Original Article

Anatomical & Histological Study to Explore Possible Connections Between Ascending Aorta & Pulmonary trunk

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Abstract

Introduction: Our previous study described additional connection between ascending aorta & pulmonary trunk with absence of Tendon of Infundibulum in between them. But no comprehensive study was conducted so far regarding the detailed analysis of the structure of such connections.

Methods: A descriptive observational study was conducted taking fifty-seven formalin fixed cadaveric specimens. All specimens were dissected between the aortic and pulmonary roots to detect the tendon of infundibulum or any other connection. Any measurement was taken by digital calipers.

Observations: No fascial band was found at the root of ascending aorta and pulmonary trunk. But additional band like connections were observe in between them fifty-four cases. The Haematoxylin-Eosin Masson's Trichrome, Verhoeff's & Gomori's Silver stains revealed variable composition of such connections. Among them 70.3 percent connections showed a dens zone inside.

Conclusion: The prime fibre of the connections are collagen. But the dense zone inside the connection showed a variable composition of collagen, elastic & reticulin fibres.

Key words: Tendon of Infundibulum, Haematoxylin-Eosin, Masson's Trichrome, Verhoeff & Silver nitrate.

Introduction

Cardiac anatomy is indispensable for the proper understanding of cardiac disease. But, some anatomical structures like Tendon of Infundibulum within the heart still remain as a unanswered question. There have been many references describing its presence between the aortic and pulmonary roots [1, 2, 3]. But the presence or absence of such a tendon or ligament (conus tendon) has not been confirmed and furthermore proper function of such a tendon has not been yet established. Interestingly, many medical textbooks and atlases still keep using such terminology but on the other hand the presence or absence of such a structure has never been mentioned in the context of surgical procedures taking place on the ventricular outflow tracts [1, 2, 3]. Moreover, we, the authors found and reported some other connections between ascending aorta & pulmonary trunk in few cases which were primarily collagenous in nature[4]. But further study is essential to establish the nature and distribution of such connections.

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Aims & Objectives

The purpose of the present study is to find out the existence & nature of additional connections between ascending aorta & pulmonary trunk and to search for any tendinous structure (like tendon of infundibulum) at the root of these great vessels.

Materials & Methods

A descriptive observational study with cross sectional design of data collection was conducted in Calcutta National Medical College & Hospital over a period of six months. Only the undamaged formalin fixed hearts of either sex were selected for study. Persons died of any cardiovascular cause (obtained from death certificates), any macroscopic pathological changes of the specimens of hearts and any visible injury of the specimens of hearts were excluded from the study. All the specimens will be prosected and fixed in 10% formalin solution. All specimens will be dissected between the aortic and pulmonary roots, to detect the tendon of infundibulum or any other connection. Special care will be taken during the dissection to visualize the space between the aortic and pulmonary roots from different planes. If any connection will be found the length and width of such connection was measured with the help of the digital calipers. The connections will be cut meticulously from both ends. Cases where tendon of infundibulum or any other connection were absent, tissues adjacent to the root of great vessels were collected by making serial sections. Both types of specimens were processed for histological examination and stained by haematoxylin-Eosin, Masson's Trichrome, Verhoeff's & Gomori's Silver impregnation methods.

Observations & Results

Fifty-seven cadaveric specimens of heart were dissected. Average age of the cadavers was 66.61 years with standard deviation of 8.4869 years (range=48-82 years). The commonest cadaveric age was 68 years. Among the cadavers 78.95% cases were male & rests were female. 87.72% cadavers were Hindu & rests were Muslim. Three cases were obtained where no visible communication was observed between ascending aorta & pulmonary trunk. Tendon of Infundibulum was also not found at the root of the vessels in any case. Among the rest of the cases single communication was observed in each case. The communications appeared to be a band. However, multiple bands did not be found in any case. The average length & width of the bands were 20.11mm with standard deviation of 3.89 mm (range=12.3-27.32mm) and 3.15 with standard deviation of 0.71 mm (range=1.92-5.51mm) respectively. No significant difference in average values were observed between male & female or between Hindu & Muslim. (Table-I) ($p>0.05$). No significant correlation was obtained between age and different parameters (length & width) of the band (Table-II)

