Assiut Vet. Med. J. Vol. 36 No. 72, January 1997

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MORPHOLOGICAL AND MORPHOMETRICAL STUDIES ON THE AXILLARY AND ISCHIATIC ARTERIES IN RELATION TO MODE OF LOCOMOTION IN CHIKEN, DUCK AND PIGEON

(With 4 Tables and 24 Figures)

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(Received at 29/12/1996)

دراسات مورفولوجية و قياسية على الشريانين الابطى والوركى وعلاقتهما بطبيعة الحركة فى الدجاج والبط والحمام

كمال الدين هاشم عبدالله و احمد الزهرى زايد

اجرى هذا البحث على ثمانية طيور بالغه من كل من الدجاج والبط والحمام وذلك للتعرف على الفروق المورفولوجيه والقياسيه للشريانين الابطى والوركى فى هذه الطيور. وقد تبين من البحث وجود فروق واضحه بين قطر وسمك جدار وكذلك مساحة المقطع العرضى فى هذه الشرايين بين الطيور تحت الدراسه. بالاضافه الى ذلك وجدت علاقه بين قطر الشريان ومساحة المقطع العرضى لكل من تجويف وجدار هذا الشريان من ناحيه وطبيعة حركة الطائر من ناحيه اخرى. يتميز الشريان الابطى فى الحمام بكبر قطره عنه فى البط والدجاج، وعلى العكس فان الشريان الوركى فى الطائرين الاخيرين يتميز بكبر قطره عنه فى الطائر الاول. وقد اوضحت الدراسه ايضا ان الشريان الابطى فى الحمام يتميز بتجويف واسع وجدار رقيق عنه فى الشريان الوركى، بينما فى الدجاج فان الشريان الوركى يتميز بتجويف واسع وجدار رقيق. كذلك وقد تبين من البحث ان كمية النسيج المرن فى الطبقه الوسطى للشريانين تحت الدراسه تزداد وفقا لاحتياجات المنطقه المغذاه بهذه الشرايين. ولهذا فان الشريان الابطى فى الحمام غنى بالنسيج المرن اذا ما قورن بنظيره فى البط والدجاج، وبالعكس فان الشريان الوركى يحتوى فى البط على اكبر كميه من النسيج المرن يليه الدجاج ثم الحمام.

SUMMARY

This study was carried out on eight adult birds of each of the chicken (walking bird), duck (swimming bird) and pigeon (flying bird). Blood vessels develop according to the particular requirements of the region supplied.

Clearly distinguished differences of diameter, wall thickness and cross-sectional area of the axillary and ischiatic arteries were recorded between the studied birds. There is a correlation between the diameter of the artery, cross-sectional area of its lumen as well as its wall and the mode of locomotion. The axillary artery in pigeon has a larger diameter than that in duck and chicken. On the other hand, the ischiatic artery in duck and chicken has a larger diameter than in pigeon. The axillary artery in pigeon has a wider lumen and a thinner wall than those of the ischiatic artery, but in chicken the latter artery has a wider lumen and a thinner wall than the former one. The present work indicates also that the amount of the elastic tissue in the tunica media of the studied arteries increases corresponding to the particular needs of the region supplied. The axillary artery contains abundant elastic tissue in pigeon compared to that in duck and chicken. On the contrary, the ischiatic artery has the largest amount of the elastic tissue in duck followed by chicken then pigeon.

Key words: *Axillary, ischiatic arteries, chicken, duck, pigeon*

INTRODUCTION

The blood vessels develop in accordance with the particular requirements of a local region. For this reason, many types of blood vessels exist that depart markedly, both qualitatively and quantitatively, from the generalized structural plan (Arey,1963). In birds, the axillary artery which is the continuation of the subclavian artery is considered to be the main blood supply of the wing. The ischiatic artery which is the largest branch of descending aorta, is the principal artery of the pelvic limb in birds (Baumel,1975). The basic structure of various types of arteries has been extensively investigated (Parker,1958; Hodges,1974; Pellegrin,1976; Fawcett,1986; Cormack,1987; Currie,1988). Informations about the structure of arteries in relation to mode of locomotion are lacking in the available literature. Therefore, this study was undertaken to throw some light on the structure of both axillary and ischiatic arteries in chicken (walking bird), duck (swimming bird) and pigeon (flying bird) in relation to mode of locomotion.

MATERIAL and METHODS

This work was carried out on eight adult birds of each of chicken (Gallus domesticus), duck (Anas domestica) and pigeon (Columbia domestica). The birds were anesthetized by inhalation using chloroform, then were carefully dissected and the blood was withdrawn from the heart. The birds were thenafter injected with paraformaldehyde-glutaraldehyde fixative (Karnovsky, 1965). Segments from the axillary and ischiatic arteries were taken and immersed in fixative for four houres. The samples were then transefered to 0.1M phosphate buffer and put in refregerator. Successive changes using 0.1M phosphate buffer were applied before the samples were osmicated (1% OsO_4). The samples were dehydrated in ascending grades of ethanol and embedded in ERL (Spurr,1969). Semithin sections were cut, stained with Methylene blue-azur II (Richardson et al.,1960) and Weigert's elastic stain (Drury and Wallington,1980), then they were examined by light microscope.

Using Quantiment Q500 MC image processing and analysis system (Leica), the total as well as luminal diameters and cross-sectional area (CSA) of both arteries, in addition to the thickness of their different layers were measured.These measurements were applied on ten cross sections in each bird of each studied species. The mean values and standard errors were calculated and listed in tables.

RESULTS

Axillary artery:

The wall of the axillary artery consists of tunica intima, tunica media and tunica adventitia (Fig.1-9). The tunica intima is composed generally of flat endothelial cells beneath which a layer of subendothelial connective tissue. The elastic fibres aggregate at the outer border of the intima forming a corrugated interrupted layer of internal elastic lamina. The thickness of the tunica intima is larger in chicken than in duck and pigeon (Table 1, Fig.21).

The tunica media is generally the thickest layer of the axillary artery in all examined birds (Table 1, Fig.21). The structure of the tunica media concerning its smooth muscle and elastic fibres accounts for the main differences between the species under investigation. In chicken, the tunica media contains abundant smooth muscle fibres in the form of 9-11 layers in circular or oblique arrangement. Few fine discontinuous elastic membranes are scattered between the smooth muscle layers. The thickness and corrugation of these elastic membranes decrease towards the tunica adventitia. The external elastic lamina is well developed in chicken in comparison to the other studied birds, it is made up of 4-6 thick corrugated and anastomosing membranes (Fig.4, 7). In duck, the tunica media consists almost entirely of closely packed thin smooth muscle fibres together with scarce fine elastic fibres. The external elastic lamina is made up of 3-4 thick discontinuous and less corrugated elastic membranes (Fig.5, 8). In pigeon, the tunica media consists mainly of elastic fibres which are arranged in 10-13 elastic membranes, from which the outermost membrane is the external elastic lamina (Fig.6, 9). On the contrary to that observed in chicken, the corrugation and thickness of the elastic membranes in pigeon increase towards the tunica adventitia. Some elastic fibres are interlaced. Circularly disposed smooth muscle fibres are found between the elastic membranes.

