Original article

Dimensions of the human adult mitral valve in the embalmed cadaver

Gupta, C.[1]*, Shetti, VR.[1] and Manju, BVM.[2]

[1]Assistant Professor, Department of Anatomy, Kasturba Medical College, Manipal University, Manipal India, 576104
[2]Assistant Professor, Department of Anatomy, Kasturba Medical College, Manipal University, Manglore India, 575004
*E-mail: chandnipalimar@gmail.com

Abstract

Objectives: In human heart left atrioventricular orifice is guarded by mitral valve, which lies at the junction of the left atrium and the left ventricle of the heart controlling and directing unidirectional blood flow during ventricular diastole. Irrepairable damage to the mitral valve calls for its replacement using either a valve made up of biological tissue or metal, pyrolytic carbon, vulcanised silicon rubber and similar materials. Prostheses of these synthetic valve needs detailed knowledge of mitral orifice and valve dimensions. In the present study an attempt was made to study the dimensions of mitral orifice and mitral valve in formalin fixed adult human heart specimens. **Methods:** Mitral orifice was cut opened in these specimens and photographed with a scale. This image was used for Scion image analysis for measurement of (i) Length of free margin and area of each leaflet, (ii). Inner circumference of the mitral valve and (iii) Surface area of the mitral valve leaflets. **Results:** It was found that circumference of annulus of mitral valve was 8-10 cm, length of free margin of anterior leaflet was 5-7 cm, length of free margin of posterior leaflet was 7-9 cm, area of anterior leaflet was 1-3 cm^2, and area of posterior leaflet was 2-4 cm^2. **Conclusion:** These data may be useful in designing the prosthetic valves.

Keywords: human mitral valve, prostheses, measurements.

1 Introduction

Mitral orifice is a well-defined zone between the atrial wall and bases of the leaflets. Mitral valve consists of an orifice with its supporting annulus, leaflets, chordae tendinae and papillary muscles (LAWRENCE, BERRY, COLLINS et al., 1992). Mitral annulus is an area where muscular fibres of atrium and the ventricle are attached. Two fibrous trigones are attached to the mitral annulus (ARTHUR, GEHA, HAMMOND et al., 1992). Mitral valve consists of two leaflets – anterior and posterior. When the valve is open, the anterior leaflets cover one-third of the circumference of orifice and is semi-circular or triangular in shape. Posterior leaflet has two or more indentations which divide it into a large middle scallop and a two small anterolateral and posterolateral commissural scallop.

There are many diseases of heart which affects the valves like stenosis and regurgitation of valves or prolapse of the leaflets which result in valve insufficiency. These diseases require repair of the valve and when repair is not possible due to severe damage as in cases of endocarditis, rheumatic valve diseases or dysplastic valve pathology, valve replacement surgery will be attempted (GOPAL, TAHA, JOHN et al., 2006). Valve replacement is a cardiac surgical procedure in which a patient's mitral valve is replaced with a prosthetic heart valves. The artificial valve may be 1) A metal or mechanical valve, 2) Tissue valve or biological valve (CATHERINE, LENEHAN and GINSBURG, 1999). Mechanical valves are made up of 1) Stainless steel alloys, 2) Molybedenum alloys, 3) Pyrolytic carbon, 4) Silicon, Teflon, 5) Polyester (dacron).

Tissue heart valves can be either homograft (allograft) in which human cadaveric valves (mitral, pulmonary) are taken and transplanted in the diseased person. Tissue valves can also be autograft in which the patient pulmonary valve (Ross procedure), fascia lata or pericardium is taken and transplanted in the diseased person (BULKLEY and ROBERTS, 1975). Tissue valve can be heterograft (xenograft) in which porcine mitral or bovine pericardial tissue is taken and transplanted in the diseased person.

For better selection of prostheses the exact anatomy of valve is needed. However there are only a few studies on the measurement of mitral valve and its leaflets, using conventional, manual methods. Aim of the present study was to measure the 1) Circumference of the annulus of mitral valve, 2) Length (perimeter) of the free margin of anterior leaflet, 3) Length (perimeter) of the free margin of posterior leaflet, 4) Area of anterior leaflet, 5) Area of posterior leaflet, 6) Total Area of mitral valve leaflets using Scion image software.