Composition of band like connections between Ascending Aorta & Pulmonary Trunk:

Thirteen cases (24.07%) showed pure connective tissue band and the others were mixture of fatty and connective tissue (75.93% cases). Regarding the connective tissue component, the special stains showed four cases pure collagen fibres (7.4%), two cases of mixed collagen & elastic fibres (2.7%), ten cases of mixed collagen & reticulin fibres (18.51%). Thirty-eight cases showed mixture of all three types of fibres (70.37%).

Among all types of bands observed in fifty-four cases, thirty-eight cases (70.37%) show dense connective tissue zone inside the band. Special stain revealed that connective tissue thickening was made up of collagen fibres in thirty-two cases (84.21%) (Fig-1), elastic fibre in one cases (2.63%) (Fig-2) & reticulin fibres in three cases (7.89%) (Fig-3) respectively. Moreover, one case of mixed dens zone of collagen with elastic fibres (2.63%) and one case of collagen with reticulin fibres (2.63%) were also found.

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The other bands (Where no specific thickened area of connective tissue was absent) shows a mixture of collagen, elastic & reticulin fibres except in three cases where a mixture of collagen & reticulin fibres were noted (18.75%).

Composition of tissue obtained from the root where band like connections were absent (three cases):

Area in between the cardiac muscles showed the homogeneous distribution of connective tissue without any specific dense zone. The collagen fibres are present in all cases along with reticulin and elastic fibres in first & second cases respectively. The third specimen showed a mixture of all types of fibres (collagen, elastic, reticulin).

Table-I: Mean length & width of the bands with standard deviation, mode & range according to gender, race. (n=54)

Length of the band (mm)						
		Mean	**Standard Deviation**	**Mode**	**Range**	**Test of significance**
Gender	**Male (n=44)**	20.198	3.8657	12.3	12.3-27.32	T Statistic = 0.3362 P-value = 0.7381
	Female (n=10)	19.736	4.184	14.4	14.4-24.86	
Race	**Hindu (n=48)**	19.9527	4.0170	12.3	12.3-27.32	T Statistic = 0.8511 P-value = 0.3986
	Muslim (n=6)	21.39	2.5485	18.22	18.22-24.34	
Width of the band (mm)						
		Mean	**Standard Deviation**	**Mode**	**Range**	**Test of significance**
Gender	**Male (n=44)**	3.1414	0.7243	2.86	1.92-5.51	T Statistic = 0.1137 P-value = 0.9099
	Female (n=10)	3.17	0.6925	1.94	1.94-3.88	
Race	**Hindu (n=48)**	3.1442	0.7452	2.86	1.92-5.51	T Statistic = 0.0723 P-value = 0.9427
	Muslim (n=6)	3.1667	0.3943	2.67	2.67-3.72	

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Table-II: Correlation among length & width of the band with age (n=54)

Parameter	Length of the band (mm) (n=54) [L]		Width of the band (mm) (n=54) [W]	
Age (Years)	r= 0.1	r^2 =0.01	r=0.17	r^2 =0.03
	= 0.048+16.957×**L**		= -0.015+4.108×**W**	

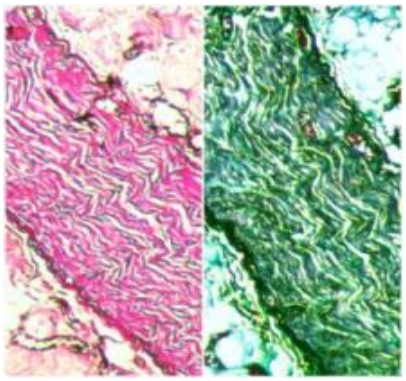

Fig-I: Dense zone of collagen fibres in a fatty-connective tissue band (Special stain- Masson's Trichrome)

