Chapter 6 DISCUSSION

6.1TRICUSPID VALVE

The TV is the largest of the four cardiac valves and its area is between 7 and 9 cm^2. The tricuspid annulus (TA) is an asymmetrical, saddle-shaped ellipsoid that is dynamic in nature, allowing it to change with varying loading conditions. The normal TV complex includes a fibrous annulus, usually three leaflets (anterior, septal, posterior), chordae tendinae, papillary muscles, RA myocardium, and RV myocardium.

6.1.1 Number of Tricuspid Cusps

Previous studies by J.C.Boileau Grant (1951), Chummy S. Sinnatamby12 (2006), Keith .L.Moore(1980), Stephen C . Yang, Duke .E .Cameron51 (2004), R .Wayne Alexander et al(1998) , Susan Standring (2005), B.N Vijaya Ragava Roa(2007) mentioned that tricuspid valve has 3 valves namely Anterorsuperior, Posterior and Septal .

In recent studies authors mentioned that tricuspid valve vary in number of leaflets from 2 to 7 due to presence of accessory leaflets.

Wafae N et al (1990) stated that the tricuspid valve was not consistently tricuspid , but was observed to present 2 , 4 , 5 , or 6 cusps in 72 % of cases T. Ikegaya et al (1991) stated that during necropsy of a 59 years old women of heart failure he found the tricuspid valve has six leaflets. Sutton J P et al (1995) stated that the fifty hearts were studied the majority of specimens (62%) had readily identifiable leaflets, but some (30%) having two leaflets, 8% had four leaflets.

L.R.Gerola et al (2001) stated that the number of cusps varied from two to four. Three cusps was the commonest finding and the fourth cusp , if present, was classified as anterolateral in location.

Aytac Kocak et al (2004) studied that in fourty hearts they found two leaflets (20%), in 140 hearts (70%) three leaflets and in twenty hearts there were four leaflets (10%) in deaths of non cardiac origin. They also found two leaflets in 36 hearts (18%),

three leaflets in 130 hearts (65%) and there were four leaflets in 34hearts (17%) in deaths of cardiac origin.

Lapenna E et al (2008) reported a case of a 52 year old man of severe mitral and tricuspid regurgitations of Barlow's disease he found that tricuspid valve was "four leaflet valve" due to the presence of a small accessory leaflet between the septal and posterior leaflets.

In the study by S.Satish Kumar (2011) number of leaflets varied from 3 to 6.Three leaflet were found in 36 (80%) of hearts ,4 leaflets were found in 6 (13.3%) hearts and 5 leaflets were found in 1 (2.2%) heart. 6 leaflets were found in 2 (4.4%) hearts.

In the present study out of total 100 specimens, an additional cusp (four cuspidial) was found in 8 specimen and missing cusp (Bicuspidial) in 2 specimens.

In one specimen single cusp was found which was extending along the entire peripheral margin of annulus, such cases were also reported by Sunita Athavale (2017) in 6 specimens.

The presence of an accessory cusp may lead to the obstruction of atrioventricular outflow tract. The knowledge of accessory or missing cusp in atrioventricular valves is necessary for cardiac surgeons.

Table: 6.1 Frequency of Number of Tricuspid Leaflets

Authors	Sample Size	1 Cusps	2 Cusps	3 Cusps	4 Cusps	5 Cusps	6 Cusps
Sutton J P et al (1995)	50	-	30% (15)	62% (31)	8% (04)	-	-
Aytac Kocak (2004)	200	-	20% (40)	70% (140)	10% (20)	-	-
S.Satish Kumar (2011)	45	-	-	80% (36)	13.3% (6)	2.2% (1)	4.4% (2)
Krunal (2014)	100	-	1% (01)	89% (89)	10% (10)	-	-
Parmatma P. Mishra (2016)	120	-	5.83% (7)	51.66% (62)	29.16% (35)	8.33% (10)	4.16% (5)
Sunita Athavale (2017)	36	16.66 % (06)	72.22% (26)	11.11% (4)	-	-	-
Present Study (2023)	100	1% (01)	2% (2)	89% (89)	8% (8)	-	-

6.1.2 Shape Of Cusps Of Tricuspid Valve

Silver MD et al (1971) reported that anterior leaflet was semicircular, but may be quadrangular in shape. The posterior leaflet had several indentation or clefts, mostly semicircular in shape but it may vary and the septal leaflet is semi oval in shape.

Keith .L. Moore25 (1980) stated that the cusps were more or less triangular in outline.

Stephen C .Yang , Duke .E .Cameron (2004) stated that three leaflets of tricuspid valve are the septal , which is semicircular in shape. The anterior which is largest and nearly quadrangular , and the posterior which is usually the smallest , somewhat triangular in shape.

Aytac Kocak et al (2004) reported that in non-cardiac death cases the anterior leaflet was triangular in 100 case (95%), rectangular in 10 cases. The posterior leaflet was the smallest and it appeared as rectangular in 20 cases (10%), square in 20 (10%) , triangular in 160 (80%) cases. The septal leaflet appeared rectangular in 32 cases (16%), square in 12 (6%) and triangular in 156 (78%) cases.

In cardiac death cases the anterior leaflet was the largest component of the tricuspid valve and was triangular in 182 cases (91%), rectangular in 11 (5.5%) and square in 7(3.5%) cases. The posterior leaflet appeared as rectangular in 16 cases (8%) , square in 14 (7%) and triangular in 170 (85%) cases. The septal leaflet appeared rectangular in 28 cases (14%) ,square in 21 (10.5%) andtriangular in 151 (75.5%) cases.

Mohamed A . B. Motabagani (2006) reported that the gross examination of the human tricuspid valve of 10 heart showed, the anterior leaflet was always (100%) the largest , triangular . The posterior leaflet was the second in size and also triangular. It had either no cleft in 2 hearts (2%) or a single cleft in the remaining human hearts (80%). The septal leaflet of the human tricuspid valve was semicircular.

In the **study** by S.Satish Kumar (2011) all the 45 hearts anterior leaflets were triangular (100%) in shape and the posterior leaflets also triangular in all hearts (100%). The septal leaflets were triangular in 42 hearts (93.3%) and semicircular in 3 hearts (6.7%).

From table 6.2 it is clear that the most common shape observed among all the 3 cusps was triangular unlike other studies like Motabagani (2006), in which septal cusp was either semicircular or rectangular rather than triangular.

Our study findings were supported by the findings of the Aytac Kocak et al (2004), Paramatma P Mishra et al. Therefore, we could say that the most common type of shape for the cusp was triangular shape.

Table: 6.2 Shape Of Tricuspid Valve

Study	Cusp Of Tricuspid Valve	Triangular	D Shape	Rectangular	Missing Cusp
Parmatma P. Mishra (2017)	Anterior cusp	95% (114)	5% (06)	0	-
	Inferior cusp	92.5% (111)	1.67% (02)	0	5.83%(07)
	Septal cusp	97.5% (117)	0.83% (01)	0.83% (01)	0.83% (01)
	Accessory cusps	100%	0	0	-
Present study (2022)	Anterior cusp(n-100)	98% (98)	1.00% (01)	1.00% (01)	-
	Inferior cusp (n-97)	94.84% (92)	3.09% (03)	2.06% (02)	(03)
	Septal cusp (n-99)	93.94% (93)	3.03% (03)	3.03% (03)	(01)
	Accessory cusps (n-8)	87.50% (7)	12.50% (1)		

Variation in the shape of the cusp may result in incomplete closure of the valve, leading to regurgitation. Knowledge of variation in the shape of cusps will serve as a guideline to the cardiac surgeons. It will also help in designing the valve prosthesis.

