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DEEP DISTRIBUTION OF SPINAL ARTERIES IN THE CERVICAL AND LUMBOSACRAL ENLARGEMENTS IN PIGEON, DUCK and CHICKEN

(With 10 Figures)

By

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التوزيع الغائر للشرايين الشوكية في التضخم العنقي والقطني العجزي في الحمام والبط والفراخ

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ان التوزيع الغائر للمدد الدموي الشرياني بالنخاع الشوكي لكل من الحمام والبط والفراخ ينشأ أساسا من التفرعات المركزية (الأخدوديه والأخدوديه الملتقيه) للشريان الشوكي البطني وكذلك من التفرعات الهامشيه لكل من الشرايين الجذرية الظهرية والبطنية وايضا من الضفائر الشوكيه الجانبية والظهريه كما أن الشرايين الظهرية والظهرية الجانبية ترسل تفرعات غائرة لتغذية البنا المجاور لها من مادة النخاع الشوكي. اما الفروع المركزيه تكون مسئولة عن تغذية الأحبال البطنيه والملتقى البطني والمنطقه الغلاميه المركزيه وكذلك الأجزاء الداخلية من قواعد القرون البطنيه من المادة السنجابيه. أما التفرعات الهامشيه تكون مسئولة عن تغذية الجزء الأعظم من القرون السنجابيه البطنية والمنطقة المتوسطة والقرون السنجابيه الظهريه وكلا من الأحبال الظهرية الوحشيه المحيطه بهم . وقد لوحظ أن بعض التفرعات الهامشيه وكذلك بعض الشرايين الشقاقية قد تتحول مباشرة من الجانب الشرياني الى الجانب الوريدي بدون وجود التحام وريدي شرياني.

SUMMARY

The arterial blood supply of the substance of the spinal cord in pigeon, duck and chicken comes mainly from the central branches (sulcal and sulco-commissural arteries) of the ventral spinal artery and from the marginal branches of the dorsal and ventral radicular arteries. The lateral and dorsal spinal plexuses, in addition to the dorsolateral and dorsal spinal arteries also send deep branches for the neighbouring texture of the spinal cord. The central branches are responsible for the vasculature of the ventral funiculi, ventral commissures, Area gelatinosa centralis and the medial portion of the base of the ventral gray column. The marginal branches are responsible for the vasculature of most of the ventral gray column, intermediate zone, dorsal gray column and the surrounding lateral and dorsal funiculi. Some marginal and fissural arteries have changed directly from the arterial side to the venous one without forming any sort of capillaries or arterio venous anastomoses.

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*: The data of the cervical enlargement is submitted from the Ph.D. thesis entitled "Some studies on the vasculature, cytoarchitecture and morphometry of the cervical enlargement of chicken (Gallus demesticus), pigeon (Columba livia) and duck (Anas domestica) by *HASOUNA (1990).*

Keypwords: *Deep distribution, spinal arteries, cervical, lumbosacral enlargement, pigeon, duck, chicken.*

INTRODUCTION

STERZI (1904) LOB (1961) and BAUMEL (1975) pointed to the arterial vasculature of the substance of the spinal cord in chicken. The arerial vasculature of the substance of the spinal cord of mammals was studied by *BRADSHAW (1986)* in cat, *AHMED (1986)* in rabbit and *AHMED and MOUSTAFA (1990)* in dog fetuses.

The distribution of the deep branches of the spinal arteries within the substance of the spinal cord segments forming the cervical and lumbosacral enlargements in pigeon, duck and chicken is the aim of this study.

MATERIAL and METHODS

The materials used in this study were the serum-indian ink injected spinal cords previously used in describing the macroscopic arterial vasculature of the cervical and lumbosacral enlargements in pigeon, duck and chickens.

The spinal segments forming the two enlargements were processed for histological examination. Thick paraffin sections were serially obtained and fixed by the evaporation of 40% formalin solution in a hot air oven at 37°C for several days. Some chosen slides were stained with Cresyl violet to examine the distribution of the fine vessels in relation to the stained neurons.

RESULTS

The arterial blood supply of the substance of the spinal cord in pigeon, duck and chicken comes mainly from the central branches sulcal and sulco-commissural of the ventral spinal artery and from the marginal branches of the dorsal and ventral radicular arteries. The lateral and dorsal spinal plexuses, in addition to the dorso-lateral and dorsal spinal arteries also send deep branches for the neighbouring texture of the spinal cord.