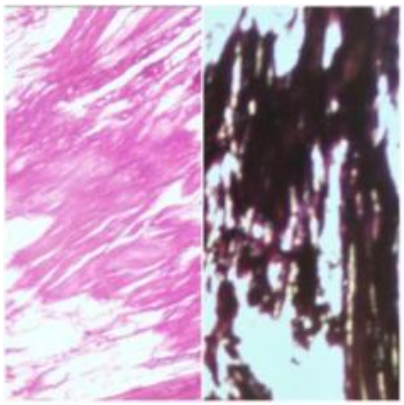

Fig-II: Dense zone of elastic fibres in a fatty-connective tissue band (Special stain- Verhoeff's)

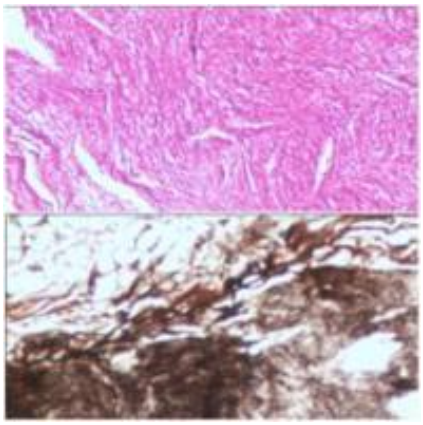

Fig-III: Dense zone of reticulin fibres in a fatty-connective tissue band (Special stain- Gomori's Silver impregnation)

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Discussion

Mall (1911)[5] was the first author who described the tendon of infundibulum as a part of the fibrous skeleton of the heart. He defined it as a structure occupying the region between the right side of the aorta, opposite the right coronary cusp of the aortic valve below the right coronary artery and the facing wall of the pulmonary trunk. Zimmerman and Bailey (1962)[6] said that the Ligamentum of Conus serves as a rope between the aortic and pulmonary roots, which permits a certain degree of torsional movement between them, while preventing them from being torn asunder by differentially directed ejaculatory forces of the ventricles. However, in their paper no macroscopic or histological picture was shown to prove their findings. Walmsley and Watson (1978)[7] illustrated that the fibrous skeleton of the heart contains a strip of tendinous-like fibrous tissue known as Conus ligament. Interestingly Gray's Anatomy[1] still retains two illustrations of the fibrous skeleton of the heart.

McAlpine (1975)[8] was the first researcher who was unable to demonstrate the tendon of infundibulum in his dissections and he described the connection as 'fascia', the connective tissue between the aortic and pulmonary roots. Furthermore, Lal et al. (1997)[9] were also unable to detect any fibrous structure connecting the aortic and pulmonary roots. However, they were able to identify only one specimen showing the so-called fascia or fascial bands. In addition, these fascial bands do not correspond to the initial description of the tendon of infundibulum and furthermore they cannot be defined as the tendon of infundibulum.

Loukas M et al. (2001)[10] could not demonstrate macroscopically or histologically any structure which could be significantly approximating to the initial description of the tendon of infundibulum. They described that entire heart encompassed by many fascial bands made up of connective tissue and the fascial bands were not concrete structures and could not be termed 'tendons'. Bhattacharya S et al. (2017)[4] described that Ascending aorta & Pulmonary trunk was connected with each other by connective tissue and no classical band was found at the root of the blood vessels.

Conclusion

The present study supports the findings of McAlpine (1975)[7], Lal et al. (1997)[9] and also our previous study, Bhattacharya S et al. (2017)[4]. These communications between ascending aorta and pulmonary trunk are made up of pure connective tissue or a mixture of fatty-connective tissue. Different morphometric parameters of such connections had no specific gender & racial predisposition and had no correlation with age. It may be situated at the root or at higher level. A significant number of communications also showed a dense zone inside that is made up any of the fibres (collagen, elastic, reticulin) or a mixture of different fibres.

Whether this can be called 'a band within a band' is a matter of debate but the present study described some new findings that have to correlate with health & disease in future.

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