2 Material and methods

In this study 18 adult cadaveric isolated hearts (formalin fixed) were examined. These hearts belonged to age group of 40-60 years. Mitral valve are laid open by giving a lateral incision on the ventricle to view the leaflets (Figure 1). It was photographed along with a scale, using a sony digital camera. These digital images were reduced to 4'' × 6'' size and saved as bitmap (bmp) images. These bmp images were opened in the scion image programme (www.scioncorporation.com) for image analysis in the computer. The bmp images were opened individually in the scion image programme, and the programmme was calibrated using the scale on the image. Using this programme, the measurements were taken 1) Circumference of the annulus of mitral valve, 2) Length (perimeter) of the free margin of anterior leaflets, 3) Length (perimeter)of the free margin of posterior leaflets, (Figure 2a), 4) Area of anterior leaflet, 5) Area of posterior leaflet, 6) Total area of mitral valve was measured (Figure 2b). Data was copied into graph pad in Stat statistical software for calculating the mean measurements. Data was expressed as Mean ± SEM, and percentage.

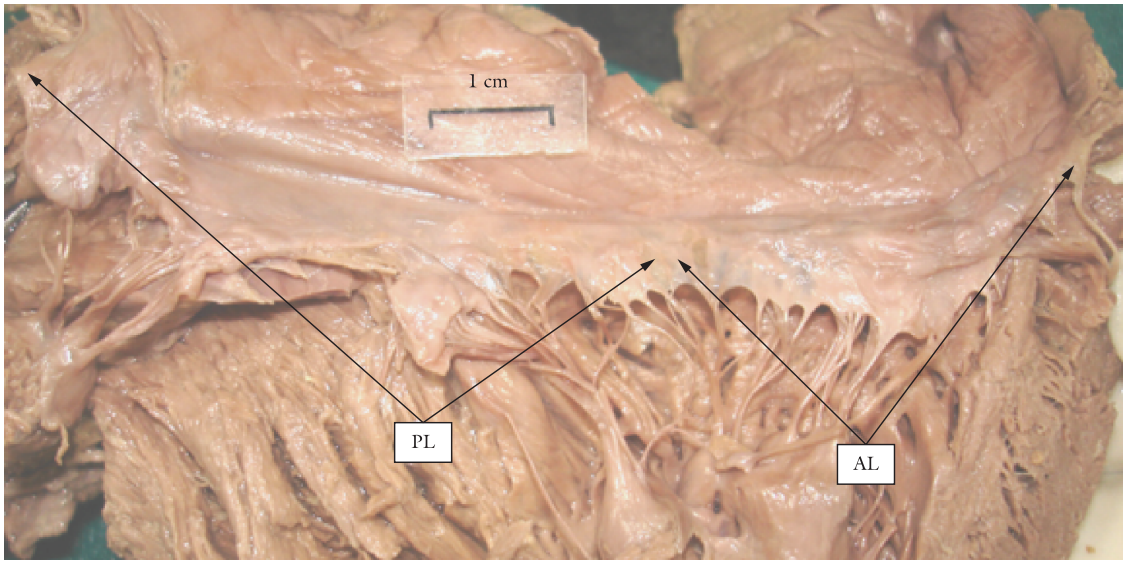

Figure 1. Mitral valve opened to measure the inner circumference, length of free margin of each leaflet and area of each leaflet. PL – posterior leaflet, AL - anterior leaflet.