The central branches which are represented by the sulcal arteries (Fig. 1/1; 2/3; 3/2; 6/13) originate from the ventral spinal artery at right angles; ascend within the whole length of the ventral median fissure where they detach minor sulcal branches and continue as the major sulcal arteries. The latter is divided into right and left sulco-commissural arteries (Fig. 2/2; 6/14; 7/8; 9/1) which distribute within the ventral commissures, the neighbouring Area gelatinosa centralis, and the medial portions of the base of the ventral gray horns. The minor sulcal branches vascularize the ventral funiculi (Fig. 5). The central branches anastomose with each other and with twigs from another spinal arteries forming a dense complicated narrow-meshed networks. These arterial networks in injected specimens can easily demarcate the gray from the white matter in cross sections.

At the level of the rhomboid sinus the sulcal arteries are very short (Fig. 7) and each divides directly or after a short course into the right and left sulco-commissural arteries (Fig. 7 & 9). These ascend along the diverged portions of the ventral funiculi to reach the area gelatinosa centralis where they join other arterial branches to form the dense arterial plexus of the central gray matter.

The great part of the ventral gray horn is supplied by Rr. corni ventrales mediales and laterales (Fig. 1/2,3; 5/2; 6/15,16; 7/5; 8/1). The Rr. corni ventrales mediales are detathed from the ventral radicular arteries. They are of considrable calibre and pass in a tortous course within the texture of the ventral funiculus between the fibers of the ventral motor roots. They are distributed within the medial portion of the ventral gray column and anastomose with branches of other spinal arteries to share in the formation of the arterial networks of the gray matter. The Rr. corni ventrales laterales are detached from the initial portion of the ventral radicular arteries. They pass directly in a slight tortous course within the substance of the lateral funiculus to reach the lateral portion of the ventral gray horn where they distribute. The medial and lateral branches of the ventral horns form wide-meshed arterial plexuses during their course within the white matter, moreover their branches anastomose with each other forming the dense narrow-meshed arterial network of the ventral gray column.

The intermediate zone of the gray matter and the neighbouring lateral funiculi are vascularized by the marginal branches which are detached from the dorsal and ventral radicular arteries and from the lateral spinal plexus. These Rr. marginales (Fig. 1/4; 5/3; 6/17; 7/4; 8/2; 9/2) pass radially within the texture of the lateral funiculus describing a slight tortous course to supply the lateral portion of the intermediate zone and the bases of the dorsal and ventral gray column. The marginal branches are well developed at the level of the rbromboid fossa in chicken (Fig. 7/4; 8/2; 9/2) and penetrate the substance of the lateral funciculus in a tortous course to form a rather wide meshed network within the gray matter (Fig. 9/5).

The dorsal portion of the spinal cord is vascularized mainly by branches from the dorso-lateral spinal arteries and the dorsal spinal plexuses, moreover, the dorsal spinal artery in pigeon and duck share also in this mission. The dorsal column receives large Rr. corni dorsales (Fig. 1/5; 5/4; 6/18; 8/3; 9/3) which pass together with the dorsal root fibers to distribute in the lateral portion of the dorsal gray column. Other Rr. corni dorsales comming from the dorsal spinal plexus distribute in the apex of the dorsal horn and the neighbouring dorsal funiculus. The medial portion of the dorsal gray column receives its arterial vasculature from Aa. interfunicularies which descend between the gracil and cunate fasciculi. The Aa. interfuniculares (Fig. 1/6; 5/5; 6/19; 8/5) originate from the dorso-lateral spinal arteries and supply the medial part of the dorsal gray colum and the neighbouring dorsal funiculus. The dorsal spinal arteries [dorso-lateral in chicken] detach Aa. fissurae (Fig. 1/7; 2,1; 3/1; 4/1; 5/6; 6/20) which descend within the dorsal median sulcus into the septum in a fine serepentine course to reach the dorsal commissure. Here each divides into two equal branches for both halves of the dorsal commissure. The fissural arteries supply the

neigbhbouring portions of the dorsal funiculi.

The fissural arteries are present in the segments forming the lumbosacral enlargement which situated just cranial and caudal to the level of the rhomboid fossa. However, the Rr. spinales dorsales (Fig. 8/4) which originate from the dorsolateral spinal arteries at the level of the rhomboid fossa descend between the medial surface of the diverged dorsal funiculi and the glycogen body which occupies the fossa. These branches vascularize the dorsal funiculi, the medial portion of the dorsal column and also detach the Aa. interfunicularies.

