Study on direction and arrangement of muscle pattern in cadaveric hearts

Pandit TK, Nimmgadda HK

ABSTRACT

Background: Knowledge of the muscle pattern in the heart is important to understand cardiac contraction and propagation of the electric stimulus. Knowledge about arrangement of cardiac muscle is very less in available literatures.

Aim: To study the orientation of cardiac muscle by gross dissection.

Methods: Twenty five hearts were procured from embalmed cadavers during routine dissection hours. The hearts were properly cleared by blunt dissection. Using hand lens the pattern of arrangement of cardiac muscle was observed in each chamber on both surfaces. The direction of fibers of each heart were noted and analyzed.

Results: The arrangement of cardiac muscle fibers was seen in three directions, longitudinal, transverse and oblique. In both atria mostly transverse and rarely longitudinal fibers were seen where as in both the ventricles transverse as well as oblique fibers were seen.

Conclusions: The arrangement and the direction of the muscle fibers determine the proper function of the heart. So the better understanding of the arrangement of muscle fibers can be used more effectively to correct impaired heart function during the heart surgery.

Keywords: cardiac muscle fibers, direction of fibers, human cadaveric hearts

INTRODUCTION

The walls of the heart are composed of a thick layer of cardiac muscles, the myocardium. The muscle fibers of the heart are arranged in different directions. It could be oblique, transverse or longitudinal. The arrangement of the muscle pattern is important for the contraction of the heart. The atrial portion of the heart has thin wall as compared to the ventricle which has thick wall.

Atrial fibers are arranged in two layers, superficial layer which are transverse fibers and deep layer which are looped and annular fibers.[1] Ventricular fibers are also arranged in two layers, superficial layer which is arranged spirally (clockwise as seen from the apex) and deep layer which consists of horizontal bundles in S –shape. The muscle fibers are made up of two separate rather complex systems of spiraling and looping bundles of fibers, one for atrium and one for ventricles.[2] The ventricular wall is thickest near the cardiac base and thins to 1-2 mm at the apex.

Characteristically, the muscle bundles at the apical portion are thin, but there are also thicker bundles and very fine strands that may be mistaken for pathologies while imaging. Transmurally through the ventricular wall, the myoarchitecture has a typical arrangement of myocardial strands that change orientation from being oblique in the subepicardium to circumferential in the middle and to longitudinal in the subendocardium. The circumferential portion is the thickest while the longitudinal portion the thinnest. In hypertrophied ventricle the circumferential portion is reduced. In combination with alterations in the quality and quantity of the connective tissue matrix, myoarchitecture impacts on myocardial function. The direction of the cardiac muscle fibers in subepicardial region had shown differences in pattern in different individuals. But literature is insufficient regarding the arrangement of cardiac muscle in the subepicardial region. The present study is taken up to establish the organization of cardiac muscle pattern in cadaveric hearts.

MATERIALS AND METHODS

The present study was conducted in Mahatma Gandhi Mission's Institute of Health Sciences. After obtaining ethical approval, a total 25 hearts were procured from embalmed cadavers; dissection method was carried out following Cunningham's manual of practical anatomy.[3] Pericardium was reflected from the heart. Heart was incised at the roots of great vessels and removed separately. The hearts were properly cleared by blunt dissection removing the pericardial fat on the wall of each heart. With the help of hand lens the pattern of arrangement of cardiac muscle was observed in each chamber on both surfaces. The direction of fibers of each heart were noted and analyzed.

RESULTS

The arrangement of cardiac muscle fibers was seen in three directions, longitudinal (fig.1), transverse (fig.2) and oblique (fig.3). The arrangement of the muscle fibers in the atrium was usually transverse but rarely longitudinal. Transverse fibers were seen in 100% cases posteriorly in both atria, where as in 16% cases longitudinal fibers were seen on anterior surface of right atrium. The ventricles did not show the presence of longitudinal fibers. The presence of fibers in different directions was shown in table-1.

Table: 1. Percentages of direction of fibers in two views of different chambers

Anterior view		Posterior view	
Right atrium	Transverse fibers =84%	Right atrium	Transverse fibers =100%
	Longitudinal fibers=16%		
Left atrium	Transverse fibers =100%	Left atrium	Transverse fibers =100%
Right ventricle	Transverse fibers =84%	Right ventricle	Transverse fibers =88%
	Oblique fibers =16%		Oblique fibers =12%
Left ventricle	Oblique fibers =100%	Left ventricle	Transverse fibers =24%
			Oblique fibers =76%

Fig. 1. Cardiac fibers in longitudinal direction

Fig. 2. Cardiac fibers in transverse direction

Fig.3. Cardiac fibers in oblique direction

DISCUSSION

The tissues that comprise the myocardium, as well as the adjacent tissues of the endocardium and pericardium, are continuous, which implies that cardiac muscle is one single tissue that wraps around itself to form the heart. This unity allows for very efficient contractions, which maintains the ejection fraction. The myocardial tissue in the normal heart spirals up from the base of the apex, causing a series of clear intersections of cardiac muscle tissue. Proper cardiac contraction depends on these definite tissue crossing patterns, which in turn leads to an effective ejection fraction from the given stroke volume. To be specific, the double spiral formation of the myocardial tissue allows a 60% increase in ejection fraction with a fiber shortening of 15%.

