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ORIGINAL ARTICLE

HISTOLOGICAL STUDY OF MEDIUM SIZED ARTERIES OF NECK IN RELATION WITH THEIR PULSE PRESSURE AND PULSATORY POWER

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ABSTRACT: INTRODUCTION: There are several studies on the microstructure of main arteries of the body but limited have been dealt with the neck arteries. It has been mentioned that the vascular pathologies like the thrombo-embolism, atherosclerosis and infarction are common in the branches of vertebral and internal carotid artery as compared to the branches of external carotid artery. **OBJECTIVE:** To study the histological structure of the 3 medium sized arteries of neck namely external carotid, internal carotid and vertebral artery, calculation of their mean pulse pressure and pulsatory power and to find any association between them if present. **METHOD:** Fresh samples of external carotid, internal carotid and vertebral artery each measuring 10mm in length were taken from five cadavers and prepared for histological examination under microscope using orcein and H&E stain. The mean pressure and pulsatory power of these arteries were calculated by taking the measurements such as wall thickness, lumen circumference, arterial wall area, and smooth muscle fibre density in tunica media in that arterial segment. **RESULT:** The pulsatory power of external carotid artery, internal carotid artery and vertebral artery is found to be 120, 273.3, 400 Joules /heart beat and the mean pressure is 17.1 mm Hg, 27.3 mm Hg and 33.3 mm Hg respectively. **CONCLUSION:** The thickness of tunica media of an artery is directly proportional to its pulsatory power. The mean pulse pressure, pulsatory power as well the number of smooth muscles fibres in tunica media are more in internal carotid artery and vertebral artery in comparison to external carotid artery. It may be a very important reason why vascular pathologies are less common in branches of external carotid as compare to internal carotid and vertebral artery.

KEYWORDS: neck arteries, mean pressure, pulsatory power, atherosclerosis.

INTRODUCTION: Histological structure of human arteries has been drawing attention of the workers for many years. The study of neck arteries has a special interest to Anatomists as well as clinicians. The common carotid artery, which is the main artery for head and neck region, gives two branches in the neck- external carotid and the internal carotid. The branches of external carotid artery supply the region of face & neck and the branches of internal carotid enter into the cranial cavity and supply the brain and the meninges. Vertebral artery, a branch of subclavian artery also enters the cranial cavity to supply the brain and meninges.[1]

All the vascular pathologies like the thrombo-embolism, atherosclerosis and infarction are common in the branches of vertebral and internal carotid artery as compared to the branches of external carotid artery. A study by Crouse JR identifies strong associations of coronary artery status with mean (near plus far wall) Intimal Medial Thickness (IMT) at each of three carotid segments as well as with the mean aggregate Intimal Medial Thickness.[2] Marsha L. also suggested that arterial diameters enlarge in response to wall thickening, plaque formation and other atherosclerotic risk

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factors. For both men & women right common carotid artery intimal medial thickness (IMT), lumen diameter & wall area were positively associated with baseline prevalent myocardial Infarction (MI) & with cardiac events.[3]

Antonio M. Orsi noted in Mongrel dog that the mean vascular diameter of ICA (2000 micron) is somewhat higher than ECA (1500 micron). He also mentioned that the medial layer in ICA and ECA in dog showed myoelastic histoarchitecture having predominance of smooth muscle fibres which may be due to local subjection to functional adaptations.[4]

It has been reported that the microstructure of all medium sized human arteries is not similar; it differs from artery to artery. There is variation in the structure of all its coats namely tunica intima, media and adventitia specially tunica media which is the thickest of the three coats. The tunica media of an artery consists of alternate layers of smooth muscles and elastic fibres, that of the medium sized arteries consist chiefly of smooth muscle cells arranged in circular or helical layers, so these are also known as muscular arteries.

The main function of these arteries is to distribute blood to various parts of the body hence these are also called distributing arteries. Since different parts of the body, under varied conditions of activity, require unequal amounts of blood, there is variation in the microstructure of this arteries.[5]

MATERIAL & METHODS: The external carotid, internal carotid and vertebral artery of neck region were studied. Five fresh samples of each of the artery were taken from five cadavers immediately after death after excluding the history of any cardiovascular involvement of the patient. 10mm long arterial segments were obtained from all arteries 1 cm distal to their commencement and the tissues were preserved in 10% formalin. For the measurement of lumen circumference each arterial segment was cut by longitudinal incision and was measured with the help of scale.