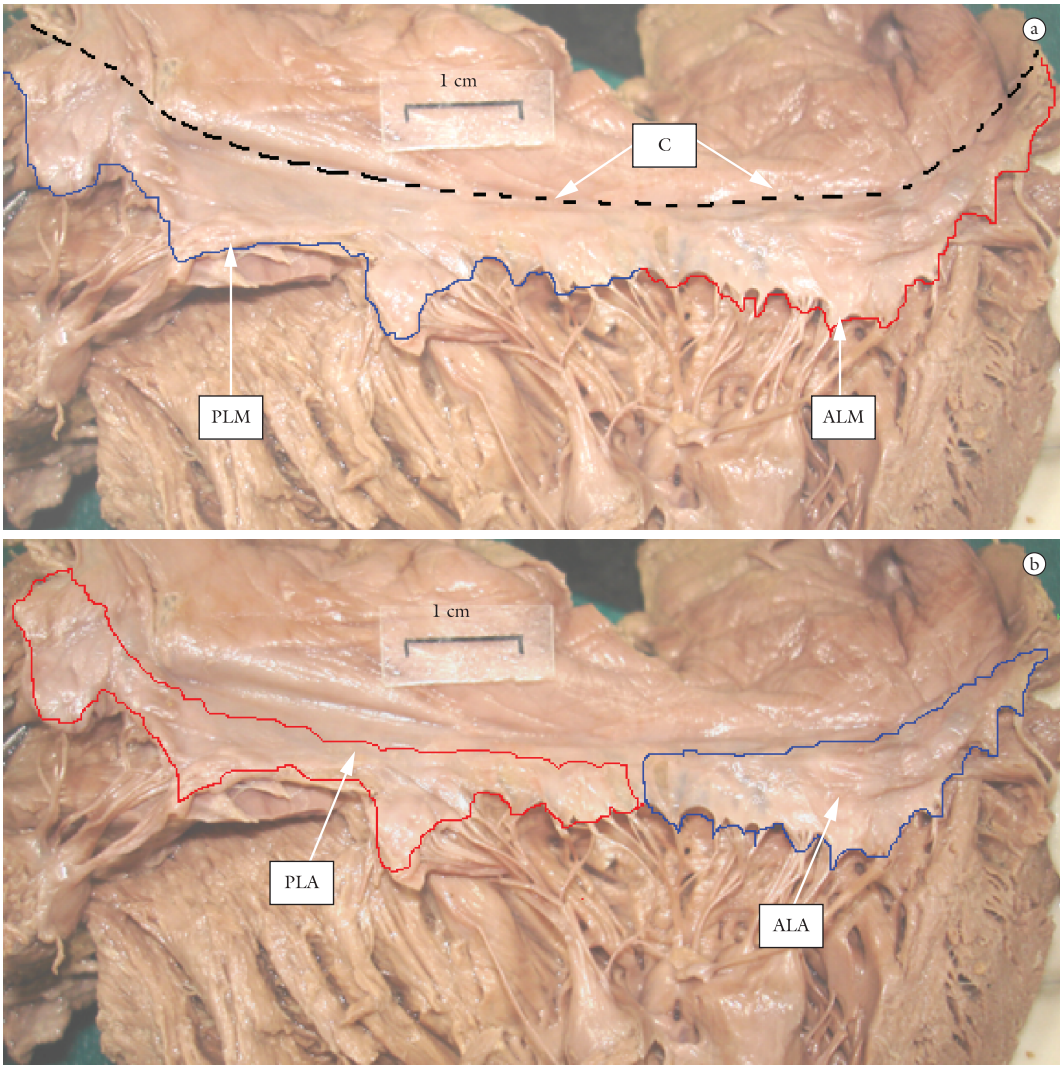

Figure 2. Mitral Valve opened a) Shows line of inner circumference measurement and length of free margin of anterior and posterior leaflets. b) Shows the area of anterior and posterior leaflets. C - Inner circumference, PLM - Posterior leaflet margin, ALM - anterior leaflet margin, PLA - Posterior leaflet area, ALA - anterior leaflet area.

3 Result

3.1 Circumference of mitral valve

Mean circumference of the mitral valve was found to be 9.11 ± 0.44 cm (Mean ± SEM, n = 18, Figure 3a). In 7% of the cases, circumference was in the range of 6-8 cm (1 specimen, Figure 3d) or 12-14 cm (1 specimen) in length. In Majority of cases circumference was 8-10 cm (57%, 10 specimen). In rest of the cases (29%, 6 specimens) circumference was found to be 10-12 centimeters.

3.2 Length of the free margin of anterior leaflet

Mean length the free margin of the anterior leaflet was 5.6 ± 0.21 cm (n = 18, Figure 3a). In 78% of cases (14 specimens), length was in the range of 5-7 cm, and in the rest (22%, 4 specimens), it was 3-5 cm (Figure 3b).

3.3 Length of the free margin of posterior leaflet

Mean Length of the posterior leaflet was 8.89 ± 0.43 cm (n = 18, Figure 3a). In 11% of the cases (2 specimens) free margin length of posterior leaflet was in the range of 5-7 cm, in 44% of cases (8 specimens), it was 7-9 cm, in 33% of cases (6 specimens) it was 9-11 cm and rest 11% it was 11-13 cm in length (Figure 3c).

