Volume : 4 | Issue : 7 | July 2015 • ISSN No 2277 - 8179

Research Paper

Arterial Segments Having Equal Length and Equal Pulsatory Power Have Equal Number of Smooth Muscle Fibres in Their Tunica Media"—Theory of Arterial Pulsation

Medical Science

KEYWORDS : Tunica media, Elastic fibres Smooth muscle fibres, Pulsatory power.

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ABSTRACT

During autopsy 10mm long arterial segments were obtained from ascending aorta, pulmonary trunk and femoral artery immediately distal to their commencements to be preserved in 10% formalin from 300 human adults not suffering from any cardiovascular disease in order to create theory of arterial pulsation. Lumen of each arterial segment was opened by cutting its wall longitudinally to measure lumen circumference and wall thickness. Paraffin sections of 10 micron thickness were cut and stained with orcein and counterstained with haematoxylin and eosin to observe densities of elastic fibres and smooth muscle fibres per magnified field in tunica media of each artery. Number of elastic/smooth muscle fibres in ascending aorta, pulmonary trunk and femoral artery was calculated by multiplying arterial wall areas with tunica medial densities of these fibres in the arteries. Arterial pulsatory power was calculated applying the second law arterial pulsation (Keshaw Kumar, 1993, 2015)11,12. It was observed that "arterial segments having equal length and equal pulsatory power have equal number of smooth muscle fibres in their tunica media"--Theory of arterial pulsation created by Dr. Keshaw Kumar.

INTRODUCTION

Effect of ageing in the tunica medial elastic fibres of aorta was studied by Foster (1909)[1], Hass (1943)[2], Saxton (1942)[3] and Smith et. al. (1951)[4], Gray et al (1953)[5] reported the effect of ageing in tunica medial elastic fibres of aorta as well as pulmonary artery. Ahmed (1967)[6] described the age and sex differences in tunica medial structure of human aorta. Laitinen (1963)[7] noticed the effect of experimental atherosclerosis in the elemental structure of aorta. Fischer (1971)[8] showed the effect of oestrogen on collagen and elastin dynamic in arterial wall. Keshaw Kumar (2002)[9] observed effect of tangential pressure of pulsation on tunica media of human arteries. present study was conducted to create theory of arterial pulsation which is not available in the literature as yet.

MATERIAL AND METHODS

10 mm. long arterial segments were obtained from ascending aorta, pulmonary trunk and femoral artery immediately distal to their commencements from 300 human adults immediately after their death due to accidents after knowing history from their relatives that they were not suffering from any cardiovascular disease. Arterial segments were preserved in 10% formalin. Lumen of each arterial seqment was opened by cutting its wall longitudinally to measure lumen circumference and wall thickness. Mean of the wall thickness and mean of the lumen circumference were calculated separately for ascending aorta, pulmonary trunk and femoral artery.

Paraffin sections of 10 micron thickness were cut to be stained with orcein and counter stained with haematoxylin and eosin. Each layer of arteries was graded for fibres +, ++, +++, ++++ according to density of elastic fibres as well as smooth muscle fibres with + representing the minimum and ++++ representing the maximum density of fibres. Results were obtained as visual assessments by a single observer to record tunica medial densities of elastic fibres and smooth muscle fibres per magnified field in each artery.

Number of ealstic fibres and smooth muscle fibres in tunica media of ascending aorta, pulmonary trunk and femoral artery was calculated by multiplying arterial wall areas with tunica medial densities of these fibres in the arteries. Arterial wall area was obtained by multiplying arterial length, arterial wall thickness and arterial lumen circumference with one another. (Keshaw Kumar, 1998)[10]. Pulsatory power of above arteries was calculated applying the second law of arterial pulsation i.e. "Pulsatory power of an artery is directly proportional to wall (tunica media) thickness of that artery having 1mm wall thickness is reported as 2000 Joule per heart beat (Keshaw Kumar 1993, 2015)[11,12].