6.1.3 Number Of Cleft & Scallops Present In Each Cusp

In our study, 90 specimens had Single Scallop no cleft present in anterosuperior cusp & septal cusp. Inferior cusp in 16 specimens had been observed with single cleft & double cleft in 13% and 3% specimen respectively. As there is a limited literature available for the occurrence of cleft, we could not comment on generalisation of our findings.

Table 6.3 Cleft & Scallops Presnt On Cusps Of Tricuapid Valve

Study	Cusp	No Cleft 1 Scallop	1 Cleft 2 Scallop	2 Cleft 3 Scallop	3 Cleft 4 Scallop
Sunita Athavale (2017)	Anterior cusp	(07)	(12)	(06)	(01)
	Inferior cusp	(02)	(01)	(00)	0
	Septal cusp	(15)	(05)	(03)	0
Noriyasu Kawada et al (2017)	Inferior cusp (27)	3.7% (1)	62.9% (17)	29.6% (8)	3.7% (1)
Present study (2022)	Anterior cusp (100)	90% (90)	10% (10)	0	0
	Inferior cusp (97)	83.50% (81)	13.40% (13)	3.09% (3)	0
	Septal (99) cusp	90.9% (90)	3.03% (3)	6.06% (6)	0
	Accessory cusps (8)	87.50% (7)	12.50% (1)	0	0

Study done by Noriyasu Kawada et al (2017) revealed that posterior (inferior) cusp was the most observed leaflets with clefts & scallops and with majority of them having 2 or 3 scallops. In our study we also had observed that inferior leaflet had more number of scallops as compared to other leaflets. There is limited literature available regarding scallops in other leaflets. Therefore, we could not comment on the occurrence of scallops in general population.

6.1.4 Annular Circumference of Valve

Silver M.D et al (1971) ,Paulo A et al19 (2000) stated that annular circumference of tricuspid valve for male was 11.4 ± 1.1cm and for female 10.8 ± 1.3 cm.

R .Wayne Alexander et al (1998) stated that tricuspid valve annular circumference varies from 10-12.5cm.

Aytac Kocak et al (2004) found that in non cardiac death origin heart specimen, annular circumference was 12.4 ± 1.1 cm in male and 11.8 ± 1.3cm in female.

Annular circumference for cardiac death origin was 11.2 ± 1.2cm in males and 10.8 ± 1.1 cm in females.

Seccombe J.F et al (2005) stated that average tricuspid valve circumference was 11.3 ± 0.1 cm.

Susan Standring (2005) mentioned that tricuspid valve orifice measured 11.4 cm in men and 10.8 cm in female .

Mohamed A.B Motabugami33 (2006) found that average tricuspid valve circumference ranged from 11.3cm to 13.9 cm.

In the study by S.Satish Kumar (2011) the average circumference of the tricuspid valve was found to be 11.8 cm but it ranged from 10.3 cm to 13 cm.

Table: 6.4 Annular Circumference Of Tricuspid Valve

Study	Sample Size	Annular Circumference (cm)
Tei C (1982)		13.5 ± 0.8
Westaby S **(**1984)		11.9 ± 2.72
Kouji Chida et al **(**1994)		9.9 ± 1.0
M. Skwarek (2008)	107	10.28 ± 1.66
S.Satish Kumar (2011)	45	11.8 ± 0.81
Aarti Rohilla (2015)	100	9.496 ± 1.6
S.Ilankathir (2015)	50	10.372
Lama CP (2018)	50	11.22 ± 0.20
Nagarathnamma B (2018)	120	9.52 ±1.15
Present study (2023)	100	9.11 ±1.87

The frequency of the annular circumference of the heart valves were compared with the other available literatures in (Table.6.4).

The present observation of average annular circumference of the tricuspid valve

was measured as 9.112 ± 1.865 cm with values ranging from 4.70 to 13.23 mm which coincides with that of reported by Kouji Chida et al who have reported a range of (9.9 ± 1.0 cm) but lower than that of reported by Westaby S (11.9 ± 2.72 cm) ,Tei C (13.5 ± 0.8 cm), S.Satish Kumar (11.8) and S.Ilankathir (10.37).

6.1.5 Length Of Cusps Of Tricuspid Valve

In our study the length of cusps of tricuspid valve varies extremely from 5.07mm to 64.92mm, additional being the shortest and anterosuperior cusp being largest.

R.Wayne Alexander et al (1998) mentioned that the anterior leaflet is usually the largest with a width of 2.2 cm. The septal and posterior leaflets measures about 1.5cm and 2.0 cm in width respectively.

Seccombe J.F et al (2005) mentioned that mean length were similar for the anterior, posterior and septal leaflets (38-42 mm).

Mohamed A. B. Motabagani33 (2006) reported that annular length of anterior leaflet ranges between 2.7-4.7cm , for posterior leaflet 1.8-3.2cm and for septal leaflet 2.5-3.7cm.

In the study by S.Satish Kumar (2011) the length of the anterior leaflet ranges from 3.0-3.9 (mean 3.51cm). The length of the posterior leaflet ranges from 2.0-3.2 (mean 2.51cm) and for septal leaflet height ranges from 2.8-3.9 (mean 3.26cm). The length of the accessory leaflet varied from 0.7 – 1.4 cm (mean 1.08)

Table 6.5 show length of all the cusps of tricuspid valve observed by various other authors. Our study findings of Anterosuperior cusp are similar to that of Aarti Rohilla et al and Nagarathnamma B et al. On the contrary the findings were higher in the study done by P Preethi et al. The differences may be due to gender, racial and geographical differences or may be due to any present pathological condition.

For septal cusp, our study findings were supported by the findings of P Preethi et al, but the other study findings were higher as compared to our study. The differences may be due to gender, racial and geographical differences or may be due to any present pathological condition.

Inferior cups length in our study was 21.73±4.63, which was lower as compared to other studies mentioned in the table. Inferior cusp had lowest length among all the cusps in our study and it is supported by all the study findings. It is clear from above table that inferior cusp has lowest length and anterosuperior cusp had the highest length.

Table 6.5 Length of Cusps of Tricuspid Valve

Study	Sample Size	Anterosuperior Cusp (mm)	Septal Cusp (mm)	Inferior Cusp (mm)	Additional Cusp(mm)
S.Satish Kumar (2011)	45	35.10 ±2.7	32.6 ±3.6	25.10 ±3.9	10.8
Aarti Rohilla (2015)	100	27.28 ± 5.43	28.74 ± 4.89	22.02 ± 4.35	-
Parmatma P. Mishra (2016)	120	50 ±1.32	32 ± 9.32	17 ±6.7	-
Nagarathnamma B (2018)	120	26.87±6.88	29.44±5.77	23.07±9.21	-
P. Preethi (2020)	45	45.5±5.11	27.00±6.99	33.7±7.66	19.7±4.0
Present Study (2023)	100	27.61±6.84	27.40±4.84	21.73±4.63	12.43±4.68

6.1.6 Width of Cusp Of Tricuspid Valve

Table 6.6 compares width of three cusp of tricuspid valve and Additional Cusp with other studies from various author.