3.4 Area of anterior leaflet

Mean area of the anterior leaflet was 3.23 ± 0.25 cm^2 (Figure 4a). In 50% of the cases (9 specimens) area of anterior leaflet was in the range of 1-3 cm^2, in 39% of cases (7 specimens) it was 3-5 cm^2, and in 11% of cases (2 specimens) area was in the range of 5-7 cm^2 (Figure 4b).

3.5 Area of posterior leaflet

Mean area of the posterior leaflet was 4.14 ± 0.34 cm^2 (Figure 4a). In 50% of the cases (9 specimens) area of posterior leaflet was in the range of 2-4 cm^2, in 39% of cases (7 specimens) it was 4-6 cm^2, and in 11% of cases (2 specimens) area was in the range of 8-8 cm^2 (Figure 4b).

3.6 Total area of the valve leaflets.

Total area of anterior and posterior leaflets was found to be 7.37 ± 0.44 cm^2 (Figure 4a). In 55% of cases (10 specimens) total area was in the range of 5-7 cm^2, in 22% of cases (4 specimens) it was 7-9 cm^2, in 17% of the cases (3 specimens) total area was in the range of 9-11 cm^2, and in 6% of cases it was in the range of 11-13 cm^2 (Figure 4d).

4 Discussion

Observations about mitral valve show variable findings depending upon method used. In 2D Echocardiography method mitral leaflets and their annular attachments were noted during the cardiac cycle, the present study done by dissection method mitral leaflet and annular attachment demonstrated in cadaveric hearts.

Present study revealed the dimensions of mitral valve and leaflet length and area using the scion image analysis software. Andrade, Tinois, Vieira et al. (2005) measured the dimensions of mitral valve, tricuspid valve and left ventricle

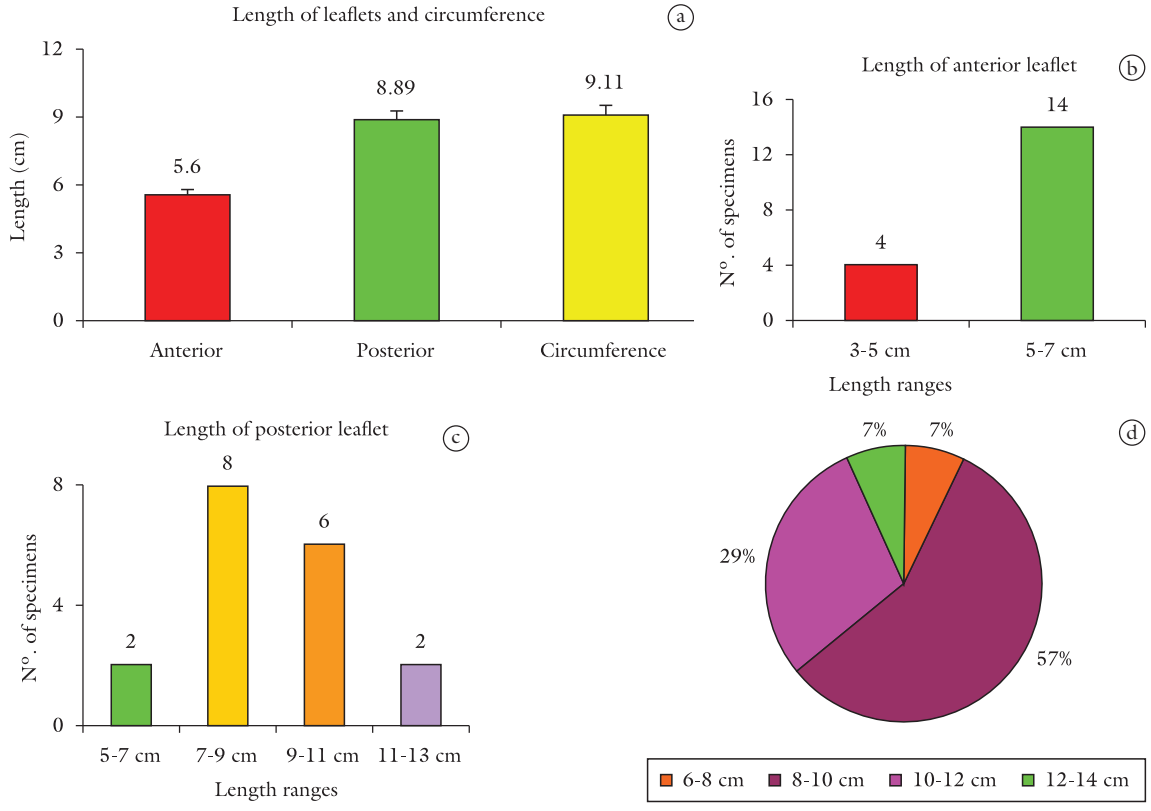

Figure 3. a) Mean length of free margin of the leaflets and inner circumference of mitral valve, b) Number of anterior leaflets having different length ranges, c) number of posterior leaflets having different length ranges, d) Circumference of mitral valve.

using software specially developed for the project. The software was developed in MATLAB.