For the histological study, tissues were processed in graded alcohol; xylene and paraffin blocks were prepared. Paraffin section of 10micron thickness were cut with the help of rotary microtome and stained with orcein for elastic fibres and H & E staining for smooth muscle fibres. The single observer noted the density of elastic and smooth muscle fibres per magnified field. Maximum density was graded as 5+ and minimum as 1+. Nil means no smooth muscle/elastic fibres present in that magnified field.

Photomicrographs of magnified field were taken under 100 times magnification. For measuring the wall thickness (Tunica media) the section of each artery was measured between external & internal elastic lamina in mm after magnifying it 100 times on the screen of computer. Later dividing the measured thickness of arterial wall by 100, the actual arterial wall thickness of each artery was obtained. With these procedures following 3 parameters were recorded;

1. Lumen circumference.
2. Density of smooth muscle fibres in tunica media.
3. Arterial wall thickness/thickness of tunica media.

With the help of these 3 parameters the arterial wall area and the total number of smooth muscle fibres in that arterial segment was obtained.

ARTERIAL WALL AREA (mm^3) = Wall thickness x length of arterial segment (i.e. 10mm) x lumen circumference.

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TOTAL NUMBER OF SMOOTH MUSCLE FIBRES = Arterial wall area x density of smooth ms fibre per magnified field.

By using the above mentioned parameters and formulas we calculated the pulsatory power and mean pressure of External carotid (ECA), Internal Carotid (ICA) and the vertebral artery (VA).

Table IV was prepared to calculate the pulsatory power and mean pressure of these arteries.

PULSATORY POWER = Total no. of smooth muscle fibre in tunica media (Joules /heart beat) x 10/3. The value 10/3 or 3.33 joules/ heart beat is the Pulsatory power of a single smooth ms fibre.[6]

MEAN PRESSURE = Pulsatory Power/Volume of blood entering in the lumen during each heartbeat.

RESULTS: According to table I, II & III, the mean of the lumen circumference of ECA, ICA & VA is 7mm, 10.02mm & 12.2mm respectively, the mean arterial wall thickness of the 3 vessels is 0.17mm, 0.20mm & 0.25mm, the calculated mean arterial wall area is 11.9mm^3, 20.43mm^3 & 29.96mm,^{3} per magnified field tunica medial density of smooth muscle fibres is 3+, 4+ & 4+ and the mean of total number of smooth muscle fibres in TM is 36, 82 & 120 respectively. The mean of the lumen circumference is 7 mm in case of E.C.A.

It means that during each heart beat 7 ml of blood enters into the lumen of the artery because according to third law of arterial pulsation, lumen circumference of an artery in mm. equals to the volume of blood in milliliters entering the lumen of the artery during each heartbeat.[7] Similarly blood entering during each heartbeat in the lumen of ICA & VA is 10 ml & 12 ml respectively. By using the above mentioned parameters and formulas the pulsatory power of ECA, ICA & VA comes out to be 120, 273.3, 400 Joules /heart beat respectively and the mean pulse pressure is 17.1 mm Hg, 27.3 mm Hg and 33.3 mm Hg respectively.

DISCUSSION: In the present study it is revealed that the thickness of tunica media of medium size arteries of neck namely external carotid, internal carotid and vertebral artery varies considerably. It is minimum in ECA (0.17mm) followed by ICA (0.20mm) and VA (0.25mm). The pulsatory power required to propel blood forward into its different branches is also lowest in ECA (120 joules/heart beat) followed by ICA and VA (273.3 joules/heart beat and 400 joules/heart beat respectively). This shows that the thickness of tunica media of an artery is directly proportional to its pulsatory power as stated by Kumar Keshaw for large, elastic arteries.

