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Original Article

Anatomy Section

2D ECHO Study to Correlate Anthropometric Parameters and Dimensions of Semilunar Valves in Population of Telangana, India

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ABSTRACT

Introduction: Measurement of the aortic and pulmonary valve dimensions is critical in diagnosing stenotic diseases as well as preparation of prosthetic valves. A study of these valve dimensions in a normal population as well as comparing it with the built of a person could give us more insight to help prepare better prostheses and achieve better results after valve replacement procedures.

Aim: To study the diameters of semilunar valve annuli, correlate the values with the anthropometric parameters and establish the normal diameter values in the population of Telangana region.

Materials and Methods: A cross-sectional study was conducted on 100 subjects, in Osmania General Hospital, Hyderabad, Telangana, India, from October 2019 to September 2020, using 2-Dimensional Echocardiography (2D ECHO). The diameters of aortic and pulmonary valve annuli were measured. The weight and height of the patients were also recorded and Body Surface Area (BSA) was calculated. The results were then compared with the diameter of the aortic and pulmonary valve annulus to find any correlation between the two parameters using unpaired t-test in Microsoft Excel (version 2019).

Results: Out of the total 100 case,60 were male and 40 were females. A significant correlation was found between the weight of a person and the size of the aortic valve annulus (r-value=0.22, p-value=0.026). There was also a significant correlation between BSA and aortic valve annulus diameter (r-value=0.22, p-value=0.027). No correlation was found between weight or BSA and pulmonary valve annulus diameter (r=0.12 and 0.15 respectively). No correlation was found between the height of a person and the diameter of either of the semilunar valves (r=0.10 for arotic value and r=0.17 for pulmonary value).

Conclusion: The weight and BSA of a person can be used as an important parameter in making better fitting aortic valve prosthesis in cases of aortic valve diseases.

Keywords: Annulus, Aortic valve, Body surface area, Height, Pulmonary valve, Ultrasound, Weight

INTRODUCTION

The outlet of the right and left ventricles are guarded by the aortic and pulmonary valves, respectively [1]. Predicting the normal dimensions of the aortic valve annulus and the pulmonary valve annulus is important to cardiologists and cardiac surgeons [2]. Transcatheter Aortic Valve Implantation (TAVI) is usually done in cases of severe aortic stenosis. The most common limitation of this procedure is paravalvular aortic stenosis, which can be seen in more than 50% of the cases [3]. Appropriate annular measurements and sizing of the prosthesis are critical to minimise paravalvular aortic stenosis. A 2D Echocardiography (2D-ECHO) is usually used for this purpose [3].

The pulmonary valve can also be affected by a wide variety of pathologic processes, such as PV atresia, insufficiency, stenosis, unicuspid, bicuspid, or quadricuspid arrangements. A prosthetic pulmonary valve may be used depending on various factors such as size and function of the right ventricle along with the extent of the patient's symptoms [4].

Size of prosthesis is critical to prevent paravalvular aortic regurgitation, especially in patients undergoing TAVI, where there is high occurrence of paravalvular aortic regurgitation [3]. The results found would add a level of confidence for the surgeon in selecting the most beneficial prosthetic valve for each individual case based on the anthropometric data of the patient. The normal baseline values established by the study will also help the companies manufacturing the prosthetic valves to create better fitting prosthetics in the Telangana region.

Previous studies correlated the size of aortic and pulmonary valves with various anatomical variables like height, weight, age, sex, and BSA [2,5,6]. These studies had different population bases, sample sizes, measurement techniques but the results showed a similar relation between the built of a person and the size of the annuli. However, the results showed some quantitative variation which warrants further study. Furthermore, most of these studies were done in United States of America and there aren't any such studies done in Telangana region [2,4,10]. The present study examines the relation of height, weight, and the BSA of a person to the size of aortic and pulmonary valve annuli in 100 adult hearts and correlation between these parameters.