It was noticed that some marginal branches and also some fissural arteries have changed directly from the pattern of the arterial side [characterized by the narrow lumen and tortous course] into the pattern of the venous side [characterized by he wide-increasing lumen and the straight course]. This change occurs without forming capillaries or arterio-venous anastomoses and appears as direct arterio-venous shunts. This phenomenon can be observed in the cross sections of the injected spinal cord (Fig. 10 & 11).

DISCUSSION

The results of this study indicate that the marginal branches are more in number than the sulcal ones this indicats that the amount of arterial blood conveyed by the marginal arterial system is more than that conveyed by the central system. However, this is contrary to *STERZI (1904)* who stated that the amount of blood conveyed by the central [sulcal] arterial system is more than that of the peripheral [marginal] system in birds.

The marginal branches are responsible for the vasculature of the white matter and the most part of the gray matter, while the sulcal arteries supply only the central area of the gray matter. However, *STERZI (1904)* reported that the centripetal [marginal] arterial distribution in birds vascularizes completely the white matter, while the centrifugal [sulcal] one is responsible for the supply of the gray matter.

The general pattern of distribution of the arteries supplying the substance of the spinal cord in pigeon, duck and chicken is similar to that described in man by *CLEMENS and CUAST (1960)* in rabbit by *AHMED (1986)* and in dog fetuses by *Ahmed and MOSTAFA (1990).*

The Aa. corni ventrales in the examined bird species divide into medial and lateral groups similar to that stated also by *CLEMENS and QUAST (1960)* in man. The suclal arteries described in pigeon, duck and chicken are responsible for the vasculature of both halves of the cord as stated also by *BRADSHAW (1985)* in cat, *AHMED (1986)* in rabbit and *AHMED and MOSTAFA (1990)* in dog fetuses. However, the statement of *ADAMKIEWICZ (1882)* that each sulcal artery in man divides into two sulco-commissural arteries for the right and left halves of the spinal cord was defined by *KADYI (1886); SUH and ALEXANDER (1939); HERREN and*

ALEXANDER (1939) and CLEMENS and QUAST (1960).

The blood capilaries of the gray matter in pigeon, duck and chicken are very dense and form complicated rich networks much more than those found in the white matter, as the case described also by *STERZI (1904)* in mammals, *AHMED (1986)* in rabbit and *AHMED and MOSTAFA (1990)* in dog fetuses. The density of the arterial Plexuses which vascularize the spinal cord segments forming the cervical enlargement in flying birds was found to be more than that in running and swimming ones. However, these plexuses were found to be more complicated in the gray matter of the lumbosacral segments in chicken [running bird] and duck [swimming bird].

The marginal and fissural arteries which have changed directly from the arterial to the venous side without forming capillaries or arterio-venous anastomoses reflects the high importance of the free flow of blood from the arterial to the venous direction within the substance of the cervical enlargement specially in the flying birds. However, such pattern was also noticed within the substance of the spinal segments forming the lumbosacral enlargement in duck and chicken. The large marginal branches which penetrate the lateral funiculi in chicken are similar in their superficial course to the coiled screw-like arterioles described by *LOB (1967).*

REFERENCES

Adamkiewicz, A. (1882): Die Blutgefässe des Menschlichen Rückenmarkes, I. Tiel: Die Gefasse der Ruckenmarkesubstance. SB. Akad Wiss, Wien III, 84: 469. (Cited after Clemens and Quast, 1960).

Ahmed, A.K. (1986): Arterial blood supply of the spinal cord of rabbit. Assiut Vet. Med. J. 15 No. 30, 21-28.

Ahmed, A.K. and M.N. Moustafa (1990): A developmental study on the Angioarchitecture of the spinal cord in dog. Assiut Vet. Med. J. 23 No. 46, 12-21.

Baumel, J.J. (1975): Aves heart and blood vessels in: Sission and Grossman's: The anatomy of the domestic animals, 2, 5th Edition. Rev. by R. Getty W.B. Saunders Comp., Philadelphia, London, Tornto.

Bradshaw, P. (1958): Arteries of the spinal cord in the cat. J. Neurology (London), 21: 284-289.

Climens, H.J. und Quast, H.V. (1960): Untersuchungen uber die Gefässe des measchlichen Rüchenmarkes. Acta Anatomica (Basal) 42: 277-306.