According to him; the pulsatory power of an artery affects the number of smooth muscle fibre present in its tunica media but not the number of elastic fibres. Hence pulsatory power affects the arterial contraction, which is dependent on the number of smooth muscle fibres but not its expansion, which depends on the number of elastic fibres in the tunica media of an artery[6]. In the present study we have also found that the pulsatory power as well the number of smooth muscles fibres in tunica media is more in VA & ICA compared to ECA.

He has also mentioned that the arterial segments having equal length and equal pulsatory power have equal number of smooth muscle fibres in their tunica media as is seen for arterial segments 1 & 4 in table I and arterial segments 1 & 5 in table II. Hence what he found true for large arteries is also found to be true for medium sized arteries. The tunica medial density of smooth muscle fibres per magnified field as found in the present study in ECA is 3+, in ICA and VA is 4+. The density of smooth muscle fibres per magnified field in the tunica media of the 3 mentioned vessels is more as compared to the density of elastic fibres.

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Kumar Keshaw (2001) suggested that arterial elasticity is directly proportional to arterial proximity to the heart and arterial muscularity is directly proportional to arterial distance from the heart.[8] The 3 vessels chosen in this study are the muscular arteries hence the results.

The mean pulse pressure in our study is 17.1 mm Hg, 27.3mm Hg and 33.3 mmHg in ECA, ICA and VA respectively. Pulse pressure of an artery plays an important role in the structure of an artery because pulse pressure is a specific component of function of an artery. Wehn (1957) observed that pulse pressure varied considerably in peripheral arteries as is evident in the present study.[9] Frank (1905) found in his study that the pressure level in the major arteries was not uniform.

An abnormally high arterial pressure will undoubtedly increase the load born by the arterial wall. Not only the maximum pressure differs in the various arteries but in general the pulse pressure also increases towards the periphery.[10] Kumar Keshav also stated that increasing pulse pressure of blood might be a cause of atherosclerosis in arteries.[11] Hence higher pulse pressure in VA and ICA than ECA may be a contributory factor of various vascular pathologies in brain. Further Iain M.S. Wilkinson (1972) observed that as the vertebral artery enters the skull its adventitia and media undergo a significant reduction in thickness, associated with gross diminution or total loss of elastic fibres in these two layers of the artery wall. This transformation is most marked in the last 0.50 cm extradurally.[12]

CONCLUSION: Increasing pulse pressure, high pulsatory power, significant reduction in the wall thickness and loss of elastic fibres of vertebral artery and internal carotid artery as they enter the skull maybe the contributory factors of various vascular pathologies in brain as compared to face and neck which are supplied mainly by the external carotid artery.

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Sl. No.	Lumen circumference	Wall thickness	Arterial wall area	Density of smooth muscle fibre in T. media (Per magnified field)	Total no. of smooth muscle fibres in arterial segment
01	7mm	0.17mm	11.9 mm^3	3+	35.7 = 36
02.	6.8mm	0.16mm	10.88 mm^3	3+	32.6 =33
03	7.1mm	0.16mm	11.36 mm^3	3+	34.0 = 34
04.	7 mm	0.17 mm	11.9 mm^3	3+	35.7 = 36
05.	7.1mm	0.19mm	13.49 mm^3	3+	41.47 = 41

Table I: Total no. of Smooth muscle fibres in tunica media in each arterial segment of ECA

Sl. No.	Lumen circumference	Wall thickness	Arterial wall area	Density of smooth muscle fibre in T. media (Per magnified field	Total no. of smooth muscle fibres in arterial segment
01	10mm	0.20mm	20 mm^3	4+	80
02.	10.2mm	0.20mm	20.4 mm^3	4+	81
03	9.8mm	0.23mm	22.54 mm^3	4+	90
04.	10.1mm	0.19 mm	19.19 mm^3	4+	77
05.	10.0mm	0.20mm	20 mm^3	4+	80

Table II: Total no. of smooth muscle fibres in tunica media in each arterial segment of ICA

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Sl. No.	Lumen circumference	Wall thickness	Arterial wall area	Density of smooth muscle fibre in T. media (Per magnified field	Total no. of smooth muscle fibres in arterial segment
01	12mm	0.25mm	30 mm^3	4+	120
02.	12.2mm	0.24mm	29.04 mm^3	4+	116
03	12.5mm	0.24mm	30 mm^3	4+	120
04.	12.1mm	0.25 mm	30 mm^3	4+	120
05.	12.3mm	0.25mm	30.75 mm^3	4+	122.8=123