OBSERVATIONS

Mean wall thickness of ascending aorta was 1.5mm while in case of pulmonary trunk and femoral artery it was 0.5mm (Table I). Mean lumen circumference of femoral artery was 15mm while in case of ascending aorta and pulmonary trunk it was 60mm (Table I).

Density of elastic fibres was ++++ in tunica media of ascending aorta (Fig. 1) as well as pulmonary trunk (Fig. 2) but in tunica media of femoral artery (Fig. 3) density of elastic fibres was + (Table II).

Table-I

Arterial wall area of arterial segments having equal length

Arterial segment	Arterial wall thickness	Lumen circumference	Length of arterial segment	Arterial wall area
Ascending aorta	1.5mm	60mm	10mm	900 mm^3
Pulmonary trunk	0.5mm	60mm	10mm	300 mm^3
Femoral artery	0.5mm	15mm	10mm	75 mm^3

Table-II

Tunica medial densities of elastic fibres and smooth muscle fibres in per magnified field of different arteries

Arteries	Density of elastic fibres	Density of smooth muscle fibres
Ascending aorta	++++	+
Pulmonary trunk	++++	+
Femoral artery	+	++++

Density of smooth muscle fibres was + in tunica media of ascending aorta (Fig. 1) as well as pulmonary trunk (Fig. 2) but in tunica media of femoral artery (Fig. 3) density of smooth muscle fibres was ++++ (Table II).

Arterial wall area of pulmonary trunk segment was four times greater than the arterial wall area of femoral arterial segment and arterial wall area of ascending aorta segment was thrice more than the arterial wall area of pulmonary trunk segment (Table I).

Ratio of 3:1 (Table VI) between number of elastic fibres (Table III) as well as smooth muscle fibres (Table IV) of ascending aorta pulmonary trunk equalled with ratio between pulsatory powers of these arteries (Table V). Pulmonary trunk segment and femoral arterial segment had equal number of smooth muscle fibres (Table IV, VII & VIII) and equal pulsatory powers (Table V & VIII) but in the number of elastic fibres a ratio of 16:1 was existing between pulmonary trunk segment and femoral arterial

Volume : 4 | Issue : 7 | July 2015 • ISSN No 2277 - 8179

segment (Table VII). Therefore, it was concluded that pulsatory power of an artery had its effects only on the number of smooth muscle fibres in tunica media of that artery. Arterial segments having equal length and equal pulsatory power have equal number of smooth muscle fibres in their tunica media--Theory of arterial pulsation created by Dr. Keshaw Kumar.

Table-III
Number of tunica medial elastic fibres in arterial segments having equal length

Arterial segments	Arterial wall area (mm³)	Density of elastic fibres	Number of elastic fibres
Ascending aorta	900	++++	900 x 4 '+'=3600+
Pulmonary trunk	300	++++	300 x 4'+' =1200+
Femoral artery	75	+	75 x1 '+'=75+

Pulsatory power of ascending aorta was 3000 Joule per heart beat while in case of pulmonary trunk and femoral artery it was 1000 Joule per heart beat (Table V).

Table-IV
Number of tunica medial smooth muscle fibres in arterial segments having equal length

Arterial segments	Arterial wall area (mm³)	Density of smooth muscle fibres	Number of smooth muscle fibres
Ascending aorta	900	+	900 x 1 '+'=900+
Pulmonary trunk	300	+	300 x 1'+' =300+
Femoral artery	75	++++	75 x4 '+'=300+

Table-V
Pulsatory power and number of the tunica medial elastic fibres & smooth muscle fibres in arterial segments having equal length

Arterial segments	Pulsatory power (Joule per heart beat)	Number of elastic fibres	Number of smooth muscle fibres
Ascending aorta	3000	3600+	900+
Pulmonary trunk	1000	1200+	300+
Femoral artery	1000	75+	300+

Table-VI
Ratio between number of tunica medial elastic fibres/ smooth muscle fibres in ascending aorta and pulmonary trunk segments having equal length

