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Research Paper

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Laws of Arterial Elasticity or Muscularity

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ABSTRACT

In order to create laws of arterial elasticity or muscularity segments of ascending aorta, coronary arteries, pulmonary trunk and pulmonary arteries were taken at constant levels during autopsy for histological study. In the tunica media of ascending aorta and pulmonary trunk density of elastic fibres was maximum but distal to aortico coronary junctions and bifurcation of pulmonary trunk density of elastic fibres was gradually decreasing from maximum to minimum in the tunica media of coronary arteries and pulmonary trunk. Density of smooth muscle fibres was observed to be minimum in tunica media of ascending aorta & pulmonary trunk but distal to aortico coronary junctions and bifurcation of pulmonary trunk density of smooth muscle fibres was increasing gradually from minimum to maximum in tunica media of coronary arteries and pulmonary arteries. On the basis of observations recorded in the present study following laws of arterial elasticity or muscularity were created by Dr. Keshaw Kumar.

(1) All the arteries expand during systole and contract during diastole of heart.

(2) Arterial expansion is directly proportional to arterial elasticity and arterial contraction is directly proportional to arterial muscularity.

(3) Arterial elasticity is directly proportional to arterial proximity to commencement of great arterial trunks from heart and arterial muscularity is directly proportional to arterial distance from commencement of great arterial trunks from heart.

INTRODUCTION

In the past Boucek et al (1963)1, Gross et al (1934)2, Parker (1958)3, Lukenheimer et al (1973)4,Spiro and Wiener (1963)5, observed elastic fibres in coronary arteries. Ahmed (1967)6, Foster (1909)7, Gerrity & Cliff (1972)8, Hass (1943)9, Haust et al (1965)10, Keech (1960)11, Pease (1955)12, Smith et al (1951)13, Saxton (1942)14, described elastic fibres in aorta. Gray et al (1953)15 and Keshaw Kumar (1995)16 studied elastic fibres in ascending aorta and pulmonary trunk. Keshaw Kumar (2001)17 discussed microstructure of human arteries. McDonald (1957)18 showed collagen and elastin content of arterial wall. Wehn (1957)19 reported pulsatory activity of peripheral arteries.

Why do different arteries have a different structure? Why an artery is elastic or muscular? These questions were seldom asked but never answered. Therefore, present study was conducted to compare density of elastic fibres and smooth muscle fibres in tunica media of ascending aorta, coronary arteries (systemic circulation) pulmonary trunk and pulmonary arteries (pulmonary circulation) correlating the function of elastic fibres and smooth muscle fibres during arterial pulsation (arterial expansion and arterial contraction) so that the real cause of elasticity or muscularity of human arteries could be explained.

MATERIAL AND METHODS

During autopsy segments of ascending aorta, coronary arteries, pulmonary trunk and pulmonary arteries from 100 human adults were taken immediately after their death due to accidents after knowing history from their relatives that they were not suffering from any cardiovascular disease. Segments of ascending aorta and pulmonary trunk were taken immediately distal to their commencements while segments of coronary arteries and pulmonary arteries were taken 5 cm., 10 cm. and 15 cm. distal to their commencements from ascending aorta and pulmonary trunk respectively. The segments were preserved in 10% formalin. Sections of 10 micron thickness were cut with the help of rotary microtome to be stained with orcein and counterstained with hematoxylin and eosin.

Tunica media of each artery was graded for elastic fibres and smooth muscle fibres as +, ++, +++, ++++, according to density of elastic fibres and smooth muscle fibres per magnified field with + representing the lowest density and ++++ representing the highest density of elastic/smooth muscle fibres. All the observations were made by visual assessment by a single observer.

OBSERVATIONS

(Table I & II)

Tunica media of ascending aorta and pulmonary trunk showed ++++ density of elastic fibres and + density of smooth muscle fibres (Fig. 1).

Tunica media of pulmonary arteries 5 cm distal to their commencements from pulmonary trunk and tunica media of coronary arteries 5 cm distal to their commencement from ascending aorta showed +++ density of elastic fibres and ++ density of smooth muscle fibres (Fig-2).

