

قسم التشريخ والهستولوجيا  
كلية الطب البيطرى - جامعة أسيوط  
رئيس القسم : ا. د / حلمى محمد بدوى

## بعض الدراسات التشريخية على فلقات النخاع الشوكى فى الجمل

هد الله حفى ، أحمد قناوى ، على عبدالقادر ، محمد المحرزى

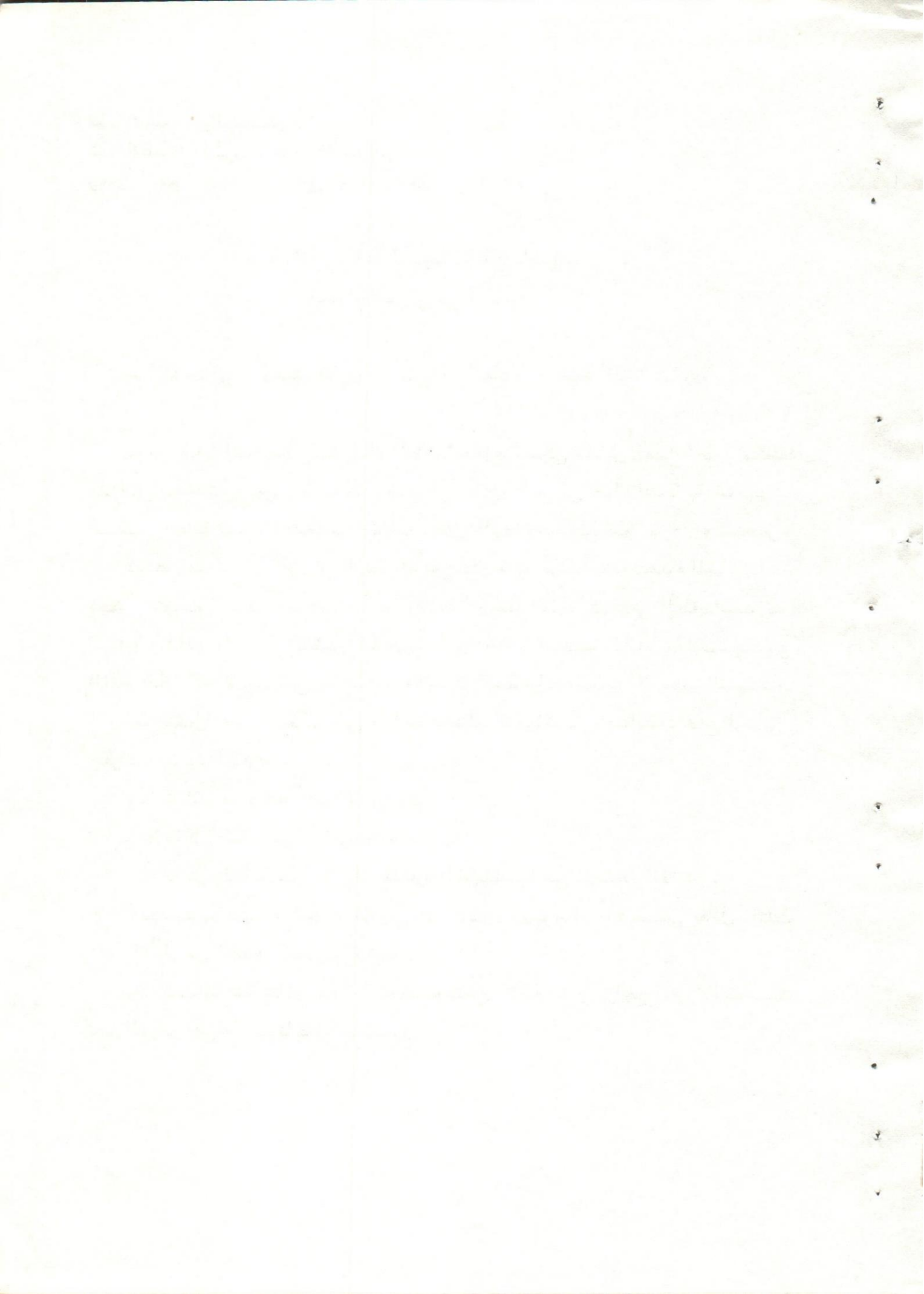
تم فى هذا البحث دراسة طول فلقات النخاع الشوكى بقياس المسافة بين منتصف مسافتين متالتين بين جذريه وقد وجد ان اطول فلقة على طول النخاع الشوكى هى الفلقة العنقية الخامسة ومتوسط طول النخاع الشوكى هو ٢١٣ر٦ سنمىتر كذلك فقد تم قياس كل من القطر الأفقى لكل فلقة حيث أوضحت هذه القياسات وجود التضخم العنقى الذى يبدأ من الفلقة العنقية السادسة حتى الفلقة الصدرية الثانية وكذلك التضخم القطنى الذى يبدأ من الفلقة القطنية السادسة وحتى الفلقة العجزية الاولى الى جانب دراسة عدد الجذيرات المكونة للأعصاب الشوكية كما اشتمل هذا البحث على دراسة تفصيلية للعلاقة بين فلقات النخاع الشوكى وفقرات العمود الفقرى .