The tunica adventitia of the axillary artery, in all examined birds, is thinner than the tunica media. The relation between the thickness of the two tunics differs in the various studied birds (Table 1, Fig.21). In case of duck, this tunic is thinner than that of the chicken and pigeon. The tunica adventitia is composed mainly of collagenous fibres which run predominantly in a longitudinal direction. Scarce elastic fibres are seen immediately adjacent to the tunica media (Fig.4-9). The fibres in the outer part of the tunica adventitia are somewhat loosely arranged, this character is more evident in chicken than in duck and pigeon.

The dimensions of the axillary artery differ in the different examined birds (Table 1,2, Fig.1-3, 19-21). It has the largest diameter in pigeon (1054.9μm), followed by duck (739.4μm) and chicken (517.1μm). The luminal diameter of the axillary artery shows also the highest value in pigeon (806.9μm), the lowest value in chicken (168.5μm), but the duck shows a relatively high luminal diameter (508.2μm).

The percentage of the cross sectional area (CSA) of the wall of the axillary artery to its total CSA is the highest in chicken (87.90%), the lowest in pigeon (43.87%). The duck occupies an intermediate position (51.45%). On the contrary, the percentage of the luminal CSA is the smallest in chicken (12.10%), the highest in pigeon (56.13%) and is relatively high in duck (48.55%).

Ischiatic artery:

Generally the ischiatic artery is composed also of tunica intima, tunica media and tunica adventitia (Fig.10-18). The thickness of the tunica intima in chicken (5.01μm) is nearly double that in duck (2.02μm) and in pigeon (2.56µm). This tunic has the same basic structure as that of the axillary artery, but in chicken, the thick subendothelial layer is highly cellular containing large numbers of fibroblasts, smooth muscle cells and collagenous fibres.

The thickness of the tunica media of the ischiatic artery differs in the various examined birds (Table 3, Fig. 24). In chicken, this tunic is nearly double that of pigeon and one and half fold that of duck. It is composed mainly of smooth muscle fibres which are arranged in 12-14 layers in chicken, 14-16 layers in duck and 9-11 layers in pigeon. The smooth muscle fibres of this tunic are arranged mostly circularly in duck and pigeon, but in chicken they tend to be longitudinal in some parts of the wall (Fig.13-15). These layers are interposed by 4-6 thin interrupted elastic membranes in chicken, 10-13 in duck and 3-4 membranes in pigeon. The external elastic lamina is represented by relatively thick corrugated elastic membranes which are 3-5 in number in chicken, 3-4 in duck and 2-3 in pigeon (Fig.16-18).

The tunica adventitia of the ischiatic artery in pigeon is relatively thinner than that of the chicken and duck as shown in Table (3) and Fig.(24). In chicken, this tunic is characterized by the presence of dense collagenous boundles arranged longitudinally in the inner part and circularly in the outer part. The collagenous fibres run predominantly in a circular direction in duck, and in a longitudinal direction in pigeon. In chicken and duck few elastic fibres are seen immediately adjacent to the external elastic lamina. In pigeon, the tunica adventitia contains more elastic fibres than the foregoing birds (Fig.13-18).

The morphometric data of the ischiatic artery in the different examined birds are shown in Table (3,4) and Fig. (22-24). The total diameter of this artery is 1044.6µm, 1156.4µm and 674.1µm in chicken, duck and pigeon respectively. In duck, the luminal diameter constitutes the highest percentage of the total arterial diameter. The luminal diameter of the small sized ischiatic artery in pigeon constitutes a higher percentage of the total arterial diameter when compared with that of chicken.

The percentage of the CSA of the wall of the ischiatic artery to its total CSA is the highest in chicken (72.92%), followed by pigeon (55.53%) then duck (50.35%). On the other hand, the percentage of the luminal CSA is the highest in duck (49.66%), followed by pigeon (44.48%) then the chicken (27.08%).

DISCUSSION

The blood vessels develop in accordance with the particular requirements of a local region. For this reason, many types of blood vessels exist that depart markedly, both qualitatively and quantitatively, from the generalized structural plan (Arey,1963). In this respect, the present study reveals that the pigeon, inspite of being the smallest examined bird, has the largest axillary artery in comparison with duck and chicken. This is because the axillary artery which is the main blood supply of the wing performs a higher activity in such flying bird. In the same concern, the ischiatic artery (the main blood supply of the pelvic limb) in duck has the largest diameter to cover the great demand of the pelvic musculature during swimming.

Besides the fact that arteries develop according to the needs of a local region, the present study shows species characteristics, for example the chicken arteries have comparatively thick wall and narrow lumen. In pigeon the arterial lumen is generally wide. In case of duck, the arteries retain a constant ratio between the luminal and total diameters.

Williams and Warwick (1980) mentioned that in human, as a general rule, the elastic arteries have walls about one tenth the thickness of their interior diameter, muscular arteries about one quarter. Moreover, Seeley et al.(1992) stated that the walls of the muscular arteries are relatively thick when compared with their diameter. In this connection, the present investigation reveals that the axillary artery has a wall thickness about one seventh of its luminal diameter in pigeon, one fourth in duck and they are nearly equal in chicken. In case of the ischiatic artery, the thickness of the wall is about one fourth the luminal diameter in duck and pigeon but it is nearly half the luminal diameter in chicken. From all these observations, one can conclude that the axillary artery of pigeon can be considered as an elastic artery, the axillary artery of duck and the ischiatic arteries of duck and pigeon are muscular arteries. In chicken both arteries can be classified structurally as muscular arteries.

In concordance with Awal et al. (1995) in rat, the present study reveals that the internal elastic lamina of both axillary and ischiatic arteries is represented by a single wavy elastic membrane. Contrarily, this lamina has been described in fowl to be 1-2 layers (Hodges,1974) or 2-3 layers (Freeman,1984).

The tunica media of the studied arteries is composed of organized admixture of elastic tissue and smooth muscles in varying proportions which comes in agreement with Dyce et al. (1987). This variety depends upon the location of the artery in relation to the heart. The arteries away from the heart have more smooth muscle and less elastic fibres (Dellmann and Brown,1987).

In addition to the location of the arteries from the heart, the function of the arteries plays an important role in determining the ratio of elastic to smooth muscle fibres in their tunica media. The more the activity of the arteries, the more the elastic fibres. This is very pronounced in the axillary artery of pigeon where the elastic fibres predominate. This explains that the axillary artery in pigeon performs a great activity in conducting blood to the wing during flying. In the same concern, the ischiatic artery of duck contains more elastic fibres in comparison to those of the other studied birds which may reflect the need of the pelvic musculature to more blood supply during swimming. Attributing the structure of the tunica media of arteries to their function has been recorded by many authors. Clark and Clark (1940) ascertained that the differentiation of the smooth muscle in the vessel wall is influenced by blood pressure. Bone (1979) stated that the elastic quality of the arteries aids in maintaining blood pressure and acts as auxillary blood pump by squeesing the blood as they return to their original diameter to receive a new volume of blood from the heart. Currie (1988) mentioned that, the elastic character of the arterial wall provides strength and recoil potential upon deformation during each systole, which maintain arterial blood pressure during diastole. This is an important factor that maintains blood flow despite the cyclical nature of cardiac contractions.