Hasouna, E.M. (1990): Some studies on the vasculature, cytoarchitocture and morphometery of the cervical enlargement of chicken (Gallus domesticus),

pigeon (Columba livia) and duck (Anas domestica). Thesis, Ph.D. Faculty of Vet. Med., Assiut University.

Herren, R.Y. and Alexander, L. (1939): Sulcal and intrinsic blood vessels of human spinal cord. Arch. Neurol. P. sychiat. (Chicago, 41: 678-687).

Kadyi, H. (1886): Uber die Blutgefässe des menschlichen Rückenmarkes. Lemberg. (Cited after Clemens and Quast, 1960).

Lob, G. (1967): Untersuchungen am Huhn uber die Blutgefässe von Rückenmark und corpus gelatinosum. Morph. Jahr buch, 110, Heft 2: 316-358.

Sterzi, G. (1904): Die Blutgefässe des Rüchkenmarkes-untersuchungen Uber Ihre vergleichende Anatomie und entwicklungsgeschichte. Anat. Hefte, 24: 1-363.

Suh, T.H. and Alexander, L. (1939): Vascular system of the human spinal cord. Arch. Neurol. P. sychiat [Chicago], 41: 659-677. (Cited after Clemens and Quast, 1960).

LEGENDS

Fig. 1: A Photomicrograph of a thick section in the spinal cord of pigeon at the level of C12 injected with serum indian ink, X-40. showing:
1 A. sulci, 2 Rr. corni ventrales mediales, 3 Rr. corni ventrales laterales, 4 Rr. marginales, 5 Rr. corni dorsales, 6 Aa. interfuniculares, 7 Aa. fissurae.

Fig. 2: A Photomicrograph of a thick section in the spinal cord of pigeon at the level of C12 injected with serum indian ink, X-40. showing:
1 Aa. fissurae, 2 Aa. sulco-commissurales, 3 A. sulci.

Fig. 3: A Photomicrograph of a thick section in the spinal cord of pigeon at the level of T2 injected with serum indian ink, X-40. showing:
Showeing the tortous course of the fissural [1] and the sulcal [2] arteries and their division.

Fig. 4: A Photomicrograph of a thick section in the spinal cord of duck at the level of C16 injected with serum indian ink, X-40. showing:
1 Fissural artery, 2 Sulcar artery, 3 Branch to the dorsal horn.

Fig. 5: Diagram showing the area of deep distribution of the spinal arteries.
1 A. spinalis ventralis, 2 Rr. corni ventrales mediales and laterales [from dorsal and ventral radicular arteries], 3 Rr. marginales, 4 Rr. corni dorsales, 5 Aa. interfuniculares, 6 Aa. fissurae.

Fig. 6: Diagram showing the pattern of arterial vasculature of the spinal cord segments in pigeon, duck and chicken.
1 A. radicularis dorsalis, 2 R. cranialis, 3 R. caudalis, 4 R. spinalis dorsalis, 5 Plexus spinalis dorsalis, 6 A. spinalis dorsalis [except in chicken], 7 Arterial vascular zone, 8 plexus spinalis lateralis, 9 A. radicularis ventralis, 10 A. spinalis ventrolateralis [only in duck, 11

Spinal arterial circle (in part)], 12 A.spinalis ventralis, 13 sulcal, 14 sulco-commissural artery, 15 Rr. corni ventrales mediales, 16 Rr. corni ventrales laterales, 17 Rr. marginales, 18 Rr. corni dorsales, 19 Aa. interfuniculares, 20 Aa fissurae.

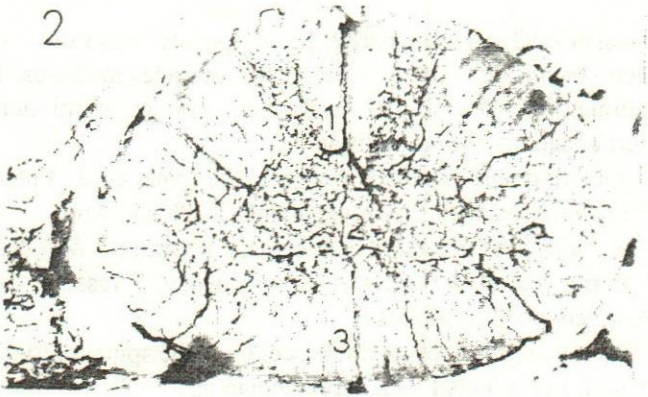
Fig. 7: A Photomicrograph of a thick section in the spinal cord of pigeon at the level of Ls3 injected with serum indian ink, X-32. showing:
1 A. radicularis ventralis, 2 A. spinalis ventralis, 3 & 4. Rr. marginales, 5 R. corni ventralis, 6 Plexus of gray matter, 7 vessels of glycogen body, 8A. sulco- commissurales

Fig. 8: A Photomicrograph of a thick section in the spinal cord of chicken at the level of Ls2 injected with serum indian ink, X-32. showing:
1 R. corni ventralis, 2 Rr. marginalis, 3 Rr. curni dorsales, 4 A. spinalis dorsalis, 5 A. interfunicularis.