M .Skwarek et al (2006) stated that the average width of the leaflets were, for anterior leaflet 20.71 ± 5.23mm , for posterior leaflet 18.88 ± 4.66 mm and for the septal leaflet 17.22 ± 4.71mm.

Mohamed A .B. Motabagani (2006) reported that width of anterior leaflet ranges between 1.9-2.7cm, for posterior leaflet 1.5-2.9cm and for septal leaflet 1.4-1.8cm.

B.N Vijaya Ragawa Rao (2007) mentioned that anterior leaflet is the largest with a width of 2.2cm , septal(medial) leaflet is the smallest with a width of 1.5cm, the posterior leaflet measures 2.0cm in width.

In the study by S.Satish Kumar (2011) the width of the anterior leaflet ranges from 1.9-2.5 (mean 2.21cm). The height of the posterior leaflet ranges from 1.7-2.2 (mean 1.92cm) and for septal leaflet height ranges from 1.4-1.9 (mean 1.68cm) and accessory leaflet ranged from 0.6 – 1.4 cm (mean 0.95cm)

In our study width of anterosuperior cusp, septal cusp and inferior were slightly lower than findings of other studies. Our study findings were supported by the findings of P Preethi (2020).

Table 6.6 Width of Cusps of Tricuspid Valve

Study	Sample Size	Anterosuperior Cusp (mm)	Septal Cusp (mm)	Inferior Cusp	Additional Cusp
S.Satish Kumar (2011)	45	22.1 ± 1.9	16.80 ±1.6	19.22 ±1.9	09.5
Aarti Rohilla (2015)	100	19.22 ±2.42	15.30 ±2.99	16.22 ±2.88	-
Parmatma P. Mishra (2016)	120	28.6±10.1	25.7±10.1	15.0± 8.4	-
Nagarathnamma B (2018)	120	19.22 ±2.42	15.13± 2.99	16.22± 2.88	-
P. Preethi (2020)	45	18.2±3.6	12.0±4.3	16.2±3.1	11.2±2.8
Present Study (2023)	**100**	**17.30± 3.1**	**13.03± 3.03**	**15.59 ±3.69**	**12.69 6.79**

6.2 Bicuspid Valve

The mitral valve consists of two leaflets (anterior and posterior) sitting within the annulus. The posterior mitral leaflet originates from the left atrial (LA) endocardium. A subvalvular apparatus, comprising of 2 papillary muscles (anterolateral and posteromedial), arise from the LV myocardium and the chordae tendineae, supporting the leaflets.

6.2.1 Number of Bicuspid Leaflets

Table 6.7 Frequency of Number of Bicuspid Leaflets

Authors	Sample Size	2 Cusps Normal	3 Cusps Additional Cusp	4 Cusps Additional Cusp
Parmatma P. Mishra (2017)	120	97.5%(117)	2.5% (3)	-
Shruthi B. N (2019)	60	80% (48)	18.3%(11)	1.7% (1)
Present study (2023)	**100**	**96%**	**4%**	**-**

Our study showed 2 cusps for bicuspid valve in majority (96%) of the specimens with one additional cusp in 4% specimens. The results are similar to the findings presented by Parmatma P Mishra (97.5%% and 2.5%) and Shruti BN (80% and 18.3%) respectively.

6.2.2 Shape Of Cusp Of Bicuspid Valve

Table 6.8 Shape Of Cusp Of Bicuspid Valve

Study	Cusp	Triangular	D shape	Rectangular
Parmatma P. Mishra (2017)	Anterior cusp	80.33% (97)	17.5% (21)	1.67% (2)
	Posterior cusp	75.83% (91)	00	24.17% (29)
Present study (2023)	Anterior cusp	74% (74)	24% (24)	2% (2)
	Posterior cusp	62% (62)	21% (34)	17% (17)

Our study showed that triangular shape of anterior and posterior cusp, i.e. 74% and 62%, is the most common presentation followed by D-shape in 24% and 21% and rectangular in 2% and 17% respectively. Similar results have been shared by Paramtma P Mishra with triangular shape of anterior and posterior cusp (80.33% and 75.83%), followed by D-shape (17.5% and 0%) and rectangular (1.67% and 24.17%).

6.2.3 Clefts And Scallops Present In The Bicuspid Valve

Table 6.9 Cleft & Scallops Present In Cusp Of Bicuspid Valve

Study	Cusp	No Cleft 1 Scallop	1 Cleft 2 Scallop	2 Cleft 3 Scallop	3 Cleft 4 Scallop	4 Cleft 5 Scallop
B. Senthil (2013)	Anterior cusp	45% (27)	10%(6)	45% (27)	0	0
	Posterior cusp	30% (18)	15%(9)	10% (06)	20%(12)	25%(15)
Agata (2017)	Anterior cusp	0	0	96.45% (136)	3.45%(5)	0
	Posterior cusp	2.83% (4)	12.05% (17)	63.83% (90)	19.85% (28)	4.41% (02)
Present study (2022)	Anterior cusp	78% (78)	14% (14)	8% (8)	0	0
	Posterior cusp	19% (19)	27% (27)	35% (35)	12%(12)	7%(7)

We found maximum a single scallop with no clefts in anterior cusp in majority of specimens (78%) followed by 2 scallops with 1 cleft (14%) and 3 scallops with 2 clefts in 8% specimens. However, Agata reported 96.45% specimens with 3 scallops and 2 clefts and B Senthil reported 45% presentation with 1 scallop with no clefts and 3 scallops with 2 clefts each.

Similarly, we found most common presentation (35%) of 3 scallops with 2 clefts in posterior cusp as also reported by Agata (63.83%)

6.2.4 Annular Circumference of Bicuspid Valve

Table 6.10 Annular Circumference Of Bicuspid Valve

Study	No.Of Specimen	Annular Circumference (Mm)
Westaby S (1984)		87.0 ± 20.8
Kouji Chida et al (1994)		83 ± 10
Gupta C (2013)	18	91.1 ± 4.4
Deopujari, R (2013)		82.7
B. Senthil (2013)	45	79.2 ± 1.4
S.Ilankathir (2015)	50	82.85
Agata (2017)	141	89.9± 12.6
Parmatma P. Mishra (2017)	120	87 ± 16
Lama CP (2018)	50	92.2 ± 14.9
Shruthi B. N (2019)	60	79.8 ±18.3
Present study (2023)	100	84.11 ± 14.25

In our study the annular circumference for bicuspid valve was measured at 84.11 ± 14.25 mm. Similar results have been shared in many studies previously.

6.2.5 Length of Cusp of Bicuspid Valve

Table 6.11 Length Of Bicuspid Valve

Study	No.Of Specimen	Anteromedial Cusp (mm)	Posterolateral Cusp (mm)	Additional Cusp (mm)
D. Patil (2008)	50	33.2	49.28	-
Gupta C (2013)	18	56 ± 2.1	88.9 ± 4.3	-
B. Senthil (2013)	45	28.5 ± 0.7	32.6 ± 0.3	-
Agata (2017)	141	30.8 ± 4.9	45.1 ± 8.2	-
Parmatma P.Mishra (2017)	120	34 ± 8.7	51.9±11.6	13.2± 2.7
Shruthi B. N (2019)	60	29.7± 7.0	30.2± 7.7	13.9± 7.3
Present study(2023)	100	26.76 ±4.16	28.65±4.16	17.85±4.48

In our study we measured the length of anteromedial cusp and posterolateral cusp as 26.76 ± 4.16 and 28.65 ± 4.16 respectively. Similar results have been shared by many studies previously. Parmatma P Mishra and Shruti BN measured the length of additional cusp as 13.2 ± 2.7 mm and 13.9 ± 7.3 mm respectively while we found higher values of 17.85 ± 4.48 mm in our study.