The external elastic lamina of all studied arteries, with exception of the pigeon's axillary artery, is composed of multiple (2-6) layers of anastomosing corrugated elastic membranes which demarcate the media from the adventitia. This finding simulates the statement of Hodges (1974) in fowl.

Generally in all studied arteries the internal elastic lamina is represented by one layer while the external elastic lamina is always more than one layer. This seems to be a characteristic feature of the arteries in birds.

The adventitia in all arteries under investigation is thinner than the tunica media and being more thinner in pigeon's arteries. On the other hand, this tunic may be equal (Krause and Kutts,1994) or thicker (Fawcett, 1986) than the tunica media in some arteries. The tunica adventitia in all studied arteries is composed mainly of collagenous fibres which run predominantly in a longitudinal direction. This longitudinal orientation of the collagenous fibres may prevent the overdilatation of the arteries during systole

(Cormack,1987). In addition, Fawcett (1986) mentioned that the loose consistency of the tunica adventitia and predominant longitudinal orientation of its components permit the continual changes in the diameter of the vessel and limit the amount of retraction that takes place when an artery is cut.

REFERENCES

Arey, L.B. (1963): The development of peripheral blood vessels. In Orbison, J.L. and Smith, D.E. The peripheral blood vessels. Williams and Wilkins Company. Baltimore.

Awal, M.A.; Matsumoto, M. and Nishinakagawa, H. (1995): Morphometrical changes of the arterial walls of main arteries from heart to the abdomino-inguinal mammary glands of rat from virgin through pregnancy , lactation and postweaning. J.Vet.Med. Sc. 57 (2): 251-256.

Baumel, J.J. (1975): Aves heart and blood vessels. In Sisson and Grossman's: The anatomy of the domestic animals Rev. by Getty, R. 5th Ed. W.B. Saunders Company, Pheladelphia, London, Toronto.

Bone, J.F. (1979): Animal anatomy and physiology. Reston Publishing Company, Inc., Reston, Virginia. A Printice-Hall Company.

Clark, E.R. and Clark, E.L.(1940): Microscopic observations on the extraendothelial cells of living mammalian blood vessels. Am.J.Anat. 66: 1-49.

Cormack, D.H. (1987): Ham's histology. 9th Ed. J.B. Lippincott Company. Philadelphia. London. Mixico City. New York. St. Louis. São Paulo. Sydney.

Currie, W.B. (1988): Structure and function of domestic animals. Butterworths, Boston, Singapore,Sydney, Toronto, Wellington.

Dellmann, H.D. and Brown, E.M. (1987): Textbook of veterinary histology. 3rd Ed. LEA & FEBIGER. Philadelphia.

Drury, R.A.B. and Wallington, E.A. (1980): Carlton's histological technique. 4th Ed. Oxford University Press. New York, Toronto.

Dyce, K.M.; Sack, W.O. and Wensing, C.J.G. (1987): Textbook of veterinary anatomy. W.B. Saunders Company. Harcourt brace Jovanovich, Inc.

Fawcett, D.W. (1986): Bloom and Fawcett: A textbook of histology. 11th Ed. W.B. Saunders Company. Igaku-Shoin, Saunders.

Freeman, B.M. (1984): Physiology and biochemistry of the domestic fowl. Volume 5. Academic Press (Harcourt Brace Jovanovech, Publishers)

Hodges, R.D. (1974): The Histology of the fowl. Academic Press. London, New York, San Francisco.

Karnovsky, M.J. (1965): A formaldehyde-glutaraldehyde fixative of high osmolarity for use in electron microscopy. J. Cell Biology, 27: 137A.

Krause, W.J. and Kutts, J.H. (1994): Essentials of histology,Text, Atlas, Review. Little, Brown and Company. Boston/ New York/ Toronto/ London.

Parker, F.(1958): An electron microscopic study of coronary arteries. Am.J.Anat. 103:247-259.

Pellegrin, M.J. (1976): Some ultrastructural aspects of rat renal artery and abdominal aorta. J.Physiol. 263:106-107.

Richardson, K.C.; Jarret, L. and Finke, E.H. (1960): Embedding in epoxy resin for ultrathin sectioning in electron microscopy. Stain Technol. 35: 313-323.

Seeley, R.R.; Stephens, T.D. and Tate, P.(1992): Anatomy and physiology. Mosby Year Book. St. Louis, Baltimore, Boston, Chicago, London, Philadelphia, Sydney, Toronto.

Spurr, A.R. (1969): A low vescosity epoxy resin embedding medium for electron microscopy. J. Ultrastruct. Res., 26: 31-43.

Williams, P.L. and Warwick, R. (1980): Gray's anatomy. 36th Ed. Churchill Livingstone, Edinburgh, London, Melbourne and New York.

LEGENDS

Fig.(1-3): Semithin sections of axillary arteries in chicken (1), duck (2) and pigeon (3). The axillary artery has the largest diameter in pigeon followed by duck and is the smallest in chicken. Methylene blue-azur II stain, X63.

Fig.(4-6): Semithin sections of axillary arteries in chicken (4), duck (5) and pigeon (6) showing: tunica intima (I), tunica media (M), tunica adventitia (A), internal elastic lamina (arrow heads) and external elastic lamina (arrows). Notice: different proportions of elastic and smooth muscle fibres of the tunica media in different birds. Methylene blue-azur II stain, X400.

Fig.(7-9): semithin sections of axillary arteries in chicken (7), duck (8) and pigeon (9) showing: tunica intima (I), tunica media (M), tunica adventitia (A), internal elastic lamina (arrow heads) and external elastic lamina (arrows). Notice: the variable amounts of elastic fibres in different birds. Weigert's elastic stain, X400.

Fig.(10-12): Semithin sections of ischiatic arteries in chicken (10), duck (11) and pigeon (12). The artery is the largest in duck followed by chicken and is the smallest in pigeon. The wall is the thickest in chicken and is the thinnest in pigeon. Methylene blue-azur II stain, X63.

Fig.(13-15): Semithin sections of ischiatic arteries in chicken (13), duck (14) and pigeon (15) showing: tunica intima (I), tunica media (M), tunica adventitia (A), internal elastic lamina (arrow heads) and external elastic lamina (arrows). Notice: the longitudinal arrangement of the smooth muscle fibres of the tunica media. Methylene blue-azur II stain, X400.