The circumference of the mitral valve in this study (9.1 ± 0.44 cm) corresponds with values reported by Sakai, Okita, Ueda et al. (1999), Brock (1952), Bulkley and Roberts (1975), Rusted, Scheifley and Edwards (1952) (both male and female), Chiechi, Lee and Thompson (1956) (both male and female), Patil, Mehta and Prajapati (2009) by dissection method, Du Plessis and Marchand (1964), Andrade, Tinois, Vieira et al. (2005) (fresh hearts) and Ormiston, Shah, Tei et al. (1981) (9.3 ± 0.9 cm) by 2D echocardiographic method but significantly lesser than findings of McAlpine (1975) using dissection method (Table 1).

Kitzman, Scholz, Hagen et al. (1988) reported that mean valve circumferences were usually higher in men than in women, but the opposite pertained when values were indexed by body surface area. In both sexes, all indexed mean valve circumferences increased progressively during the course of adult life, although this trend was greater for semilunar than for atrioventricular valves.

Our measurements on area of mitral valve 7.37 cm² did not correspond with the values reported by Andrade, Tinois, Vieira et al. (2005) (4.72 cm²), Evangelista, Del Castillo, Gonzalez-Alujas et al. (1996) (4.1 ± 0.6 cm²) and Singh and Mohan (1994) by direct planimetry was 3.37 ± 1.13 cm²

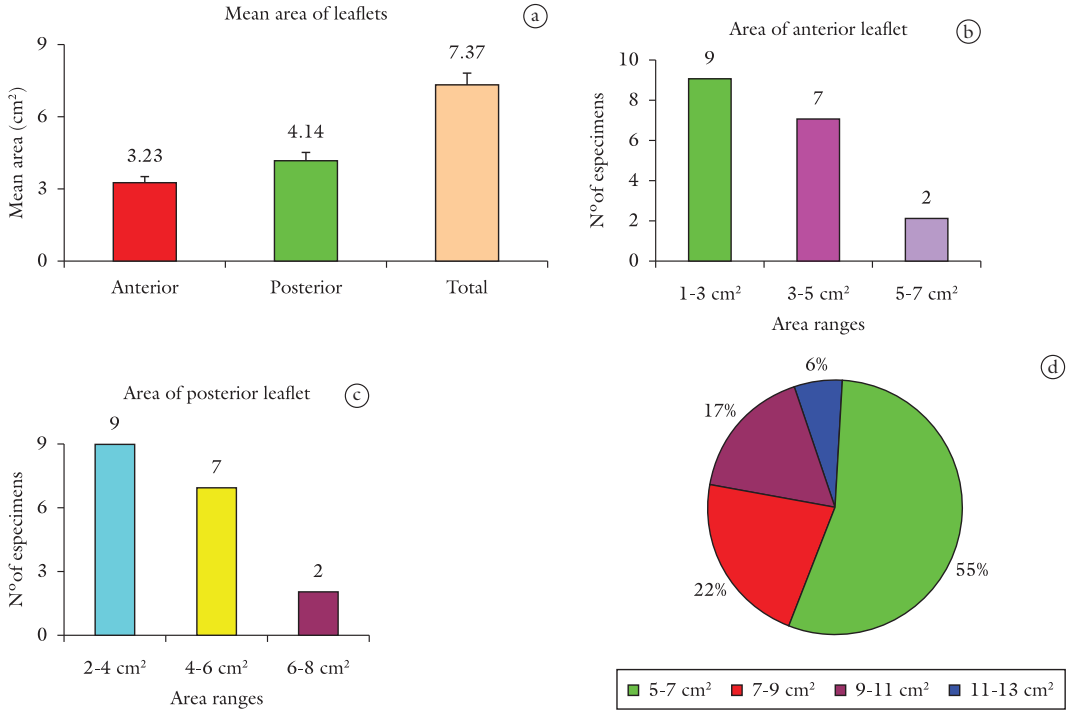

Figure 4. a) Mean area of leaflets, b) Number of anterior leaflets having different area ranges, c) number of posterior leaflets having different area ranges, d) Total area of mitral valve.