6.2.6 Width of Cusp of Bicuspid Valve

Table 6.12 Width Of Bicuspid Valve

Study	**Sample Size**	**Anteromedial Cusp (Mm)**	**Posterolateral Cusp (Mm)**	**Additional Cusp (Mm)**
D. Patil (2008)	50	19.24	11.04	-
B. Senthil (2013)	45	16.3 ±0.2	9.5 ± 0.7	-
Agata (2017)	141	20.6 ± 4.2	12.9 ± 2.8	-
Parmatma P. Mishra (2017)	120	21.1 ±8.4	15.2 ± 4.2	7.7 ± 1
Shruthi B. N (2019)	60	17.2± 5.4	16.8± 5.1	13.13± 5.5
Present Study (2023)	**100**	**18.44±3.04**	**11.51±2.52**	**10.59±2.95**

In our study we measured the width of anteromedial cusp and posterolateral cusp as 18.44 ± 3.04 and 11.51 ± 2.52 respectively. Similar results have been shared by many studies previously. Parmatma P Mishra and Shruti BN measured the width of additional cusp as 7.7 ± 1 mm and 13.13 ± 5.5 mm respectively similar to our findings of 10.59 ± 2.95 mm.

6.3 Aortic Valve

6.3.1 Postion of Ostium

In 100% of the cases in the present study the Right Coronary Ostium (RCO) was located in the right sinus and Left Coronary Ostium (LCO) was located in the left sinus. The coronary ostia in the sinus of Valsalva showed variations in the vertical placement.

Location of the coronary ostia in the aortic sinus is categorized into 3 types with respect to the sinotubular ridge as above Annulus (sinotubular ridge) i.e. Tubular, Below Annulus i.e. Sinus and at annulus i.e. Sinotubular.

In study by Jyoti P. Kulkarni (2015) 56.6% of cases the RCO and in 52.2% of the cases the LCO was located at the sinotubular junction respectively, which was completely different as compared to our studies in which only 1 case was found at the level of sinotubular junction.

In the present study 92% of cases Right Coronary Ostium and 88% of cases Left Coronary Ostium was located at Sinus respectively, which coincides with findings of Prajapati et al (2013), Kalpana (2003) and differ from Pejkovic et al. (2008) & Jyoti P. Kulkarni (2015)

Our findings were similar with the studies done by Prajapati et al (2013),

Table 6.13 Location of the coronary ostia in the aortic sinus with respect to the sinotubular ridge

Studies	Right Coronary Ostium			Left Coronary Ostium		
	Tubular (%)	Sinus (%)	Sinotubular(%)	Tubular (%)	Sinus (%)	Sinotubular(%)
Muriago et al. (1997)	13	78	02	22	69	9
Cavalcanti et al. (2003)	28	60	12	40	42	18
Kalpana (2003)	01	90	09	00	80	20
Pejkovic et al. (2008)	10	19	71	60	22	18
Bhimalli et al. (2009)	0	84	16	6.66	93	3.33
Prajapati et al (2013)	9	91	0	6	94	0
Roy et al. (2014)	-	-	-	35	65	
Jyoti P. Kulkarni (2015)	16.6	26	56	17.7	30	52.2
Hima Bindu Nalluri (2016) (80)	23.75	65	11.25	8.75	52.5	38.75
Present Study (2023) (100)	7	92	01	11	88	0

Both sinus and sinotubular location allows maximal coronary filling during ventricular diastole.

Thebesian in 1708 stated that aortic valve in systole blocks the sinus ostia. Hurst's (Keller et al.,1998) has mentioned about a high take off coronary artery whose ostium was located at a distance of 2.5 cm above the sinotubular junction.

The knowledge of shape and placement of ostium in aortic sinus is essential while manipulating a catheter in procedure of angiography, angioplasty and transcatheter

aortic valve replacement procedures. The tubular location of the ostium may pose difficulties in catheterisation for angiographic procedures.

6.3.2 Length of Cusp of Aortic Valve

Table 6.14 Length Of Cusp Of Aortic Valve

Study		Sample Size	Right Coronary Cusp (Mm)	Left Coronary Cusp (Mm)	Non Cornonary Cusp (Mm)
Marcelo (1999)		100	30.1	30.6	30.0
Arpandeep Randhawa (2019)		30	22.4±2.1	21.8±2.4	--
Khushnuda Perween (2021)	**Male**	15	36.8 ± 4.7	38.3 ±4.5	37.8±4.9
	Female	10	36.4 ±3.8	37.5±3.4	36.2±4.2
Present study(2023)		100	30.44 ± 1.37	30.73 ± 1.51	30.22 ± 1.84

The length of the cusps of tricuspid aortic valve of the heart was compared with the other available literatures in above table. (Table.).

The present observation of average length of the aortic valve was 30.44 ± 1.37 mm, 30.73 ± 1.51 mm and 30.22 ± 1.84 mm of the right coronary, left coronary and non-coronary cusps respectively which was lower than that of reported by Khushnuda Perween (2021).

Khushnuda Perween (2021) did study in Heart specimens of known sex & compares the findings of male and female.

Our study findings were similar with the studies done by Marcelo (1999).

6.3.3 Width of Cusp of Aortic Valve

Table 6.15 Width Of Cusp Of Aortic Valve

Study	Sample Size	Right Coronary Cusp (mm)	Left Coronary Cusp (mm)	Non Cornonary Cusp (mm)
Marcelo (1999)	100	4.4	4.6	4.3
Present Study(2023)	100	4.33	4.89	4.80

In present study mean width of right coronary, left coronary, non-coronary was 4.33, 4.89, 4.80 mm respectively which was similar to Marcelo (1999).

As there was limited literature available that mentioned the width of the cusp, we were only able to discuss one study.

6.3.4 Annular Circumference of Aortic Valve

Table 6.16 Annular Circumference Of Valve

Study		Sample Size	Annular Circumference (Mm)
Westaby S (1984)			48.1 ± 13.0
Kazman Et Al. (1988)			41.1
Kouji Chida Et Al (1994)			73 ± 7.0
Krishnaiah M (2012)		25	79.8
S.Ilankathir (2015)		50	75.42
Nitin Gupta (2020)	**Male**	15	88.4 ±12.9
	Female	15	82.7 ± 8.0
Khushnuda Perween (2021)	**Male**	15	71±4.24mm
	Female	10	68±3.42mm
Present Study (2023)		100	75.14 ± 1.82

In present study mean annular circumfereance of aortic valve was 75.14 mm which was similar to S.Ilankathir (75.42mm), Kouji Chida(73) and Khushnuda Perween (2021)

6.3.5 Distance Between Coronary Ostium And Commissure Of Cusp

Table 6.17 Distance Between Coronary Ostium And Commissure Of Cusp

Study	Sample Size	Right Coronary		Left Coronary	
		From Right Commissure	From Left Commissure	From Right Commissure	From Left Commissure
Jyothi Sr (2017)	49	9.73 mm.	14.55	11.74	11.27
Present Study	100	11.29 ± 1.21	11.97 ±1.93	11.25 ±1.75	10.09±1.25

The mean distance from the right and left Commissure of Cusp to the right coronary ostium was measured as 11.29 ± 1.21 mm and 11.97 ± 1.93 mm respectively. While the distance of right and left Commissure of Cusp to the left coronary ostium was measured as 11.25 ± 1.75 mm and 10.09 ± 1.25 mm respectively.