Fig.(16-18): Semithin sections of ischiatic arteries in chicken (16), duck (17) and pigeon (18) showing: tunica intima (I), tunica media (M), tunica adventitia (A), internal elastic lamina (arrow heads) and external elastic lamina (arrows). Notice: the abundant elastic fibres in the duck tunica media. In pigeon, the tunica media contains the lowest amount of elastic fibres. Weigert's elastic stain, X400

Table (1): Thickness (μm) of tunica intima, media and adventitia of axillary artery. (Mean±SE).

Bird	Tunica intima	Tunica media	Tunica adventitia
Chicken	3.73 ± 0.3	97.50 ± 2.6	73.72 ± 3.5
Duck	2.35 ± 0.2	59.94 ± 1.7	53.68 ± 2.8
Pigeon	2.88 ± 0.2	78.86 ± 3.6	63.58 ± 1.8

Table (2): Total diameter, wall thickness, luminal diameter(μm) as well as the CSA (μm^2) of wall and lumen of axillary artery. (Mean±SE).

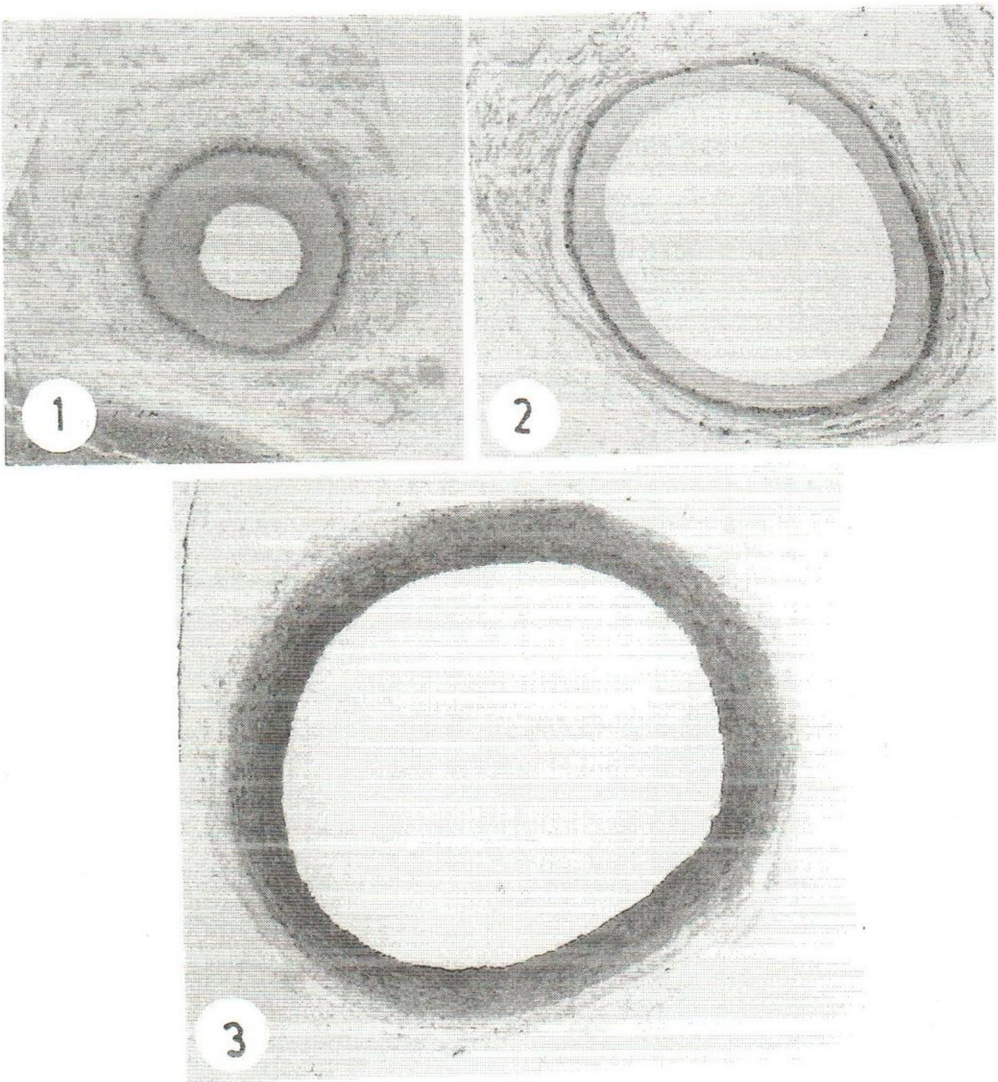
Bird	Total diameter	Wall thickness	Luminal diameter	Wall CSA	Luminal CSA
Chicken	517.1± 1.6	143.5± 3.5	168.5± 1.6	16995.3	23400.0
Duck	739.4± 22.9	115.9± 5.3	508.2± 5.1	203754.5	192275.4
Pigeon	1054.9±24.7	124.92± 3.6	806.9± 6.1	331465.0	425584.7

Table (3): Thickness (μm) of tunica intima, media and adventitia of the ischiatic artery. (Mean±SE).

Bird	Tunica intima	Tunica media	Tunica adventitia
Chicken	5.01 ± 0.3	147.31 ± 6.4	99.94 ± 2.6
Duck	2.02 ± 0.1	98.63 ± 4.2	73.43 ± 2.1
Pigeon	2.56 ± 0.2	73.14 ± 3.0	68.90 ± 2.7

Table (4): Total diameter, wall thickness, luminal diameter (μm) as well as the CSA (μm^2) of wall and lumen of ischiatic artery. (Mean±SE).

