20	7.9285	2.17062	0.48536
Clear zone of the posterior leaflet	Human	20	5.738	2.61504	0.58474
	Porcine	20	7.7.15	2.57398	0.57556

CONCLUSION

The morphology of the human and porcine heart valve shared excellent features and they can be preferred in designing of the atrio ventricular valve substitutes and tissue engineering techniques in valve replacement surgeries. Although the morphometric differences are observed, this can be reduced to minimum by prior matching of the replacement valve with the tissue prosthesis to reduce the mismatching to the bare minimum.

Conflicts of Interests: **None**

Author Contributions

All the authors have contributed in designing the study and in the interpretation of the data collected. There was immense contribution from all the authors in the designing of the manuscript.

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