As there was limited literature available that mentioned the distance between coronary ostium and commissure of cusp, we were only able to discuss one study.

6.4 Pulmonary Valve

6.4.1 Length Of Cusps of Pulmonary Valve

Table 6.18 Length Of Cusps of Pulmonary Valve

Study	Sample Size	Right Anterior (mm)	Left Anterior (mm)	Posterior (mm)
Garg S (2014)	15	24 ± 3.5	25 ± 4.5	27 ± 4
Present Study	100	22.56 ± 4.08	23.27 ± 4.49	24.11 ± 4.39

The average value of length for right anterior cusp was 22.56 ± 4.08 mm, left anterior cusp was 23.27 ± 4.49 mm and that of posterior cusp was 24.11 ± 4.39mm which were slightly lower than that of Garg S **(**2014).

6.4.2 Annular Circumference of Pulmonary Valve

Table 6.19 Annular Circumference of Pulmonary Valve

Study	Sample Size	Annular Circumference (mm)
Westaby S (1984)	160	48.8 ± 12.5
Kouji Chida et al (1994)		68 ± 8
Garg S (2014)	15	65 ± 5.9
S.Ilankathir (2015)	50	68.23
Ashalatha P R (2017)	213	Male : 64.3; Females: 62
Present study (2023)	100	65.06 ± 6.85

In the present study the average annular circumference of pulmonary valve was calculated as 65.06 ± 6.85 mm. The values obtained in the present study are almost similar to those of Garg (2014), Ilankathir (2015), Ashalatha P R (2017) and Kouji

Chida . Our values are higher than Westaby s.

Ashalatha P R (2017, explained a definite relationship with age and circumference of the pulmonary valve & also noted that the circumference of the valve in males is more than that of females of the same age group. However in the present study no such relationship was established.

6.5 Papillary Muscle

There are 5 papillary muscles in the heart originating from the ventricular walls. These muscles attach to the tricuspid and mitral valve leaflets via the chordae tendineae and functionally prevent regurgitation of ventricular blood via tensile strength by preventing prolapse or inversion of the valves during systole. Three of these papillary muscle- anterior papillary (APM), posterior papillary muscle (PPM), and

chordae tendineae complexes are attached to the tricuspid valve cusps (anteriorosuperior, posterior, septal) and 2 are attached to the mitral valve cusps.(anterolateral and posteromedial).

6.5.1 Attachment Of Papillary Muscle On Cusps Of Tricuspid And Bicuspid Valve

Papillary Muscle Attachment To Tricuspid Valve

In our study all the specimens had attachment of papillary muscles to the anterosuperior cusp, out of them majority were anterior papillary muscles. The main papillary muscles attached to spetal cusp were septal papillary muscles. The majority of papillary muscles attached to the inferior cusp was posterior papillary muscles followed by septal muscle. 1-2 papillary muscles were attached to anterosuperior cusp in 98%, septal cusp in 96.96 %, inferior cusp in 88.65% and additional cusp in 100% of the specimen.While 3-4 papillary muscles were attached to anterosuperior in 02%, septal in 3.03%, inferior in 11.34% of specimens. Additional cusp was attached to maximum 2 papillary muscle not more than it. There is a limited study available regarding this topic. Therefore, we could not comment on generalisation of the findings.

Papillary Muscle Attachment To Bicuspid Valve

1-2 papillary muscles were attached to anteromedial, posterolateral, additional cusp in 89, 79, 8 of the specimens and 3-4 papillary muscles were attached to anteromedial, posterolateral cusp in 11, 18 of the specimens respectively while 5-6 papillary muscles were attached only to posterolateral cusp in 03 specimens. Additional cusp was attached to 1-2 papillary muscles not more than it. In present study, majority of anterior papillary muscles were attached to anteromedial cusp and very minimal with the posterolateral cusp. Simultaneously, majority of posterior papillary muscles were attached to posterolateral cusp and very minimal with the anteromedial cusp.We were not able to compare it with other studies as there is very limited research material available to this topic.

6.5.2 Number Of Papillary Muscle In Ventricles

The papillary muscles arise from the walls of the left and right cardiac ventricles. The classic description of the left cardiac ventricle is as containing two papillary muscles: the anterior (APM) and posterior (PPM). The anterior arises from the sternocostal wall, and the posterior papillary muscle arises from the diaphragmatic wall of the ventricle.

The right ventricle contains three papillary muscles, classically described as anterior (APM), posterior (PPM) and septal (SPM).

Table 6.20 Number of Papillary Muscles

Study	No Of Specimen	Number Of Papillary Muscle				
		Right			Left	
		APM	PPM	SPM	APM	PPM
G R Nigri et al (2000)	79	100% (79)	100% (79)	78.5% (62)	_____	_____
Mamatha et al(2014)	15	100%	100%	100%	100%	100%
Prasenjit et al(2015)	60	_____	_____	_____	100%	100%
Kirandeep Kauret al(2016)	30	100% (30)	100% (30)	83.3% (25)	_____	_____
Bhagya Shree et al(2016)	50	_____	_____	_____	100%	100%
Dr.S.Kavitha et al(2018)	100	100%	100%	100%	100%	100%
Manisha et al(2020)	40	100%	100%	100%	100%	100%
Prithvi et al(2020)	50	_____	_____	_____	100%	100%
Pooja Bhadoria et al (2022)	50	100%	100%	100%	100%	100%
Present Study(2023)	100	100%	100%	53%	100%	100%

Above table describes incidence of right sided papillary study as compared to incidence of right sided papillary muscles in this study. Incidence of anterior papillary muscle was comparable to all the studies mentioned in the table. Although there was variation observed in posterior and septal papillary muscles. The possible reason for the same could be due to variation in number of specimen studied and geographic location of the patient.

Above table describes incidence of left sided papillary study as compared to incidence of left sided papillary muscles in this study. Incidence of anterior and posterior papillary muscle was comparable to all the studies mentioned in the table. The possible reason in variation of incidence could be due to variation in number of specimen studied and geographic location of the patient.

The anterior and posterior papillary muscles (apm, ppm) were present in 100% of the cases. The septal papillary muscle (spm) was absent in 21.5% of the hearts as described by G R Nigri et al (2000) ,Lakhanpal et al., in their research work on papillary muscles of the bicuspid valve in the Central Indian population, reported the presence of accessory anterior papillary muscles in 31% and accessory posterior papillary muscles in 25% of hearts, respectively.

In Present study, in right ventricle,132 anterior papillary muscle(APM) ,154 posterior papillary muscle(PPM) and 69 septal papillary muscle(SPM) were present.While in left ventricle 116 anterior papillary muscle (APM) and 178 posterior papillary muscle(PPM) were observed.

Various studies carried out on right ventricles of different populations by Kumar et al., Nigri et al., Balachandra et al., and Wafae et al. demonstrated the presence of anterior and posterior papillary muscles in all instances, which is consistent with the findings in our study.