MATERIALS AND METHODS

A cross-sectional study was conducted on patients who were attending Osmania General Hospital, Afzalgunj, Hyderabad, Telangana, India, for normal check-up, during the period of October 2019 to September 2020. The Ethical clearance was taken from the Institutional Ethics Committee of Osmania Medical College, Hyderabad, India, (with Reg. No. ECR/300/Inst/AP/2013/RR-19). Informed consent was obtained from the patients after explaining, the purpose and method of study in their mother tongue/language of fluency.

Inclusion criteria: Patients without any known cardiac illness, who visited the Osmania General Hospital for regular check-up, in-patients for non cardiac illnesses, and patients who had visited the hospital for preoperative check up for non cardiac illnesses which required 2D ECHO as a prerequisite were included in the study.

Exclusion criteria: Patients with pre existing cardiac problems and pathological semilunar valves such as aortic valve stenosis, aortic valve regurgitation, pulmonary valve stenosis, pulmonary atresia, pulmonary valve regurgitation etc., were not included in the study. Patients with systemic diseases like diabetes mellitus and hypertension, patients with congenital or acquired heart diseases. Patients who underwent cardiac surgeries in the past, seriously

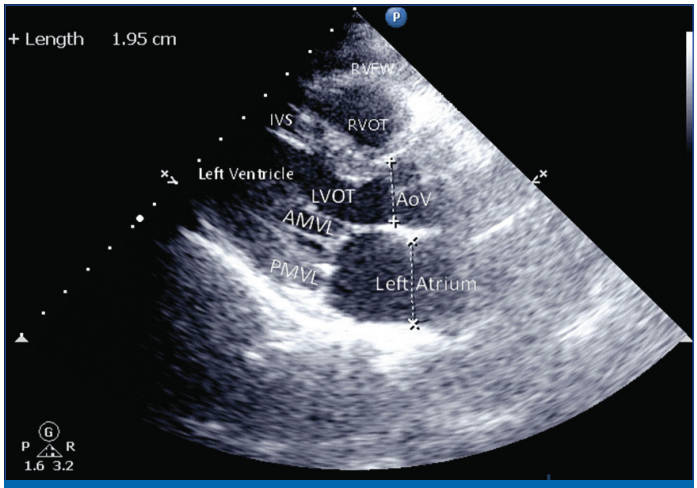
ill patients with multiorgan dysfunction, pregnant women and individuals less than 18 years were excluded from the study.

Sample size calculation: The study was carried on a total of 100 subjects, as done in the previous studies by Tacy TA et al., and Silver MA and Roberts WC [7,8].

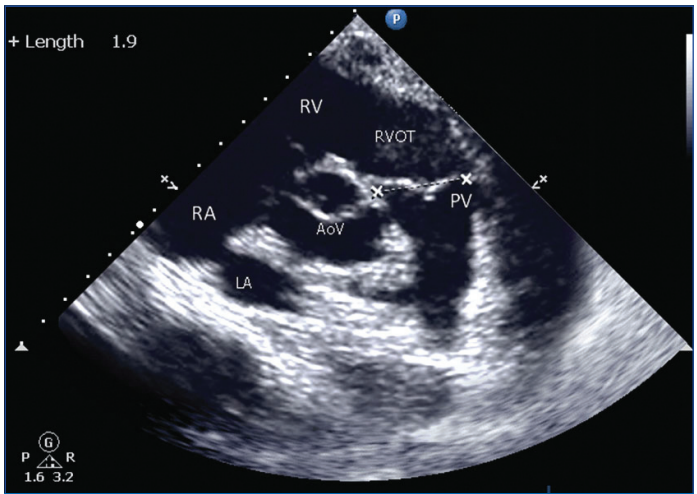
Procedure

The echocardiographic studies were performed using the Philips IE 33 Tokyo echocardiographic machine with a transducer capacity of 5 Mega Hz. The patient was made to lie comfortably on the bed in the left lateral position with the head elevated at 30 degrees and the left upper limb raised above the head.