Fibres	Ascending aorta	Pulmonary trunk	Ratio
Number of elastic fibres	3600+	1200+	3:1
Number of smooth muscle fibres	900+	300+	3:1

Table-VII
Ratio between number of tunica medial elastic fibres/ smooth muscle fibres in pulmonary trunk and femoral arterial segments having equal length

Fibres	Pulmonary trunk	Femoral artery	Ratio
Number of elastic fibres	1200+	75+	16:1
Number of smooth muscle fibres	300+	300+	1:1

Table-VIII
Ratio between pulsatory powers and number of tunica medial smooth muscle fibres in pulmonary trunk and femoral arterial segments having equal length

	Pulmonary Trunk	Femoral artery	Ratio
Pulsatory power in Joule per heart beat	1000	1000	1:1
Number of tunica medial smooth muscle fibres	300+	300+	1:1

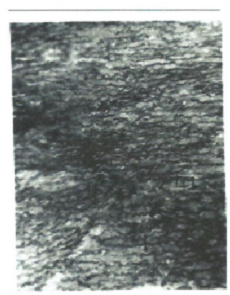

Fig-1. Transverse section of Human ascending aorta showing ++++ density of elastic fibres (EF) and + density of smooth muscle fibres (SMF) in tunica media. (TM) (Orcein X 100)

Fig-2. Transverse section of human pulmonary trunk showing ++++ density of elastic fibres (EF) and + density of smooth muscle fibres (SMF) in tunica media. (TM) (Orcein X 100)

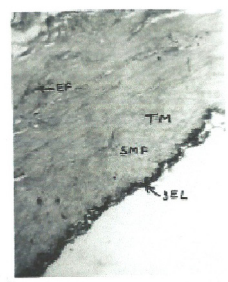

Fig-3. Transverse section of human femoral artery showing + density of elastic fibres (EF) and ++++ density of smooth muscle fibres (SMF) in tunica media. (TM) [Internal elastic lamina - IEL] (Orcein X 100)

DISCUSSION
Wehn (1957)[13] pointed that in embryos and in lower organisms the peripheral vessels contract rhythmically 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.

Keshaw Kumar (2001, 2015)[14,15] described that 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 and muscularity of an artery depends upon the density of smooth muscle fibres in its tunica media. During systole of heart arterial expansion occurs according to arterial elasticity and during diastole of heart arterial contraction occurs according to arterial muscularity.

Because elastic fibres and smooth muscle fibres are the only components related to pulsation in arterial tunica media, therefore, arterial pulsatory power must be effected by either both or one of these components. Answer of this question was not available in the literature that whether the arterial pulsatory power was effected by the arterial contraction only or by arterial expansion as well as arterial contraction both. Keshaw Kumar

(2002)[9] clarified that arterial pulsatory power was effected by the arterial contraction only and arterial expansion did not effect the arterial pulsatory power at all because pulsatory power was not effected by number of tunica medial elastic fibres in the arteries. Only the number of tunica medial smooth muscle fibres effected the arterial pulsatory power (Keshaw Kumar, 2002)[9]. Therefore arterial segments having equal length and equal pulsatory power will have equal number of smooth muscle fibres in their tunuca media- Theory of arterial pulsation created by Dr. Keshaw Kumar.

Finding obtained in the present work revealed + density of smooth muscle fibres and ++++ density of elastic fibres in the tunica media of ascending aorta which resembled with the observations made by Foster (1909)[1], Hass (1943)[2], Saxton (1942)[3], Smith et al. (1951)[4] and Fischer (1971)[8] who reported maximum distribution of elastic fibres and minimum distribution of smooth muscle fibres in tunica media of ascending aorta.

In the present study ++++ density of elastic fibres and + density of smooth muscle fibres noticed in the tunica media of pulmonary trunk support the results obtained by Gray et al. (1953)[5] where they found maximum distribution of elastic fibres and minimum distribution of smooth muscle fibres in tunica media of pulmonary artery as well as aorta.

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