Bird	Total diameter	Wall thickness	Luminal diameter	Wall CSA	Luminal CSA
Chicken	1044.6± 7.3	252.3± 6.4	544.1± 11.9	622359.9	231079.3
Duck	1156.4± 25.7	174.1± 4.2	806.2± 19.2	520557.1	513514.6
Pigeon	674.1± 6.2	106.71± 4.1	461.8± 3.3	205112.4	164324.7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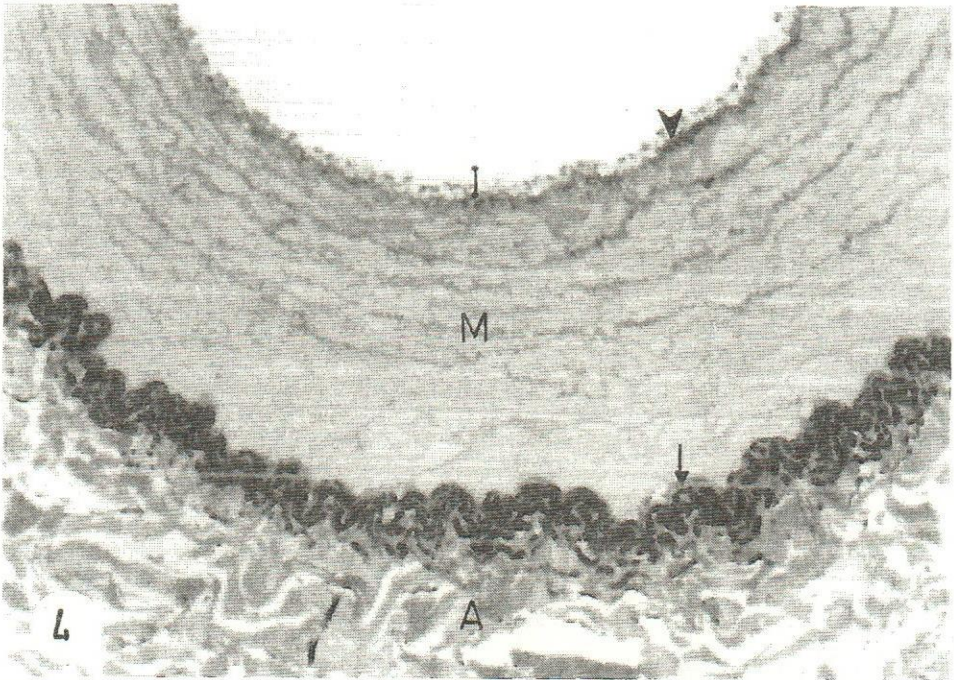
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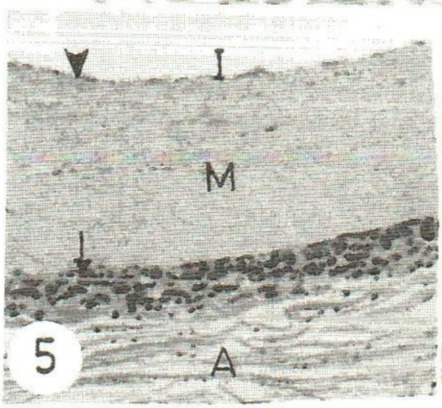
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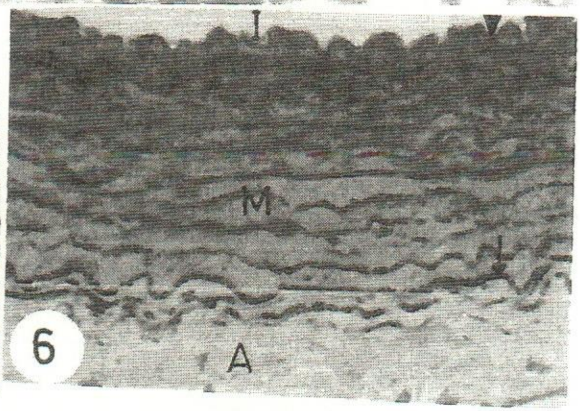
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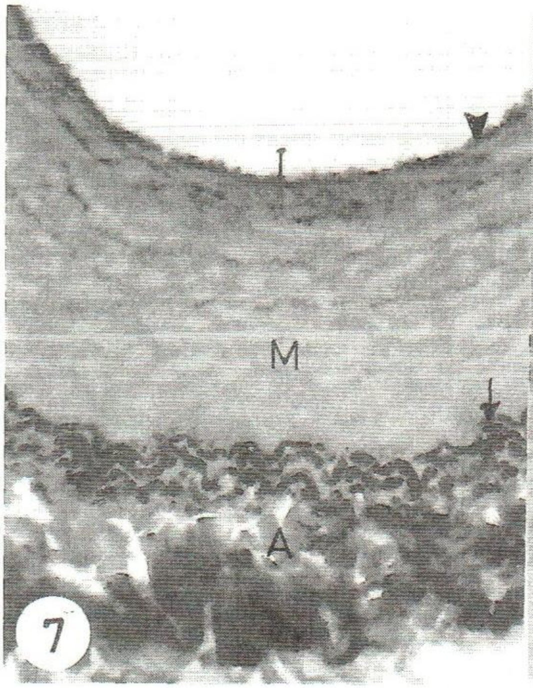
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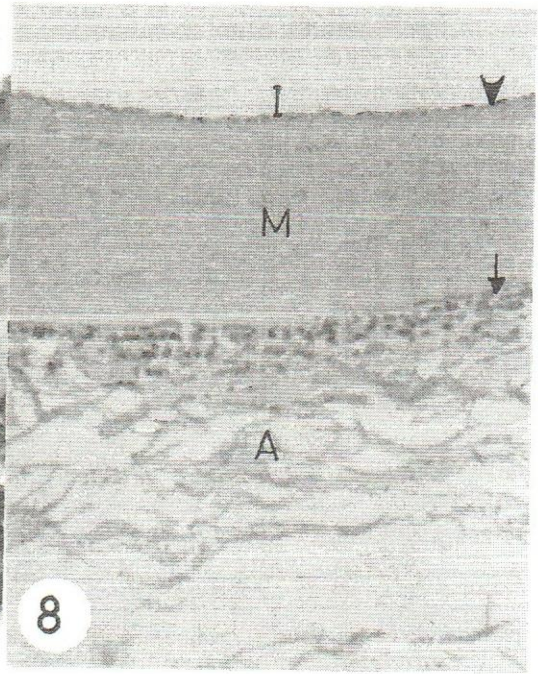
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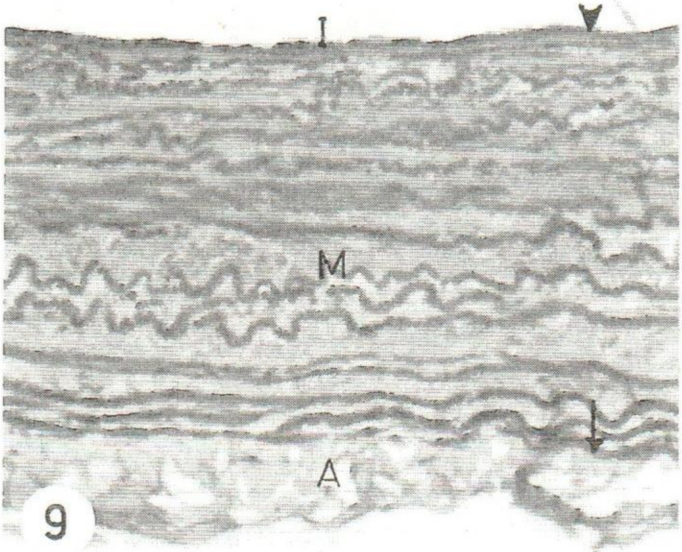
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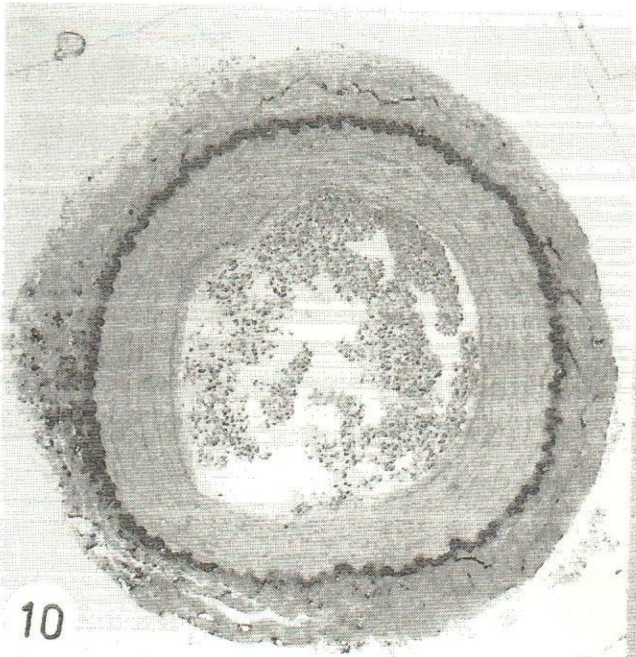