وقد شملت هذه الدراسة الآتى :-

- ١ - علاقة كل فلقة بجسم الفقرة المقابلة لها .
- ٢ - علاقة كل فلقة بالنتوء الشوكى للفقرة المقابلة لها فى العمود الفقرى .
- ٣ - تم تحديد نهاية النخاع الشوكى فى الجمل حيث وجد أنه ينتهى مقابل الثلث الأول من الفقرة العجزية الثانية .

وقد تمت مناقشة نتائج هذا البحث مع نتائج الأبحاث والمراجع التى عالجت

نفس الموضوع فى الحيوانات الاخرى .



Dept. of Anatomy and Histology,  
Faculty of Vet. Med., Assiut University,  
Head of Dept. Prof. Dr. H. Badawi.

**SOME ANATOMICAL STUDIES ON THE SPINAL CORD IN CAMEL**  
(With 2 Figs. & 3 Tables)

By  
**A. HIFNY, A.K. AHMED, A.A. MANSOUR and M.E. ABDEL MONEIM**  
(Received at 24/12/1984)

**SUMMARY**

The present study includes the topographic relations between the spinal cord segments and the skeletal landmarks of the corresponding Corpus vertebrae in camel, in addition to the length and diameters of the spinal cord segments and the number of rootlets of the spinal nerves.

The cervical portion of the spinal cord extends from the For. magnum till the caudal margin of the last cervical vertebra. A caudal displacement of the thoracic segments begins at the tenth one and continues caudally till the end of the thoracic region. However, a cranial displacement takes place at the seventh lumbar spinal cord segment.

The cervical enlargement in camel extends from C<sub>6</sub> to T<sub>2</sub>, while the lumbar one extends from L<sub>6</sub> to S<sub>1</sub>. In these two positions, the number of rootlets of the spinal nerves reach their maximum.

The present study revealed that the spinal cord terminates at the junction between the 2<sup>nd</sup> and 3<sup>rd</sup> sacral vertebrae. Its average length is about 213.6 cm.

**INTRODUCTION**

The topographic relationship between the spinal cord and the vertebrae was examined by THIEL (1941) in dog; SEIFERLE (1939) and HABEL (1951) in Cattle and horse; GOLLER (1957) in sheep; THOMAS/ COMBS (1962, 1965) in cat and monkey; JENKINS (1972) and DELLMANN/McCLVRE (1975) in horse. However, the informations about such relationship in the dromedary camel are very little. This investigation was carried out to study the topographic relation between the spinal cord and the vertebrae, in addition to the length and level of termination of the cord in camel.

**MATERIAL and METHODS**

The present work was carried out on 8 adult healthy animals of the species *Camelus dromedarius*. The animals were anesthetized, bled and injected with 10% formalin solution. Each spinal cord was exposed both dorsally by laminectomy and laterally through a paramedian section using an electric bone saw.

**RESULTS**

**I - Length of the spinal cord segments (Table 1):**

The segment length in the cervical region increases sharply from C<sub>1</sub> (5.5 cm), to C<sub>5</sub> (16.5

cm), then a rapid decrease in segment length occurs till T<sub>1</sub> (4.6 cm). In the thoracic region, the segment length shows a slight increase from T<sub>1</sub> till T<sub>5</sub> thereafter an approximate equal values with average between 7.2 to 7.6 cm are found till T<sub>12</sub>. The lumbar region shows a progressive decrease in segment length from L<sub>1</sub> (6.3 cm) to L<sub>7</sub> (1.95 cm) followed by a slight decrease from L<sub>7</sub> to the end of the spinal cord at Ca<sub>5</sub> (0.6 cm).