This dimensions of the aortic valve and pulmonary valve annulus were measured in long-axis and short-axis view [Table/Fig-1,2]. The measurement was taken in centimeters and tabulated along with the patient details including the weight of the patient in kilograms and height of the patient in centimeters [Table/Fig-3]. The BSA was then calculated for each of the patients using the Mosteller formula, √ {(height in cm×weight in kg)/3600} [11] and the analysis of the data was done.



[Table/Fig-1]: Parasternal long-axis view showing the measurement of the aortic valve annulus diameter.
AoV: Aortic valve annulus; AMVL: Anterior mitral valve leaflet; PMVL: Posterior mitral valve leaflet; LVOT: Left ventricular outflow tract, IVS: Inter ventricular septum; RVOT: Right ventricular outflow tract; RVFW: Right ventricular free wall



[Table/Fig-2]: Parasternal short-axis view showing the measurement of the aortic valve annulus diameter.
RV: Right ventricle, RVOT: Right ventricular outflow tract; RA: Right atrium; AoV: Aortic valve annulus; PV: Pulmonary valve annulus; LA: Left atrium

STATISTICAL ANALYSIS

The data were analysed using unpaired t-test in Microsoft Excel (version 2109). Mean, standard deviation, Pearson's coefficient and p-value were then calculated for each of the parameters. The p-value of less than 0.05 was considered statistically significant.

Parameters	Mean±SD	Correlation with aortic valve annulus		Correlation with pulmonary valve annulus		
		r-value	p-value	r-value	p-value	Correlated
Weight	70.76±12.82 kg	0.22	0.026	0.12	0.223	No
Height	162.38±9.52 cms	0.10	0.307	0.17	0.089	No
Body surface area	1.78±0.19 SD m^2	0.22	0.027	0.15	0.13	No

[Table/Fig-3]: Correlation between morphometric parameters and valve diameters using Pearson correlation coefficient.

RESULTS

The present study was done on healthy subjects in the age group of 25-82 years. The mean age of the subjects was 49 years. Out of total, 60 were males and 40 were females. The mean weight of the subjects were found to be 70.76±12.82 kg. The mean height of the subjects was found to be 162.38±9.52 cm. The mean BSA was found to be 1.78±0.19 m^2. The mean aortic valve annulus diameter was found to be 2.21±0.37 cm. The mean pulmonary valve annulus diameter was found to be 1.87±0.28 cm.

Significant correlation was found between the weight of a person and the diameter of the aortic valve annulus (p-value <0.026). Significant correlation was also found between the BSA and the diameter of the aortic valve annulus (p-value <0.05). No significant correlation was found between the heights with aortic or pulmonary valve annulus diameter (p-value=0.307 and p-value=0.089). There was also no correlation between the weight of a person and the diameter of the pulmonary valve annulus (p-value=0.223), and BSA of a person and the pulmonary valve annulus diameter (p-value=0.13) [Table/Fig-3].

DISCUSSION

In the present study, a significant correlation was found between the weight, BSA, and the diameter of the aortic valve annulus. These results are similar with the study done by Capps SB et al., Vasan RS et al., and Campens L et al., [2,5,9]. From their study, Tilea I et al., concluded that a thorough knowledge of the anatomy of the aortic valve and its relationships is essential to understand the aortic valve pathology and many congenital cardiac malformations, and it is also crucial for diagnosis and treatment (both surgical and conservatory) of aortic valve pathology [12].

Artificial valve replacement is most commonly performed for the aortic and mitral valves. The valves used may be either biological or mechanical [10]. From the current study, we can infer that, whenever a patient needs prosthesis for the replacement of aortic valve, weight as well as BSA of the patient should be considered when preparing the size of the prosthesis. Since, the average weight of the person in the study was 70.76±12.82 kg and the mean aortic valve annulus size was 2.21±0.37 cm, heavier patients needing valve replacement should have a bigger aortic valve and vice versa. Similarly, the mean surface area was found to be 1.78±0.19 m^2 in this study, so the patients having more BSA should be provided with bigger diameter aortic valve prosthesis. Instead of relying on a single factor, if both the weight and body surface are taken into consideration while preparing the prosthesis, the postoperative results would be better. Appropriate prosthetic sizing is critical in minimising the incidence of paravalvular aortic stenosis, which is found in at least 50% of the patients who undergo TAVI [3].