Tunica media of pulmonary arteries 10cm. distal to their commencement from pulmonary trunk and tunica media of coronary arteries 10 cm distal to their commencement from ascending aorta showed ++ density of elastic fibres and +++ density of smooth muscle fibres (Fig. 3).

Tunica media of pulmonary arteries 15 cm. distal to their commencement from pulmonary trunk and tunica media of coronary arteries 15 cm. distal to their commencement from ascending aorta showed + density of elastic fibres and ++++ density of smooth muscle fibres (Fig. 4).

Table- I

Density of elastic fibres and smooth muscle fibres in tunica media of ascending aorta and coronary arteries

Fibres	Ascending aorta	Coronary artery 5cm distal to its commencement	Coronary artery 10 cm distal to its commencement	Coronary artery 15 cm distal to its commencement
Elastic	++++	+++	++	+
Smooth muscle	+	++	+++	++++

Table- II

Density of elastic fibres and smooth muscle fibres in tunica media of pulmonary trunk and pulmonary arteries

Fibres	Pulmonary trunk	Pulmonary artery 5 cm distal to its commencement	Pulmonary artery 10 cm distal to its commencement	Pulmonary artery 15 cm distal to its commencement
Elastic	++++	+++	++	+
Smooth muscle	+	++	+++	++++

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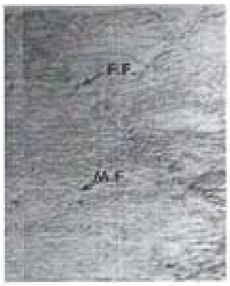

Fig. 1

Transverse section of ascending aorta showing ++++ density of elastic fibres and + density of smooth muscle fibres in its tunica media (Orcein X 100) (E.F.-Elastic Fibres ; M.F.-Smooth Muscle Fibres)

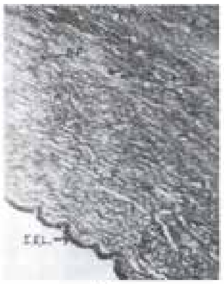

Fig. 2

Transverse section of left pulmonary artery 5cm distal to its commencement showing +++ density of elastic fibres and ++ density of smooth muscle fibres in its tunica media (Orcein X 100) (E.F.-Elastic Fibres ; M.F.-Smooth Muscle Fibres; I.E.L.-Internal Elastic lamina)

Fig. 3

Transverse section of right coronary artery 10cm distal to its commencement showing ++ density of elastic fibres and +++ density of smooth muscle fibres in its tunica media (Orcein X 100) (E.F.-Elastic Fibres ; M.F.-Smooth Muscle Fibres; I.E.L.-Internal Elastic lamina)

Fig. 4

Transverse section of right pulmonary artery 15cm distal to its commencement showing + density of elastic fibres and ++++ density of smooth muscle fibres in its tunica media (Orcein X 100) (E.F.-Elastic Fibres ; M.F.-Smooth Muscle Fibres; I.E.L.-Internal Elastic lamina)

DISCUSSION

In 1879 Lister (cited by Wehn 1957)19 pointed out that if surgeon exposes an artery which is neither angulated nor compressed by the examiner's finger, he does not find that he is dealing with a body that swells at every pulse, but with one of unvarying dimensions. This observation had also been made by Von Haller (1760) and Bichat (1803) cited by Wehn (1957)19. If arteries do not expand in systole, then some restraining mechanism must be operating. Wehn (1957)19 has studied this problem and has suggested that the muscular coat of large arteries contracts during systole. It had been thought that smooth muscle was incapable of such rapid rates of contraction but as Wehn (1957)19 points in embryos and in lower organisms the peripheral vessels contract rhythmically in this way and are responsible for the circulation of blood. Even when the heart develops it does so as a specialized type of arterial segment, so there is nothing inherently impossible about the concept that muscular arteries may be contracting rhythmically with each heart beat and that this contraction is controlled and serves some purpose.