Myoarchitecture has been and remains a contentious issue right from the early days. Based on investigation techniques, some argue that there are discreet systems of myocyte arrangements in each ventricle while others insistent of a single rope like configuration that encompass both ventricles.[4,5] Even in more recent years, using advanced reconstruction techniques and imaging tools there is much discussion on this subject.[6,7,8] Despite obvious limitations of gross dissections, the myocardial strands that are revealed using this basic technique provide a guide to the general longitudinal orientation of the myocytes and serve as an overview of myocyte arrangement, the myoarchitechture.[9,10,11,12]

On gross dissection, the ventricular wall comprises three layers according to the longitudinal alignment of the myocardial strands, superficial, middle and deep. Importantly, these layers represent changes in orientation of the myocardial strands transmurally. They are not separated by cleavage planes or sheets of fibrous tissue since strands of one layer interconnect with the strands of the next layer in a continuum.[13] When traced from the base to apex, the superficial layer extends from one ventricle to the other. The myocardial strands arise from the insertions of the cardiac valves at the cardiac base. The superficial strands on the sternocostal aspect run obliquely crossing the interventricular groove, sweep leftward over the obtuse margin and descend towards the cardiac apex. At the vortex of the left ventricle, the myocardial strands invaginate in a spiral pattern to give rise to subendocardial layer. There is a similar continuity between superficial and deep layers at the base of the ventricle.

Necrosis of myocardial tissue, as a result of an infraction, for example, alters the ventricular geometry and thus causes the muscle fibers to weaken and impairs the effect of the intersectional contraction of the individual pairs of cross-linked cardiac fibers. The weakened tissue causes the ventricle to dilate from its elliptical formation into a spherical shape, which diminishes the function of the left ventricle and causes the ejection fraction and stroke volume to decrease drastically.

CONCLUSIONS

The arrangement and the direction of the muscle fibers determine the proper function of the heart. So the better understanding of the arrangement of muscle fibers can be used more effectively to correct impaired heart function during heart surgeries.

ACKNOWLEDGEMENT

The authors cordially thank Dr. Aruna Mukherjee, Professor and Head, department of Anatomy, for giving her valuable suggestions and queries related to the topic.

AUTHOR NOTE

Tinku K Pandit, Post graduate
Haritha K Nimmagadda, Lecturer,
(**Corresponding Author**);
email:haritha_anat@yahoo.com
Department of Anatomy, Mahatma Gandhi Mission's Institute of Medical Sciences, Navi Mumbai

REFERENCES

1. G. J. Romances. Cunningham's Manual of Practical Anatomy. 15th Edition. Oxford Medica Publication. Vol.2. Pg No.65.
2. E.C.B Hall Craggs. Structure of heart. Anatomy as a basis for clinical medicine. 3rd Edition. Pg No.194.
3. Keith L. Moore, Arthur F. Dalley. Clinically Oriented Anatomy. 5th Edition. Lippincott Williams & Wilkins. Pg No.143.
4. Mall FP. On the muscular architecture of the ventricles of the human heart. *Am J Anat* 1911, 11:211-66.
5. Grant PP. Notes on the muscular architecture of the left ventricle. *Circulation* 1965, 32: 301-8.
6. Lunkenheimer PP, Redmann K, Kling N, Jiang X, Rothaus K, Cryer CW.et al. Three-dimensional architecture of the left ventricular myocardium. *Anat Rec A Discov Mol Cell Evol Biol*. 2006 Jun;288(6):565-78.
7. Wu EX, Wu Y, Tang H, Wang J, Yang J, Ng MC, et al. Study of myocardial fiber pathway using magnetic resonance diffusion tensor imaging. *Magn Reson Imaging*. 2007 Sep;25(7):1048-57.
8. Buckberg GD. Architecture must document functional evidence to explain the living rhythm. *Eur J Cardiothorac Surg*. 2005, 27: 202-9.
9. McLean M, Prothero J. Determination of relative fiber orientation in heart muscle: Methodological problems. *Anat rec*. 1992, 232:459-65.
10. Lev M, Simkins CS. Architecture of human ventricular myocardium. *Lab Invest*. 1956, 5:396-409.
11. Greenbaum R, Ho SY, Gibson DG. Left ventricular fiber architecture in man. *Br Heart J*. 1981, 54:248-63.
12. Fernandez- Tern MA, Hrule JM. Myocardial fiber architecture of the human heart. *Anat rec.* 1982, 204:137-47.
13. Siew Yen Ho. Anatomy and myoarchitecture of the left ventricular wall in normal and in disease. *Eur j Echocardiogr*.2000. 10 (8):iii3-iii7