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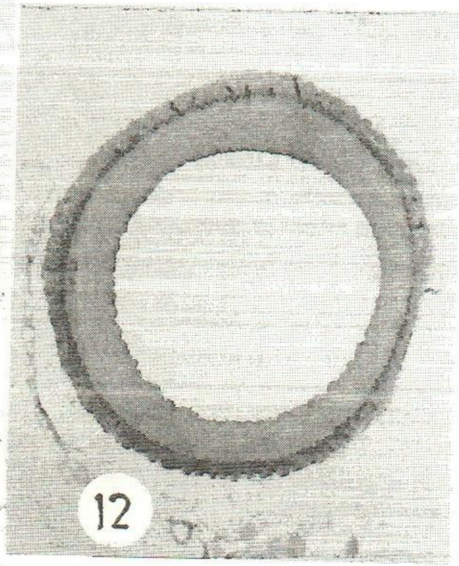

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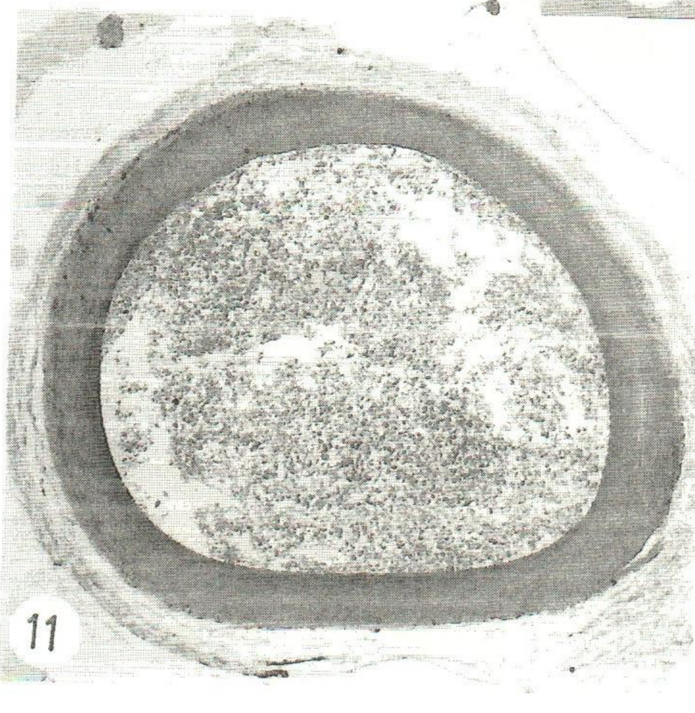