Heart beat per minute corresponds with the arterial pulsation per minute and arterial pulsation consists of arterial expansion followed by arterial contraction. Elasticity of an artery depends upon the density of elastic fibres in its tunica media (Keshaw Kumar 2001)17 and muscularity of an artery depends upon the density of smooth muscle fibres in its tunica media. During systole of heart, expansion in artery occurs according to its elasticity and during diastole of heart, contraction in an artery occurs according to its muscularity (Keshaw Kumar 2001)17. In the present study it is observed that as we proceed towards the commencement of great arterial trunks (Ascending aorta and pulmonary trunk) gradually elasticity of an artery increases and muscularity decreases and as we proceed away from the commencement of great arterial trunks gradually muscularity of an artery increases and elasticity decreases. Ahmed (1967)6, Foster (1909)7, Gerrity & Cliff (1972)8, Hass (1943)9, Haust et al (1965)10, Keech (1960)11, Pease (1955)12, Smith et al (1951)13 and Saxton (1942)14 reported maximum distribution of elastic fibres in tunica media of ascending aorta which resembles with the findings obtained in the present study where ++++ density of elastic fibres in tunica media of ascending aorta was observed.

Ascending aorta commences from left ventricle and pulmonary trunk commences from right venticle of heart, 60ml. volume of blood (stroke volume) enters the lumen of these arteries during systole with a difinite velocity and pressure, therefore, there is maximum expansion in these arteries during systole of heart. In tunica media of ascending aorta and pulmonary trunk density of elastic fibres was ++++ to permit maximum arterial expansion. Blood pressure produced in ventricles during systole of heart is sufficient to push the 60 ml. column of blood forwards, therefore, least contraction of ascending aorta and pulmonary trunk is required to propell this column of blood forwards. This is the reason that density of smooth muscle fibres in tunica media of ascending aorta and pulmonary trunk is + . In the present study ++++ density of elastic fibres noticed in the tunica media of ascending aorta and pulmonary trunk supports the results obtained by Gray et al (1953)15 and Keshaw Kumar (1995, 2001)16,17 in the tunica media of ascending aorta and pulmonary trunk where they observed maximum distribution of elastic fibres. Expansion decreases and contraction increases gradually as the arteries proceed away from the commencement of great arterial trunks from heart because velocity and pressure of blood ejected from the ventricles gradually diminishes in the arterial tree and to maintain this velocity and pressure of blood inside the lumen of arterial tree situated away from the commencement of great arterial trunks from heart contraction of arteries is required higher and higher in the same proportion in which velocity and pressure of blood is reduced. This is the reason that density of smooth muscle fibres increases gradually and density of elastic fibres decreases gradually in the tunica media of arterial tree as we proceed away from the commencement of great arterial trunk from heart. Function of elastic fibres is to allow expansion while the function of smooth muscle fibres is to produce contraction in the arteries. Findings obtained in the present study revealed that density of elastic fibres gradually decreases in the tunica media of coronary arteries while we proceed distal to aorticocoronary junctions. Boucek et al (1963)1, Spiro and Wiener (1963)5 Gross et al (1934)2, Parker (1958)3, Lukenheimer et al (1973)4 also advocated that distribution of elastic fibres in the tunica media of coronary arteries diminished gradually distal to their commencement from ascending aorta.

Arterial expansion is possible only during systole while arterial contraction is possible only during diastole of heart. Hypothesis of Haller (1760) Bichat (1803) Lister (1879) cited by Wehn (1957)19 that arterial contraction occurs during systole of heart is not correct because in this situation on one hand arterial contraction will try to close the aortic and pulmonary valves and on the other hand ventricular contraction will try to open these valves, therefore, it will not be possible to propell the column of blood forwards. During diastole of heart contraction of arterial tree is possible because in this situation aortic and pulmonary valves remain closed and blood can not return back to the left and right ventricles from ascending aorta and pulmonary trunk respectively as a result of contraction of arterial tree. During diastole of heart contraction of arterial tree helps to propell the blood forwards. During systole of heart arterial tree expands to accomodate 60ml extra volume of blood ejected by left and right ventricles in systemic and pulmonary circulation in which lumen of arterial tree remains always full of blood in a living person. Arterial contraction during diastole of heart also helps to close the aortic and pulmonary valves. On the basis of these observation following laws of arterial elasticity or muscularity were created by Dr. Keshaw Kumar.