Fig. 9: A Photomicrograph of a thick section in the spinal cord of chicken at the level of Ls5 injected with serum indian ink, X-40. showing:
1 A. sulco-commissuralis, 2 Rr. marginalis, 3 Rr. corni dorsales, 4 Branch for glycogen body, 5 Plexus of gray matter.

Fig.10: A Photomicrograph of a thick section in the spinal cord of pigeon at the level of T2 injected with serum indian ink, X-32. showing:
The arteries were injected with serum-indian ink and the section was stained with Cresyl violet and Luxol fast blue as counter stain for the Nissl substance and the myelinated nerve fibers. Fissural artery.

Fig.11: The same photo of Fig. 10 with high magnification X-400.
Showing the direct change of the fissural artery (1) from the arterial side into the venous side.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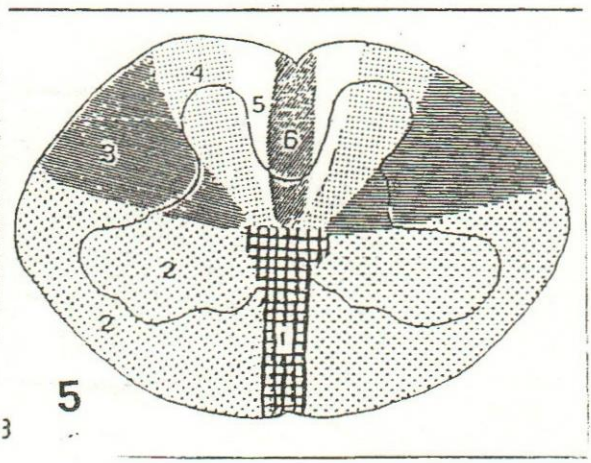
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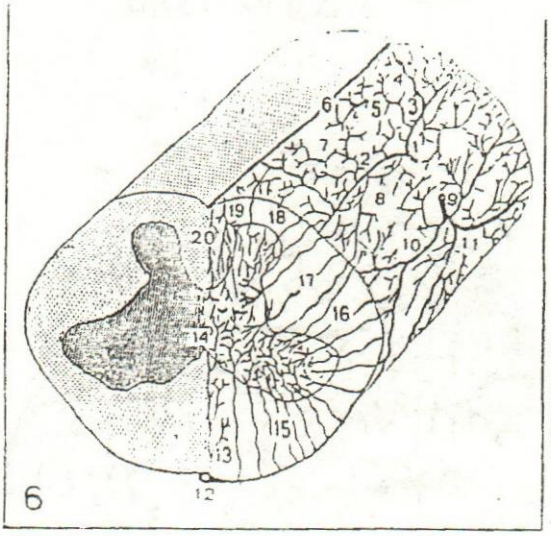
DISTRIBUTION, SPINAL ARTERIES, CERVICAL & LUMBOSACRAL ENLARGEMENTS

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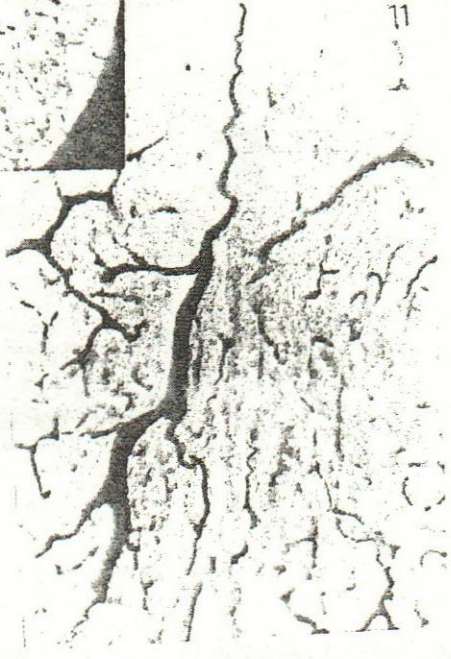
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