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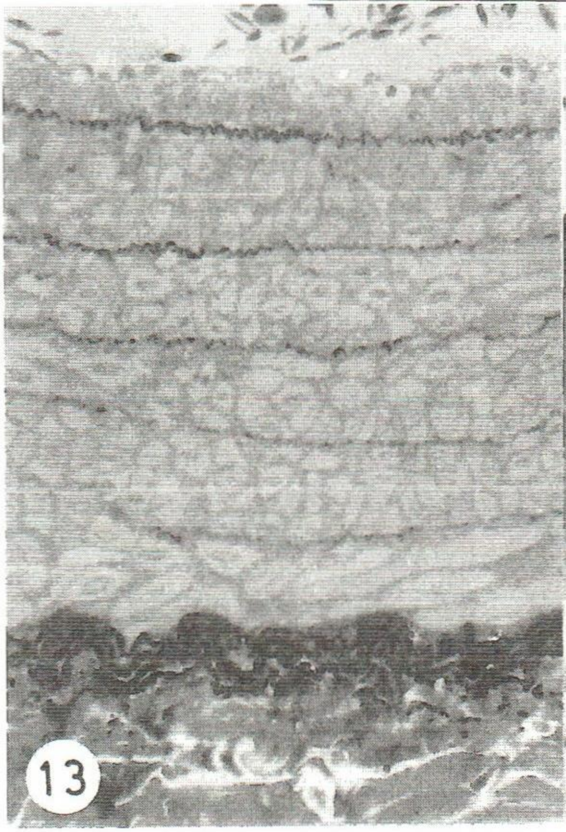
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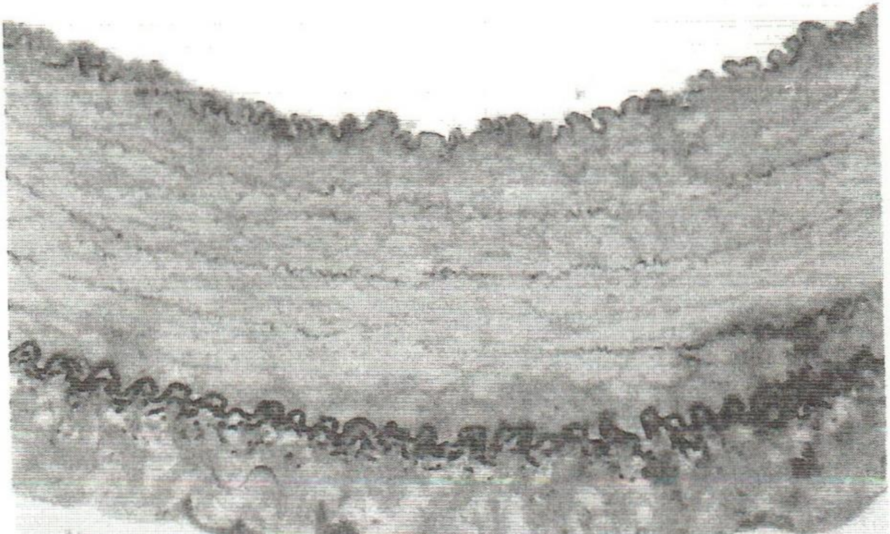
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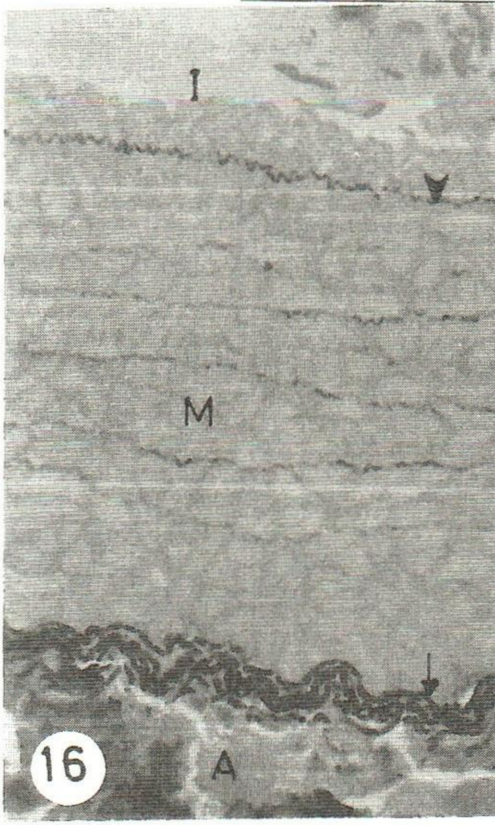
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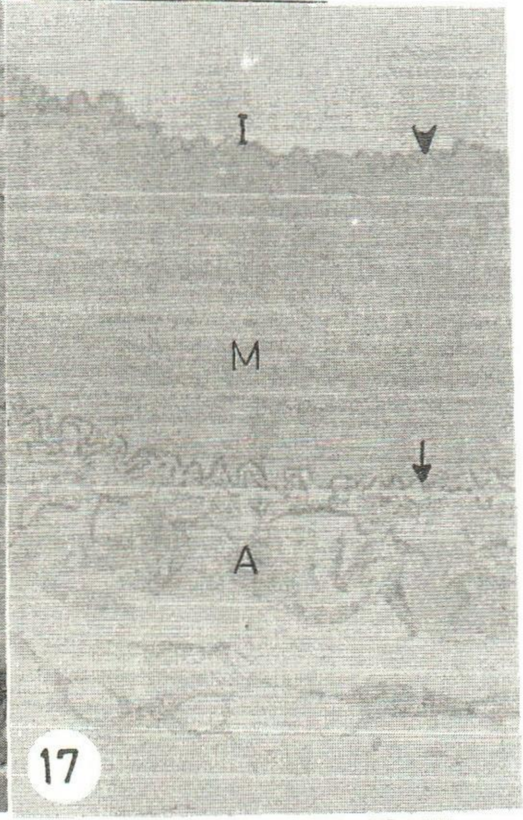
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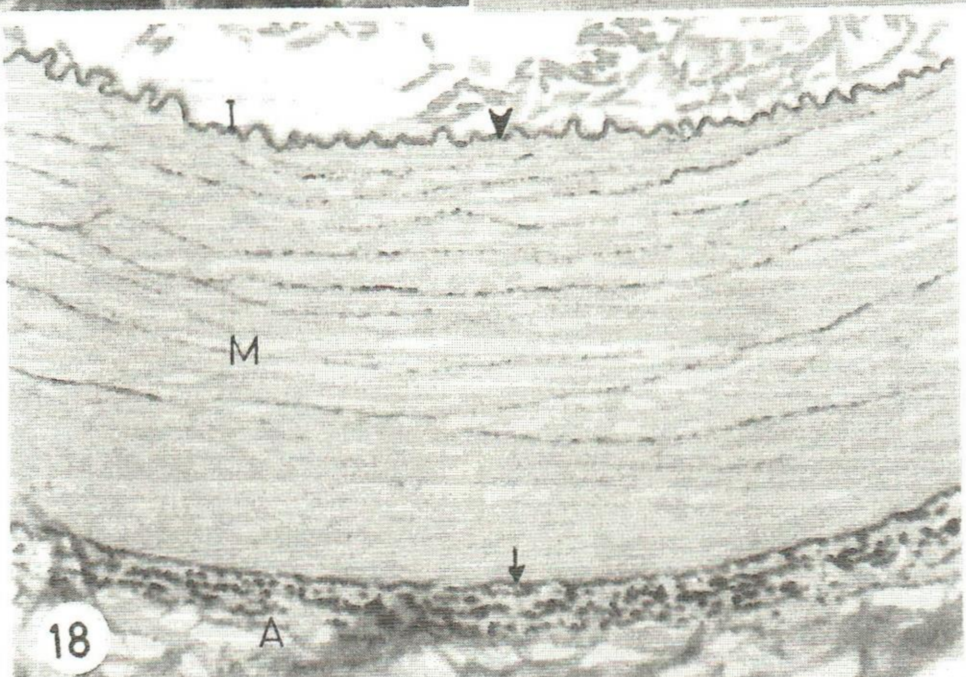
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Fig.(19): Wall thickness, luminal and total diameters (μm) of the axillary artery