6.5.3 Length Of Papillary Muscles

Table 6.21 Length Of Papillary Muscle

Study	No Of Specimen	Length Of Papillary Muscle				
		Right			Left	
		APM	PPM	SPM	APM	PPM
G R Nigri et al (2000)	79	19.16mm	11.53mm	5.59mm	Not Observed	Not Observed
Mamatha et al(2014)	15	13± 4mm	9.8± 4mm	5.5± 4mm	16± 5mm	21.4± 6mm
Kirandeep Kauret al(2016)	30	16.33± 5.53mm	10.58± 4.86mm	4.24± 1.88mm	_____	_____
Bhagya Shree et al(2016)	50	_____	_____	_____	22.75	21.28
Dr.S.Kavitha et al(2018)	100	14.89± 4.19mm	14.86± 4.05mm	10.27± 3.28mm	18.80± 3.97mm	18.89± 4.27mm
Manisha et al(2020)	40	12.7± 4.5mm	13.06± 5.2mm	09.2± 5.4mm	21.3± 4.4mm	17.6± 4.6mm
Prithvi et al(2020)	50	_____	_____	_____	22.85mm	22.43mm
Pooja Bhadoria et al (2022)	50	12.71± 3.81mm	12.40± 3.03mm	1.67± 0.48mm	16.41± 4.33mm	14.64± 3.92mm
Present Study(2023)	100	13.03± 2.44mm	10.09± 2.89mm	6.06.± 1.07mm	16.38± 2.55mm	21.01± 2.20mm

Atrioventricular regurgitation occurs when the papillary muscles are congenitally elongated, and this is caused by faulty valve closure. Pooja et al reported that the mean length calculated for anterior papillary muscles in the right and left ventricles came out to be 12.71±3.81 and 16.41±4.33, respectively, in our study. Similarly, the mean length calculated for posterior papillary muscles in the right and left ventricles was 12.40±3.03 and 14.64±3.92, respectively. The mean of septal papillary muscles measured 1,.67±0.48. In present study the mean length of APM was 13.03 ± 2.44 mm and 16.38 ± 2.55 mm on right and left side respectively. The mean length of PPM was 10.09 ±

2.89 mm and 21.01 ± 2.20 mm on right and left side respectively. The mean length of SPM was 6.06 ± 1.07 mm and on right side.

The above table shows length of right sided and left sided papillary muscles. From above comparison it is clear that anterior papillary muscle is longest muscles and septal muscle is shortest papillary muscles for right side. All the studies described in the table supports the findings of our study. For left sided papillary muscles; posterior muscle is longer as compared to anterior muscles. Other studies discussed in the table supports the finding of our study.

6.5.4 Shape Of Papillary Muscle

Table 6.22 Shape of Papillary Muscles

Study	No Of Specimen	Side	Shape Of Papillary Muscle			
			Conical	Flat	Bifid	Trifid
G R Nigri et al (2000)	79	Right APM	62.3% (49)	27% (21)	10.7% (09)	____
		Right PPM	78.2% (62)	17% (13)	4.2% (04)	____
		Right SPM	88.3% (55)	9% (05)	2.7% (02)	____
Mahatma et al(2014)	15	Right APM	100% (15)	____	____	____
		Right PPM	86.66% (13)	2% (02)	____	____
		Right SPM	100% (15)	____	____	____
		Left APM	100% (15)	____	____	____
		Left PPM	100% (15)	____	____	____
Prasenjit et al(2015)	60	Left PM	54% (45)	51.67% (62)	____	____
Kirandeep Kaur Aulakh et al(2016)	30	Right APM	26.7% (08)	____	13.33 %(04)	____
		Right PPM	10% (03)	____	23.3% (07)	____
		Right SPM	81.8% (20)	____	____	____
Bhagya Shree et al(2016)	50	Left APM	28%(14)	6% (3)	24% (12)	____
		Left PPM	16%(8)	10%(5)	8%(4)	____
Prithvi Chandra et al(2020)	50	Left APM	78%(39)	42%(21)	60% (30)	12% (6)
		Left PPM	96%(48)	24%(12)	38% (19)	10% (5)

Pooja Bhadoria et al (2022)	50	Right APM	76%(38)	24%(12)	____	____
		Right PPM	56%(28)	44%(22)	____	____
		Right SPM	100% (50)	____	____	____
		Left APM	38% (19)	52% (26)	____	____
		Left PPM	36% (18)	64% (32)	____	____
Present Study(2023)	132	Right APM	53.78% (71)	28.03% (37)	13.63 %(18)	4.54% (06)
	154	Right PPM	72.07% (111)	14.93% (23)	6.49% (10)	6.49% (10)
	69	Right SPM	94.65% (66)	____	4.34% (03)	____
	116	Left APM	35.34% (41)	16.37% (19)	37.06 %(43)	11.20 %(13)
	178	Left PPM	60.67% (108)	16.29% (29)	21.9% (39)	1.12% (2)

Above table compares the study findings of other studies with present study findings. In present study conical shape was the most common type observed in left and right sided papillary muscles. The study findings were supported by findings of Bhagyashree et al. On the contrary broad shape was observed to be the most common type of shape in a study done by Prasenjit Bose et al.

The shape of the papillary muscles has an important role in smooth blood flow. In most textbooks, papillary muscles are characterized as conical in form, which is best adapted to facilitate cardiovascular physiology by obstructing the blood flow as little as possible . In study of Pooja et al(2022), the most common shape came across among papillary muscles of right ventricles was conical: 42% in anterior, 36% in posterior, and 100% in septal papillary muscles.

Nigri et al statd that the ppm was present in 100% of the hearts. The morphology of this muscle was highly variable, presenting one to four heads. It had a single head in 25.4% of cases, and a double head in 46.8%. It presented a third head in 17 (21.5%) and a fourth head in 5 cases (6.3%)

6.5.5 Pattern of Papillary Muscles

Table 6.23 Pattern Of Papillary Muscle

Study	No Of Specimen	Side and Type	Papillary Muscle					
			Classical	2group	3group	4group	5group	6group
G R Nigri et al (2000)	79	Right APM	81.01% (64)	18.98% (15)	____	_____	____	_____
		Right PPM	25.4% (20)	46.89% (37)	21.5% (17)	6.3% (05)	_____	_____
		Right SPM	41.7% (33)	16.5% (13)	12.7% (10)	7.6% (06)	_____	_____
Mamatha et al(2014)	15	Right APM	80%(12)	20% (3)	_____	_____	_____	_____
		Right PPM	46.66% (7)	53.33% (8)	_____	_____	_____	_____
		Right SPM	100% (15)	_____	_____	_____	_____	_____
		Left APM	86.66% (13)	13.66% (2)	_____	_____	_____	_____
		Left PPM	60% (09)	40% (06)	_____	_____	_____	_____
Prasenjit et al(2015)	60	Left PM	23.33% (14)	53.33% (32)	18.33% (11)	1.67% (01)	_____	_____
Kirandeep Kaur Aulakh et al(2016)	30	Right APM	63.3% (19)	36.76% (11)	_____	_____	_____	_____
		Right PPM	20% (06)	46.66% (14)	33.3% (10)	_____	_____	_____
		Right SPM	96.6% (29)	53.33% (16)	8% (02)	8% (02)	_____	_____
Bhagya Shree et al(2016)	50	Left APM	86% (43)	14% (7)	_____	_____	_____	_____
		Left PPM	14% (7)	56% (28)	20% (10)	10% (5)	_____	_____
Prithvi Chandra et al(2020)	50	Left APM	22%(11)	38% (19)	4%(2)	_____	_____	_____
		Left PPM	6%(3)	60% (30)	16% (8)	_____	_____	_____
Present Study(2023)	100	Right APM	72%	26%		2%	_____	_____
		Right PPM	51%	27%	8%	_____	5%	_____
		Right SPM	37%	7%	_____	_____	_____	3%
		Left APM	78%	19%	_____	_____	_____	_____
		Left PPM	37%	38%	15%	6%	3%	_____

In present study anterior papillary muscle were found classical predominantly .APM was also found of 2group in both ventricle and 4group in right ventricle.The posterior papillary muscle found classical,2group,3group and 5group in both the ventricle while 4group posterior papillary muscle were absent in left ventricle.