There was no significant correlation between the height of a person and the diameter of the aortic valve annulus. These findings were similar to those from the study by Campens L et al., [9] but differed from the study by Capps SB et al., and Vasan RS et al., [2,5]. However, in the study by Vasan RS et al., height correlated with the aortic root dimension only in men. In women, no correlation was found between the height of a person and the aortic root dimensions. These findings are similar to the present study though. The study by Capps SB et al., was done on donated cadaver hearts and not

on living subjects, this along with the variation in the geographical location, general built, difference in diets and cultures of the subjects could be a reason for the difference in the findings [2].

Unlike the findings of Capps SB et al., and Gentle A et al., no correlation was found between the weight, height, BSA of a person, and the diameter of the pulmonary valve annulus [2,13]. This variation in findings can also be attributed to the differences in sample collection. Capps SB et al., used donated cadaver hearts for the measurement of pulmonary valve and correlated it with the height of the person written in the donor chart. Unlike the present study, Gentle A et al., used Computed Tomography Coronary Angiography (CTCA) to measure the diameter of the pulmonary valve. This difference in the collection of samples, along with the general built of population being studied could be the reason in the variation in findings between the present study and the previous studies [Table/Fig-4] [2,5,9,13].

Study	AV and weight correlation	AV and height correlation	PV and weight correlation	PV and height correlation
Present study	Yes	No	No	No
Campens L et al., [9], (2014, New York, USA)	Yes	No	Not compared	Not compared
Vasan RS et al., [5], (1995, Boston, USA)	Yes	Yes	Not compared	Not compared
Capps SB et al., [2], (2000, Okhlahoma, USA)	Yes	Yes	Yes	Yes
Gentle A et al., [13], (2019, Glasgow, UK)	Not compared	Not compared	Not compared	Yes

[Table/Fig-4]: Comparision of the current study with previous studies [2,5,9,13].
AV: Aortic valve; PV: Pulmonary valve

From the above findings, it can be inferred that in creating an aortic valve prosthesis, the weight and surface area of a person must be taken into consideration. This can be used clinically to prevent valve regurgitation after valve replacement surgery by preparing a better prosthesis based on the weight and body surface of the patient in cases needing aortic valve replacement. The height of a person does not correlate but will still be needed to measure to calculate the BSA using Mosteller formula [11]. However, in the case of pulmonary valve, these anthropometric parameters are of little value, at least in the selected population.

Limitation(s)

The present study was done using real-time 2D ECHO, measurement using computed tomography would have been a more accurate option, but due to financial constraints, authors conducted this study with 2D ECHO. This study was conducted on healthy adults only, since the correlation is different in children and adults, a similar study in the children of the same population would be very useful. The present study is a cross-sectional study done in a single center on a limited number of subjects with all the studies done by a single observer. Parameters like sex, age, mitral valve, tricuspid valve, sizes of the chambers were not included into account while doing the statistical analysis to avoid complications. Further studies with large sample size more parameters such as sex, age, mitral and tricuspid valves, sizes of right and left atria and ventricles, etc., can be done in the future to outcome these limitations.

CONCLUSION(S)

From the present study, it can be concluded that there is a significant correlation between the size of the aortic valve and the weight and BSA of the person. Pulmonary valve on the other hand doesn't correlate with the anthropometric parameters like height, weight, or BSA. Hence, while creating an aortic valve prosthesis, weight and BSA must be considered, and the diameter of the prosthesis should be adjusted to create a more functional prosthesis.

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