The average length of the spinal cord in camel reaches 213.60 cm measured from the Foramen magnum till its termination at the junction between the 2<sup>nd</sup> and 3<sup>rd</sup> sacral vertebrae. However, it may terminate at the cranial 1/3 of the second sacral vertebra.

#### II- Transverse and dorsoventral diameters of the spinal cord segments (Table 2):

The diameters of the spinal cord become large at the cervicothoracic and lumbosacral regions forming the Intumescentia cervicalis (cervical enlargement) and Intumescentia lumbalis (lumbar enlargement). The two enlargements represent the origin of the brachial and lumbosacral plexuses. At these two positions the rootlets of the spinal nerves reach their maximum number, however, the number of rootlets are generally larger in the ventral roots of the spinal nerves than the dorsal ones (Table 3).

#### III- Relation between the spinal cord segments and the corresponding Corpus vertebrae (Fig. 1):

The first cervical spinal cord segment lies entirely within the atlas, while the second segment occupies the cranial 2/3 of the axis. The 3<sup>rd</sup> to the 7<sup>th</sup> cervical segments undergo a cranial displacement from their corresponding vertebrae by a distance ranging between 5.7 - 9.5 cm. The maximum cranial displacement is found at the 4<sup>th</sup> cervical segment, while the minimum one located at the 7<sup>th</sup> segment. The last cervical segment occupies the caudal 2/3 of the last cervical vertebra.

The first thoracic spinal cord segment occupies the cranial half of the 1<sup>st</sup> thoracic vertebra, while the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> thoracic segments are completely cranially displaced from their corresponding vertebra to occupy the body of the preceding one. The 5<sup>th</sup> to the 8<sup>th</sup> thoracic segments show a cranial displacement in which its maximum (6.5 cm) lies at the 5<sup>th</sup> segment (which occupies the caudal half of the 4<sup>th</sup> and the cranial half of the 5<sup>th</sup> thoracic vertebrae) and the minimum (3 cm) is found at the 8<sup>th</sup> thoracic segment. The 9<sup>th</sup> thoracic segment terminates at the level of the caudal border of the body of its corresponding vertebra, while the last three segments show caudal displacement ranging between 2-3.5 cm.

The first five lumbar segments show variable degree of caudal displacement ranging between 1 - 4.8 cm, the maximum lies at the 2<sup>nd</sup> and the minimum at the 5<sup>th</sup> segment. The last two lumbar segments lie within the 6<sup>th</sup> lumbar vertebra as the 6<sup>th</sup> segment occupies the middle part of the vertebra and the 7<sup>th</sup> segment occupies the remaining caudal portion.

The five segments of the sacral part of the spinal cord are included within the last lumbar vertebra, while the pars caudalis of the spinal cord, which includes five segments, are located in the first two sacral vertebrae at which the spinal cord terminates.

#### VI- Relation between the spinal cord segment and the spinous processes:

This relation was done by making a vertical line between the caudal part of the summits of the spinous process and the corresponding spinal cord segment.

The dorsal tubercle of the atlas is vertically related to the cranialmost 1/5 of the second cervical segment. The spinous process of the axis lies opposite to the cranial 1/3 of the 3<sup>rd</sup> cervical segment, while that of the 3<sup>rd</sup> cervical vertebra is vertically related to the corresponding cervical segments, while that of the last cervical vertebra is vertically related to the caudal limit of the 8<sup>th</sup> cervical segment.

## SPINAL CORD IN CAMEL

The spinous process of the first thoracic vertebra lies opposite to the middle of the 3rd thoracic segment, those of the 2nd, 3rd and 4th thoracic vertebrae are vertically related to the caudalmost 1/5 of the 4th, 5th and 6th thoracic segments respectively. Moreover, the spinous processes of the 5th, 6th and 7th thoracic vertebrae are in relation with the middle of the 7th, 8th and 9th thoracic segments respectively, while that of the 8th thoracic vertebra is vertically related to the cranial 1/3 of the 10th thoracic segment.

The spinous processes of the 9th and 10th thoracic vertebrae lie opposite to a segment next to its corresponding one, while those of the last two thoracic vertebrae are vertically related to their corresponding segments.

The spinous process of the first lumbar vertebra lies vertical to the caudalmost 1/3 of the last thoracic segment, that of the 2nd and 3rd lumbar vertebrae are placed opposite to the caudalmost 1/4 of the 1st and 2nd lumbar segments, while that of the 4th lumbar vertebra lies against the caudalmost 1/6 of the 3rd lumbar segment. On the other hand, the spinous processes of the 5th and 6th lumbar vertebrae are placed opposite to their corresponding segments. Moreover, the spinous process of the last lumbar vertebra lies opposite to the middle of the 4th sacral segment.