A.V.Lakhanpal et al in a study carried out on 100 heart found that total number of papillary muscles present in the mitral valve complex ranged from 2 to 5 with an average of 2.63.In their study,extra-anterior and extra-posterior papillary muscles were found in 31% and 25% hearts respectively.In the tricuspid valve extra-anterior and extra-posterior papillary muscles were present . Extra posterior were present in most of the hearts.

Pattern of Papillary muscle was compared with available study of Prasenjit Bose et al. In his study he had find out that most common type of pattern was two group papillary muscle, but in our study we had finding that classical muscle pattern was the most common type.

6.6 Coronary Sinus & Thebesian Valve

The coronary sinus (CS) is a commonly cannulated structure in patients undergoing electrophysiology studies, catheter ablation of arrhythmias, implantation of resynchronization therapy devices and, more recently, percutaneous mitral valve repair. The advent of these procedures has led to a renewed interest in the anatomy of the coronary venous system including its various components. To improve our understanding of this structure, we studied the anatomy of the human CS, including the valve that guards its ostium, the Thebesian valve.

6.6.1 Prevalence of Thebesian Valve

Table 6.24 Presence Of Thebesian Valve

Study	Presence of Thebesian Valve
Amit Noheria et al (2012)	63%
M Mazur et al (2014)	77.5%
Rafal Mlynarski et al (2015)	45.9%
Julija Zhivadinovik et al (2016)	86%
Present Study(2023)	76%

The above table discusses the prevalence of thebesian valve in various studies. The prevalence of thebesian valve was lower in a study done by Rafal Mlynarski et al (2015) as compared to our study. On the other hand remaining study shows higher or equal prevalence of thebesian valve as compared to our study findings. The variability in the prevalence can be attributed to the sample size of the study, as well as racial and geographical differences.

6.6.2 Length Of Coronary Sinus

Table 6.25 Length Of Coronary Sinus

Study	Length Of Coronary Sinus	
	Cranio-Caudal(mm)	Transverse(mm)
GS Mak et al (2009)	7.9 ± 2.7 mm	7.3 ± 2.8 mm
Ghosh SK et al (2014)	9.4±2.1 mm	7.15±1.5 mm
Julija Zhivadinovik et al (2016)	8.1±1.51 mm	7.67±1.72 mm
Present Study(2023)	With Thebesian Valve	
	6.84 + 2.85mm	6.66 + 2.69 mm
	With Out Thebesian Valve	
	8.23 + 2.69 mm	8.08 + 2.85 mm

The above table discusses the length of coronary sinus. Our study findings are more or less like the finding of GS Mak et al (2009). In present study length of coronary sinus was measured according to presence and absence of thebesian valve. There was scarcity of literature for the same.The remaining variation in diameter can be attributed to racial and geographical difference.

6.6.3 Shape of Thebesian Valve

Table 6.26 Shape Of Thebesian Valve

Study	Shape of Valve	Frequency (%)
Mustafa Karaca et al(2005) (n-35)	Semilunar	29%(15)
	Fenestrated	4%(2)
	Biconcave (Band Like)	4%(2)
	Crescent	31%(16)
Sanjib et al (2013) (n-118)	Semilunar	55%(65)
	Fenestrated	30.5%(36)
	Biconcave(Band Like)	14.5%(17)
Wieslawa et al (2016) (n-97)	Fenestrated	18.2%(20)
	Biconcave(Band Like)	10.9%(12)
Present Study (2023)	Semilunar	82.89%(63)
	Fenestrated	9.20%(7)
	Biconcave(Band Like)	5.26%(4)
	Other	2.63%(2)

From above table the most common type of shape of thebesian valve was semilunar type. Lesions of the CS are very difficult or even impossible to repair and can be fatal (Noble et al., 2011). Such perforations and dissections may be a direct consequence of

the use of excessive force when guiding the catheter through the coronary sinus orifice in which a prominent Thebesian valve is present. In this study thebesian valve were also found of fenestrated and band like which are similar to findings of Mustafa Karaca et al(2005), Sanjib et al (2013), Wieslawa et al (2016).

6.6.4 Composition of Thebesian Valve

Table 6.27 Composition Of Thebesian Valve

Study	Composition	Frequency (%)
Kulkarni V e al	Membranous	46%
	Fibrous	34%
	Partly Fibrous and partly membranous	10%
Mak et al	Membranous	46%
	Fibrous	24%
	Partly Fibrous and partly membranous	11%
	Muscular	18%
Present Study(2023)	Membranous	71.05%(54)
	Fibromuscular	17.10%(13)
	Muscular	11.84%(09)

The above table discusses the composition of the thebesian valve. The discussed study and our study findings both suggests that membranous type is the most common type of composition followed by muscular type.

6.6.5 Type Of Thebesian Valve

Table 6.28 Type Of Thebesian Valve

Study	Obstructive Valve	Non Obstructive Valve
Marc A Silver(1988)(n-25)	41%(10)	59%(15)
Sanjib et al (2013)(n-118)	32%(38)	67.79%(80)
Wieslawa et al (2016)(n-97)	5.4%(6)	93.81%(91)
Present Study (2023)(n-76)	22.36%(17)	77.63%(59)

In present study out of 76, majority of the specimen 59 (77.63%) had only thebesian valve partially (non-obstructive) covering coronary sinus ostium. 17 specimens (22.36%) were obstructive type completely covering the coronary sinus ostium.

In previous studies, it was concluded that only Thebesian valves that cover >100% of coronary sinus ostium (going well beyond the CSO contour) can be established as obstructive vales and can make CS cannulation impossible (2.6% of all cases, which corresponds to clinical data) (Hołda et al., 2015). In other cases, the Thebesian valve should only be considered as hindering the CS cannulation. Access to the heart venous

system via the SVC and the left superior margin of the CSO (inserting the catheter from anterior to posterior and from left to right side with a rotational movement) can significantly reduce the risk of perforation associated with overcoming the prominent Thebesian valve.

The presence of an obstructive Thebesian valve does not rule out the possibility of successful CS cannulation: for example, the use of radiofrequency energy to traverse an occlusive Thebesian valve, may be used as an alternative method (Parikh et al., 2011).

6.7 Variables of Eustachian Valve

6.7.1 Presence of Eustachian Valve

In majority of adults, Eustachian valve is either inconspicuous or appears as a thin crescentic fold originating at the orifice of IVC.

Maddury et al., (2009) concluded that a persistent EV is mainly a benign entity but can rarely harbor pathology. Infective endocarditis and pulmonary embolism are the major complications of EV pathology (Maddury et al., 2009). A persistent Eustachian valve is a frequent finding in patients with patent foramen ovale (Powell and Mullaney, 1960)

In present study 67% of the specimens showed presence of Eustachian valve in 100 specimens of heart.