Table 1. Comparision of circumference of mitral valve with other studies.

Sr no.	Circumference of mitral valve (cm)
Dissection method (formalin preserved)	
Present study (2012)	9.1 ± 0.44
Patil, Mehta and Prajapati (2009)	8.248
Rusted, Scheifley and Edwards (1952)	9.9 (8.5-11.0) Male 8.5 (7.5-10.5) Female
Sakai, Okita, Ueda et al. (1999)	9.33 ± 1.1
Chiechi, Lee and Thompson (1956)	10 (8.5-11.5) Male 9 (8-10.5) Female
Bulkley and Roberts (1975)	9 (7-11)
Brock (1952)	10.05
McAlpine (1975)	13.4 (diastolic state heart perfusion fixation)
Dissection method (fresh hearts)	
Du Plessis and Marchand (1964)	10.1
Andrade, Tinois, Vieira et al. (2005)	7.92
Two-dimensional echocardiography method	
Ormiston, Shah, Tei et al. (1981)	9.3 ± 0.9

which is due to that they has done studies on fresh hearts and we have done the studies on formalin preserved hearts.

Mean area of anterior leaflets in present study (3.23 ± 0.25 cm^2) was similar to Andrade, Tinois, Vieira et al. (2005) (2.94 cm^2) but mean area of posterior leaflets in our study was 4.14 ± 0.34 cm^2 and in Andrade, Tinois, Vieira et al. (2005) was 1.74 cm^2.

In our study we have also measured length of free margin of anterior and posterior leaflet which no other authors have mentioned and which can help to make prosthesis of exact size of the valve.

Brownlee and Yates (1971) design valve from autologous fascia lata. Great horizontal mobility of the mitral annulus shows a considerable role in its function. The mitral annulus is not flat but oblique in the antero-posterior direction. It would, thus, seem required to eliminate the wide, round, flat, and rigid sewing ring integral to all currently used mitral valve replacements. If the valve leaflets could be sewn directly to the mitral annulus, 1 cm or more effective flow orifice diameter would be increased over those valve replacement techniques using a rigid sewing ring. Moreover, a bicuspid valve whose cusp tip orifice diameter exceeds that of the inlet diameter would abolish stenotic turbulent flow during diastole.

Vander Spuy (1964) found that the thorough anatomical and functional features are essential in the construction of an entirely anatomical whole mitral valve from autogenous tissues. We can use data assessed by us for manufacturing of these valves.

Du Plessis and Marchand (1964) stated that data on the dimensions of the valve may be of interest to surgeons and will help them to assess the exact mechanical reason for valve insufficiency.

The study which we have done will help in choice of prosthesis for replacement. The parameters which we have taken will help in finding the correct size of prosthesis for a valve replacement which will accurately fit in the valve orifice in a person. The parameters which we have measured using scion image software are more accurate than manually done. In Andrade, Tinois, Vieira et al. (2005) study they have used their own software which others can't use. Future implication of the study includes survey of larger sample and comparison with embalmed specimens and a radiological survey.

References

ANDRADE, NMM., TINOIS, E., VIEIRA, RW., BRAILE, DM., PETRUCCI JUNIOR, O., OLIVEIRA, PPMD. and SILVEIRA FILHO, LD. Coefficient of proportions of the atrioventricular valves- An anatomical study of valvular segments of normal individuals. *Brazilian Journal of Cardiovascular Surgery,* 2005, vol. 20, n. 3, p. 255-260.

ARTHUR, EB., GEHA, AS., HAMMOND, GL., LAKS, H. and NAUNHEIM, KS. *Glenn's thoracic and cardiovascular surgery*. 6th ed. 1992.

BROCK, RC. The surgical and pathological anatomy of the mitral valve. *British heart journal*, 1952, vol. 14, n. 4, p. 489-513. PMid:12987528 PMCid:503827. http://dx.doi.org/10.1136/hrt.14.4.489

BROWNLEE, RT. and YATES, AK. A fascia lata mitral valve based on the 'frustum' principle. *Thorax*, 1971, vol. 26, p. 284-7. PMid:5089493 PMCid:1019083. http://dx.doi.org/10.1136/thx.26.3.284

BULKLEY, BH. and ROBERTS, WC. Dilatation of the mitral anulus. A rare cause of mitral regurgitation. *American Journal of Medicine*, 1975, vol. 59, n. 4, p. 457-63. PMid:1172652.