1. All the arteries expand during systole and contract during diastole of heart.

2. Arterial expansion is directly proportional to arterial elasticity and arterial contraction is directly proportional to arterial muscularity.

3. Arterial elasticity is directly proportional to arterial proximity to commencement of great arterial trunks from heart and arterial muscularity is directly proportional to arterial distance from commencement of great arterial trunks from heart.

REFERENCE

Boucek, R.J. Takashita, R. and Fojaco R. : Relation between microanatomy and functional properties of the coronary arteries (dog) Anatomical Record (1963) 147 : 1999. | 2. Gross, L.E, Epstein Z. and Kugel, M.A. : Histology of coronary arteries and their branches in the human heart. American Journal of Pathology (1934), 10 pp 253-274. | 3. Parker, F. : An electron microscopic study of coronary arteries American Journal of Anatomy (1958), 103 pp 247-259. | 4. Lukenheimer, P.P. and Merket, H.J. : Morphological studies on the functional anatomy of coronary circulation, Zanat, Entwield, Gech (1973), 142 : pp 65-90. | 5. Spiro, D.M.D. and Joseph Wiener, M.D. : Fine structure of coronary artery. Coronary Heart Disease (1963) p. 11. | 6. Ahmed, M.M. : Age and sex differences in the structure of tunica media of the human aorta. Acta Anatomica (1967) 66 : pp 45-58. | 7. Foster, L.L. : Changes occuring in the elastic fibres of the aorta with advancing age. Journal of Medical Research (1909) 2 : pp 297-311. | 8. Gerrity, R.G. and Cliff, W.J. : The aortic tunica intima in young and ageing rats. Experimental Molecular Pathology (1972) 16 : pp 382-402. | 9. Hass, G.M. : Elastic Tissue-Relation between the structure of the ageing aorta and the properties of isolated aortic elastic tissue, Archives of Pathology (1943) 35 : pp 29-45. | 10. Haust, M.D. Moore, R.H. Bencosme, S.A. and Balis, J.V. : Elastogenesis in human aorta-an electron microscopic study. Experimental Molecular Pathology (1965) 4 : pp 508-524. | 11. Keech, M.K. : Electron microscope study of the normal rat aorta. Journal of Biophysical and Biochemical Cytology (1960) 7 : pp 533-538. | 12. Pease, D.C. : Electron microscopy of the aorta Anatomical Record (1955) 121: pp 350-357. | 13. Smith, C. Seitner, M.M. and Wang, H.P. : Ageing changes in the tunica media of the aorta. Anatomical Record (1951) 109 : pp 13-39. | 14. Saxton, J.A. : Elastic properties of rabbit aorta in relation to age. Archives of Pathology (1942) 34: pp: 262-274. | 15. Gray, S.H. Nandler, F.P. Blache, J.O. Zuckner, J and Blumenthal, H.T. : Ageing process of aorta and pulmonary artery in negro and white races. Archives of Pathology (1953) 56: pp 238-253. | 16. Keshaw Kumar : Histological study of ascending aorta and pulmonary trunk in different mammals. Vijnana Parishad Anusandhan Patrika (1995) Vol. 33 No. 3 : pp 233-240. | 17. Keshaw Kumar : Microstructure of human arteries. Journal of Anatomical society of India (2001) 50 (2) : 127-130. | 18. McDonald, D.A. : The collagen and elastin content of the arterial wall in the dog. Proceedings of Royal Society. B. (1957) 146 : pp 541-551. | 19. Wehn, P.S. Pulsatory activities of peripheral arteries. Scandevenion. Journal of Clinical & Laboratory Investigations I. Supple (1957) 30 p 1 |