6.7.2 Type of Eustachian Valve

There is a large variability in size, shape, thickness, and texture of the persistent eustachian valve, and in the extent to which it encroaches on neighboring structures such as the atrial septum. At one end of the spectrum, the embryonic eustachian valve disappears completely or is represented only by a thin ridge. Most commonly, it is a crescentic fold of endocardium arising from the anterior rim of the IVC orifice. The lateral horn of the crescent tends to meet the lower end of the crista terminalis, while the medial horn joins the thebesian valve, a semicircular valvular fold at the orifice of the coronary sinus.(Student's Gray 39th Edition). At the other extreme, it persists as a mobile, elongated structure projecting several centimeters into the right atrial cavity. In our study also we have discovered eustachian valve as a ridge like structure in 58.20 %of cases and remaining were of membranous type 41.79%

A membranous EV was also reported by Raffa et al., (1992), and Yavuz et al., (2002) as a case study. Ridge like EV was observed in 25% of cases. Studies also report that persistent Eustachian valve is a frequent finding with persistent foramen ovale which may prevent its closure and indirectly predispose to paradoxical embolism (Schuchlenz et al., 2004). Previous studies show that central cyanosis was found in children having ASD with the presence of large Eustachian valve and Thebasian valve (Raffa, 1992).

6.7.3 Association With Chiari Network

Jain A. et al (2013) showed the presence of Chiari network in 15% of specimens which were associated with Eustachian valve.

Klimek-Piotrowska et al. (2016) et al reported 5 hearts (4.6%) with chiari network and was always accompanied by a Eustachian valve.

In Present study 17.39% Eustachian valve was associated with chiari network.Findings of present study correlates with the findings of Jain A. et al.

6.8 Variables of Chiari Network

The Chiari network is a meshwork of thread-like strands connecting the edges of the inferior vena cava and coronary sinus valves with the crista terminalis, or sieve-like fenestrations in the valves. Hans Chiari, an Austrian pathologist, described this for the first time in 13 human right atria.

6.8.1 Prevalence of Chiari Network

Table 6.29 Prevelence Of Chiari Network

Study	Prevalence of Chairi Network
D. Devi Jansirani	3.75%
AKM Monwarul Islam	4.91%
Ashita Kaore	-
Present Study	14%

The above table discusses the prevalence of chiari network . We had discovered 14% of prevalence of chairi netwrok which was higher as compared to D Devi Jansirani and AKM Monwarul Islam. The difference may be attributed to variation in sample size or ethnic and racial differences.

6.8.2 Morphology of Chiari Network

The morphology of Chiari network was observed as Fenestrated membrane like structure by Shivadeep S et al and D Devi Jansiran. This study findings support our findings. We had also observed the Chiari network as reticular fine network. Shivadeep S et al had found out the fenestration in his study,on the other hand we were not able to find out fensestration in any cases. The Chiari network was extending to coronary sinus in 57% cases and upto right atrial wall in in 42% of cases(significance or adverse event if any caused by it)

In four cases we had found the association between the Chiari network with left valve remnant,but we were not able to find out any study which shows the association of Chiari network with left valve remnant. Therefore , association of between the Chiari network with left valve remnant remains unclear.

6.9 Left Venous Valve Remnant

The remnant of left venous valve is observed as trabeculae over the fossa ovalis.

6.9.1Prevelence Of Left Venous Valve Remnant

Table 6.30 Prevalence Of Left Venous Valve Remnant

Study	Prevalence of Left Venous Valve remanant
D. Devi Jansirani	7.5%
AKM Monwarul Islam	-
Ashita Kaore	12%
Present Study	11%

Very few cases have reported the incidence of this rare anomaly in literature. In the present study, the incidence of left venous valve remnants was observed in 22 specimens out of 100 specimens (22%) which were very high as compared to other studies. Hence this finding was significant.

In the study by Ashita Kaore (2019) remnants of left venous valve were seen in 6 out 50 specimens studied (12%). The incidence of remnants of left venous valve was reported to be 7.5% by D Devi Jansirani *et al* (2015), whereas S. D Joshi *et al*., in 2016 reported only 1 case out of the 50 cadaveric hearts studied where he found the remnants in form of large number of fibrous strands in the anteroinferior part of fossa ovalis.

Study by E. D. U. Powell and J. M. Mullaney in 1960 observed this anamoly as a trabecular network in fossa ovalis in 3 out of 100 cadaveric hearts.

To the best of our knowledge, apart from case reports by N. M. Pinto *et al*., (2007), there is no echocardiographic study that had been reported about the incidence of left venous valve remnant. N. M. Pinto *et al*. observed this anamoly in 3 pediatric cases who were brought to the catheterisation lab for device closure of ASD. In spite of its rarity, the knowledge of left venous valve remnant is mandatory for the successful device closure of atrial septal defect.

In our study there were 11% left venous valve remnant present.

6.9.2 Morphology Of Left Venous Valve Remnant

Ashita Kaore (2019) observed the remnant of left venous valve as membranous structure multiple fenestrations in 2 cases and in the form of fine strands single or multiple in 1 and 2 cases respectively. The unfused part of the left venous valve can be seen in form of 2-3 stands attached to the limbus fossa ovalis in 1 case. D Devi Jansirani *et al*., observed this anamoly as fibrous strands in 3 cases and as trabecular membranous structure in 3 cases. E. D. U. Powell and J. M. Mullaney in 1960 observed this anamoly as trabecular network in fossa ovalis in 3 out of 100 cadaveric hearts. S. D Joshi *et al.*, in 2016 reported this anamoly as fibrous strands 0.5 -1cm length arising from fossa ovalis near its middle part and directed to the anteroinferior part of limbus fossa ovalis.

Table 6.31 Morphology Of Left Venous Valve Remnant

Study	No.Of Specimen	Incidence	Types
E. D. U. Powell and J. M. Mullaney (1960)	100	3**%** (3)	trabecular network in fossa ovalis in 3
N. M. Pinto *et al*., (2007)	-	(3)	-
D Devi Jansirani (2015)	80	7.5**%** (6)	fibrous strands in 3 cases and as trabecular membranous structure in 3 cases.
S. D Joshi *et al*. (2016)	50	2**%** (1)	fibrous strands 0.5 -1cm length arising
.Ashita Kaore (2019)	50	12**%** (6)	membranous structure : 2 single strands- 1 multiple strands- 2
Present study (2023)	100	22% (22)	

In a study done by D. Devi Jansirani et al, they had observed left venous valve remanent as multiple fine strand in three specimen and trabecular network in another three specimen. Left venous valve remnant was looking like multiple fibrous strand in

majority of cases followed by single fibrous strand and some of them were looking like trabecular membranous type. In present study Left venous valve remnant with fibrous multiple strand and trabecular membranous were found in 5 specimen each while fibrous single strand type was observed only in 1 specimen.

Left Venous valve also found associated with chiari network in present study it was observed in 36.36% of specimens

6.10 Limitation Of Study

The main limitation of this study is that all the measurements and observations were made on cadaveric heart specimens that have been fixed in formalin, which could cause some slight changes to the size and shape of the heart and relevant structures. Studies performed on cadaveric material may not directly correlate to the physiology of tissues in vivo. Therefore,cannot say anything about behavior changes of various valves,remnant of venous valve,papillary muscles,coronary sinus within the cardiac cycle. Despite these limitations, we believe that they do not impede our morphological analysis. It must be emphasized, that the choice of the appropriate access to the normal and variations of structures present in the right atrium, right ventricle and left ventricle should be carried out based on a comprehensive assessment of the patient's anatomy and clinical condition.