Table III: Total no. of smooth muscle fibres in tunica media in each arterial segment of VA

Name of the artery	Total no. of smooth muscle fibres in each arterial segment	Pulsatory Power Joules /Heart beat	Volume of blood entering during each heart beat (ml)	Mean Pulse pressure mm Hg
External Carotid A	36	120	7	17.1
Internal Carotid A	82	273.3	10	27.3
Vertebral Artery	120	400	12	33.3

Table IV: Calculation of Pulse pressure in ECA, ICA and VA with the help of number of smooth muscle fibres

Fig. 1: EXTERNAL CAROTID-H & E

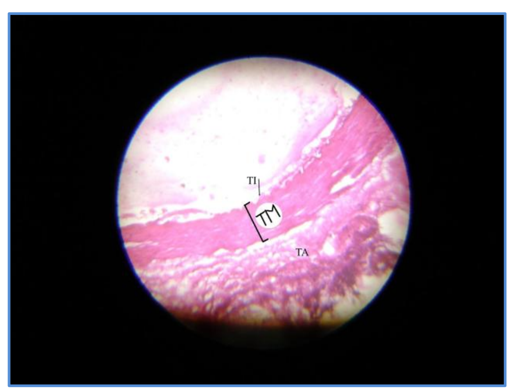

Fig. 2: EXTERNAL CAROTID-Orcein

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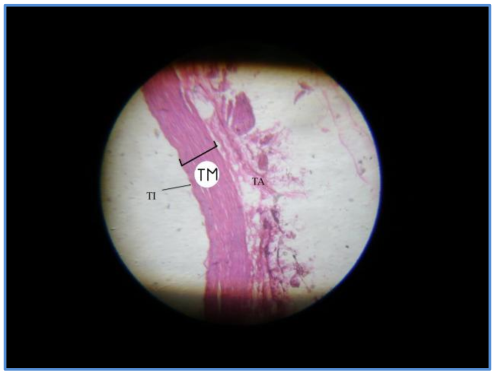

Fig. 3: INTERNAL CAROTID- H&E

Fig. 4: INTERNAL CAROTID ARTERY- orcein

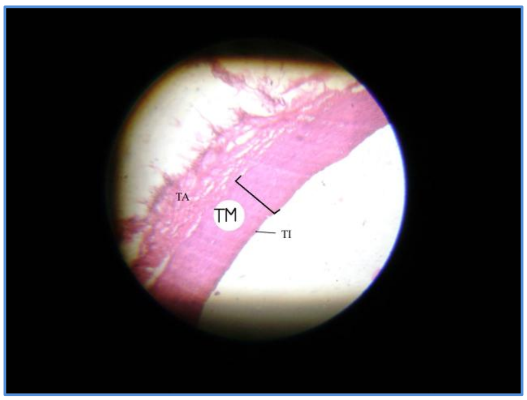

Fig. 5: VERTEBRAL-H&E

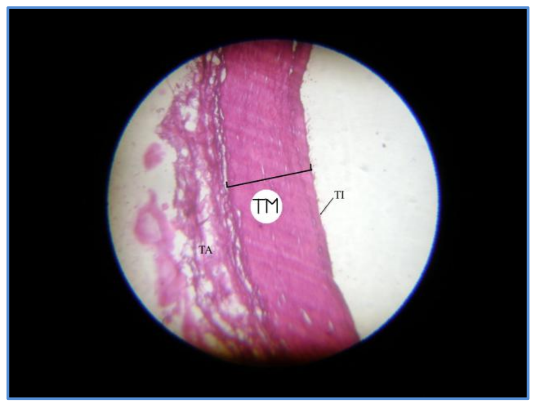

Fig. 6: VERTEBRAL ARTERY

LEGENDS USED ARE;

TM = Tunica Media
TI = Tunica Intima
TA = Tunica Adventitia
ICA = Internal Carotid Artery
ECA = External Carotid Artery
VA = Vertebral Artery

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