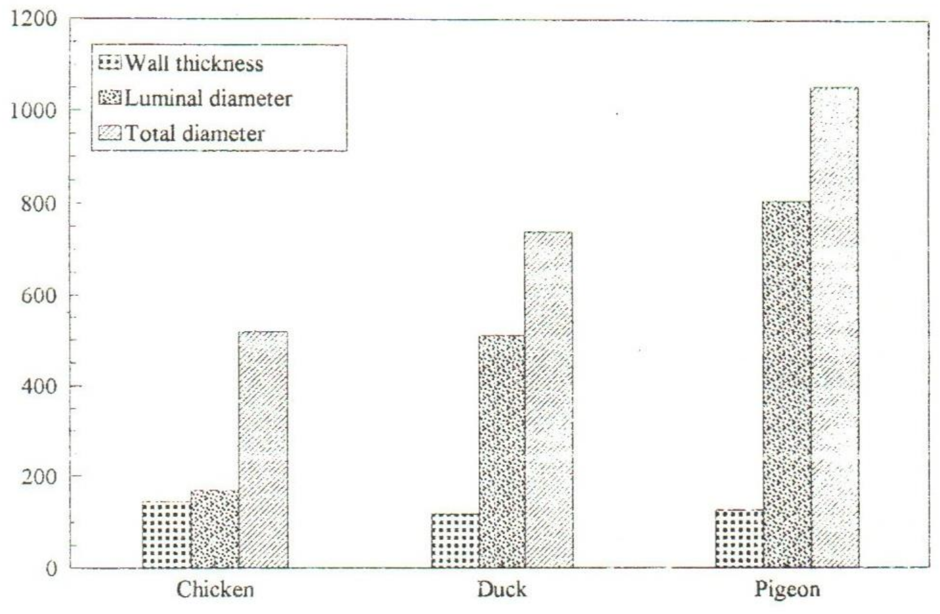

Fig.(20): Wall and luminal CSA (μm2) of the axillary artery

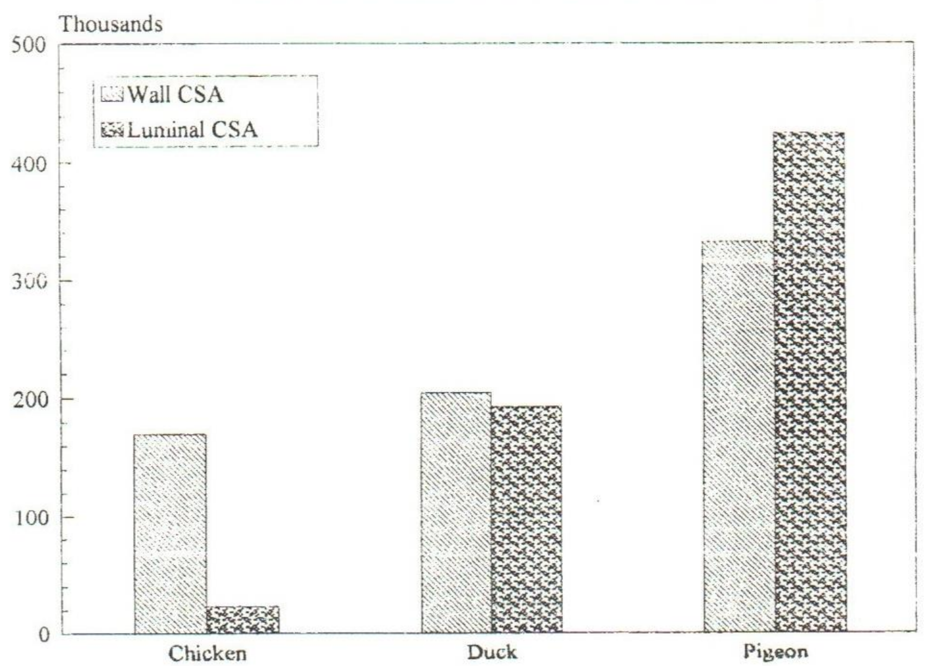

Fig.(21): Thickness (μm) of the tunica intima, tunica media and tunica adventitia of the axillary artery

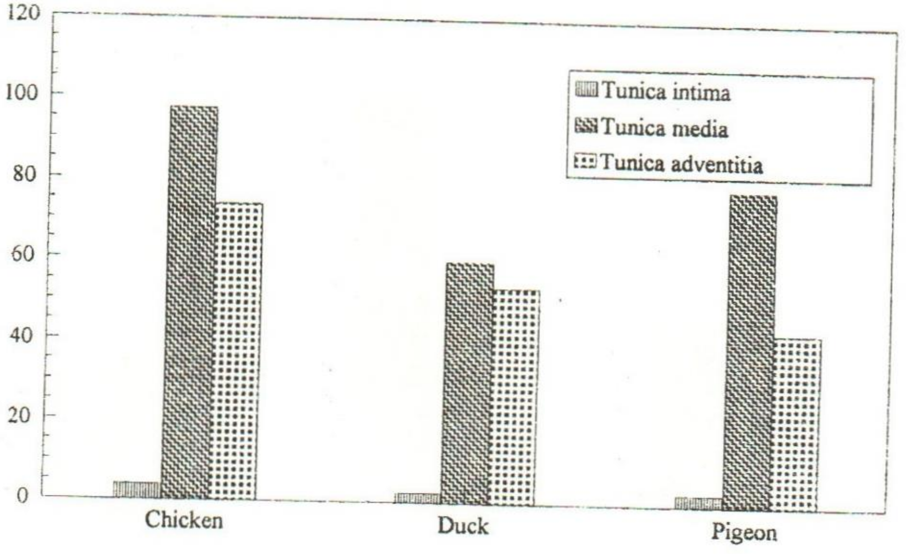

Fig.(22): Wall thickness, luminal and total diameters (μm) of the ischiatic artery

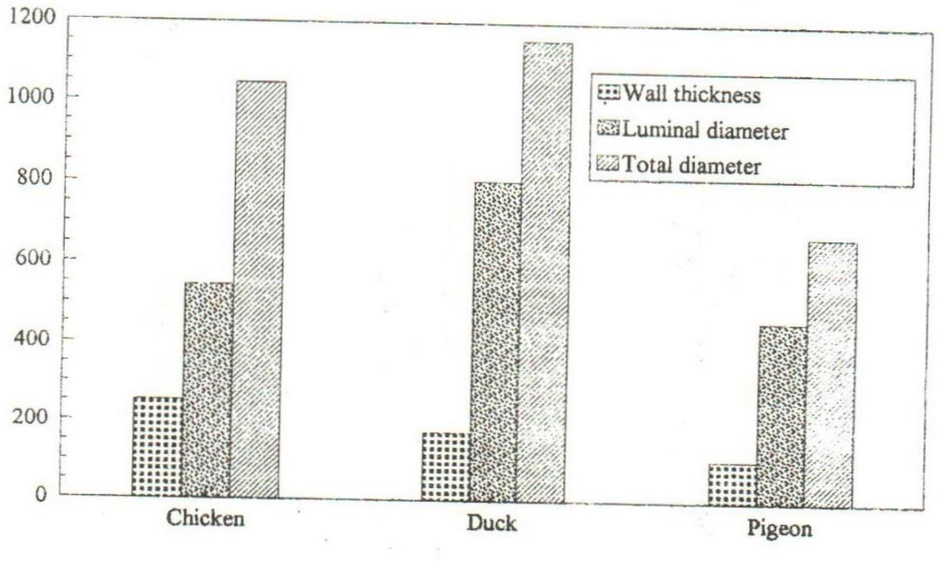

Fig.(23): Wall and luminal CSA (µm2) of the ischiatic artery

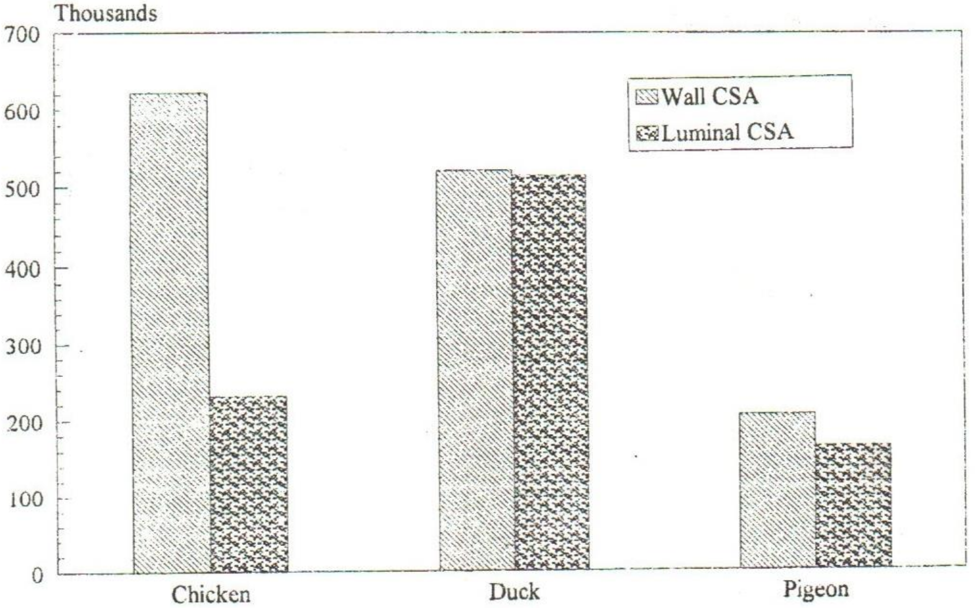

Fig.(24): Thickness (µm) of the tunica intima, tunica media and tunica adventitia of the ischiatic artery