CATHERINE, OM., LENEHAN, A. and GINSBURG, V. *Textbook of Valvular Heart disease*. 2nd ed. 1999.

CHIECHI, MA., LEE, WM. and THOMPSON, R. Functional anatomy of the normal mitral valve. *Journal of Thoracic Surgery*, 1956, vol. 32, n. 3, p. 378-98. PMid:13358125.

DU PLESSIS, LA. and MARCHAND, P. The anatomy of the mitral valve and its associated structures. *Thorax*, 1964, vol. 19, n. 3, p. 221-7. PMid:14143500 PMCid:1018824. http://dx.doi.org/10.1136/thx.19.3.221

EVANGELISTA, A., DEL CASTILLO, HG., GONZALEZ-ALUJAS, T., GARCIA-DORADO, D., GUIX, M. and SOLER-SOLER, J. Normal values of valvular annular areas: comparison of the results of a necropsy and an echocardiographic series. Revista Española de Cardiología, 1996, vol. 49, n. 2, p. 111-6. PMid:8948720.

GOPAL, MR., TAHA, A., JOHN, V., SUNNY, Z., ADIL, AL. and VENKATRAMAN. Pediatric valve replacement, 15 years' experience in oman. *Indian Journal of Thoracic and Cardiovascular Surgery*, 2006, vol. 22, p. 173-177. http://dx.doi.org/10.1007/s12055-006-0753-z

KITZMAN, DW., SCHOLZ, DG., HAGEN, PT., ILSTRUP, DM. and EDWARDS, WD. Age-related changes in normal human hearts during the first 10 decades of life. Part II (Maturity): A quantitative anatomic study of 765 specimens from subjects 20 to 99 years old. *Mayo Clinic proceedings,* 1988, vol. 63, n. 2, p. 137-46. http://dx.doi.org/10.1016/S0025-6196(12)64946-5

LAWRENCE, BH., BERRY, MM., COLLINS, P., DYSON, M., DUSSEK, JE. and FERGUSON, MWJ. *Gray's anatomy*. 39th ed. 1992.

McALPINE, WA. *Heart and Coronary Arteries*. New York: Springer Verlag, 1975. p. 12, 38, 47, 90. http://dx.doi.org/10.1007/978-3-642-65983-6

ORMISTON, JA., SHAH, PM., TEI, C. and WONG, M. Size and motion of the mitral valve annulus in man. I. A two- dimensional echocardiographic method and findings in normal subjects. *Journal of the American Heart Association Circulation*, 1981, vol. 64, p. 113-120.

PATIL, D., MEHTA, C. and PRAJAPATI, P. Morphology of Mitral valve in Human cadavers. *Internet Journal of Cardiology*, 2009, vol. 7, p. 2.

RUSTED, IE., SCHEIFLEY, CH. and EDWARDS, JE. Studies of the Mitral Valve. I. Anatomic Features of the Normal Mitral Valve and Associated Structures. *Circulation*, 1952, vol. 6, p. 825-31. PMid:12998105. http://dx.doi.org/10.1161/01.CIR.6.6.825

SAKAI, T., OKITA, Y., UEDA, Y., TAHATA, T., OGINO, H., MATSUYAMA, K. and MIKI, S. Surgery for a acquired cardiovascular disease, Distance between mitral annulus and papillary muscles : Anatomic study in normal human hearts. *Journal of Thoracic and Cardiovascular Surgery,* 1999, vol. 118, p. 636-641. http://dx.doi.org/10.1016/S0022-5223(99)70008-5

SINGH, B. and MOHAN, JC. Atrioventricular valve orifice areas in normal subjects: determination by cross-sectional and Doppler echocardiography. *International Journal of Cardiology*, 1994, vol. 44, n. 1, p. 85-91. http://dx.doi.org/10.1016/0167-5273(94)90071-X

VANDER SPUY, JC. Completely anatomical autogenous whole mitral valve. *Thorax*, 1964, vol. 19, n. 6, p. 526-9. PMid:14238390 PMCid:1018872. http://dx.doi.org/10.1136/thx.19.6.526

Received February 2, 2012
Accepted March 3, 2013