### V - Relation between the spinal cord segments and the transverse processes (Fig. 2):

This relation was done by making a transverse line from the caudolateral angle of the transverse process to the spinal cord segment.

The wing of the atlas lies opposite to the cranial 1/3 of the 2nd cervical segment, while the transverse processes of the 2nd and 3rd cervical segments are at the middle of the 3rd and 4th cervical segments. Moreover, the transverse processes of the 4th and 5th cervical vertebrae lie opposite to the cranial 1/3 of the 5th and 6th cervical segments, while that of the 6th cervical vertebra is placed opposite to the middle of the 7th cervical segment. However, the transverse process of the last cervical vertebra lies opposite to the caudal end of the 8th cervical spinal cord segment.

The transverse processes of the first seven thoracic vertebrae lie opposite to a segment next to its corresponding one, while the last five transverse processes are placed opposite to their corresponding segments.

The transverse processes of the lumbar vertebrae are generally related transversely to their corresponding lumbar spinal cord segments.

The cranial border of the wing of sacrum lies opposite to the caudal end of the 3rd sacral segment, while the caudal border is placed opposite to the last caudal spinal segment.

## DISCUSSION

The relation between the first cervical spinal cord segment and its corresponding Corpus vertebra in camel is similar to that recorded by HABEL (1951) in horse, HOLLINSHEAD (1958) in man, FIETCHER/KITCHELL (1966) in dog and MANSOUR (1980) in donkey. The whole cervical part of the spinal cord occupies its corresponding cervical portion of the vertebral column in camel, however, the cervical spinal part is displaced caudally in horse to terminate at the cranial part of the first thoracic vertebra as stated by DELLMANN/McCLURE (1975).

The cranial displacement of the thoracic spinal segments from the 2nd to the 8th in camel are similar to the results obtained by SHARMA/RAO (1971) in indian buffalo.

The caudal displacement which was observed in the position of the last, 3 thoracic segments and begins at the 10<sup>th</sup> in the camel, was also observed in the indian buffalo by SHARMA/RAO (1971) beginning at the 9<sup>th</sup> segment. Such caudal displacement was recorded also by SEIFERLE (1939) in horse.

The caudal displacement includes the first five lumbar spinal cord segments as in camel, while it includes only the first two lumbar segments in horse (HABEL, 1951) and cattle (DELLMANN/McCLURE, 1975) and only the first segment in donkey (MANSOUR, 1980).

The cranial displacement which begins in camel at the 7<sup>th</sup> lumbar segment, was observed also in the Egyptian buffalo at 6<sup>th</sup> segment (ABU-ZAID, 1982), 4<sup>th</sup> in cattle (DELLMANN/McCLURE, 1975), 3<sup>th</sup> in donkey (MANSOUR, 1980) and at the 2<sup>nd</sup> lumbar segment in indian buffalo (SHARMA/RAO, 1971).

The cranial displacement in domestic animals is more pronounced in dog in which the three sacral segments lie within the caudal 2/3 of the 5<sup>th</sup> and the cranial 1/4 of the 6<sup>th</sup> lumbar vertebrae, however, the sacral part of spinal cord in man lies within the 1<sup>st</sup> lumbar vertebra as stated by SEIFERLE (1975).

The termination of the spinal cord in camel in the sacral region resembles that described by SHARMA/RAO (1971) in indian buffalo at the middle of the sacrum and by ABU-ZAID (1982) in Egyptian buffalo at the cranial limit of the 3<sup>rd</sup> sacral vertebra. However, the termination of the spinal cord in ox was reported by HABEL (1951) at the first sacral vertebra, by CLAIR/HARDENBROOK (1956) at the second and / or at the middle of the sacrum as stated by McCLEOD (1958).

The cervical enlargement in camel extends from C<sub>6</sub> to T<sub>2</sub> similar to that observed in Egyptian buffalo (ABU-ZAID, 1982), however, it extends from C<sub>6</sub> to T<sub>1</sub> in dog (JENKINS, 1972) and sheep (GOLLER, 1957); from C<sub>5</sub> to T<sub>1</sub> in cattle (SEIFERLE, 1939) and man (MITCHELL, 1973) and from C<sub>5</sub> to T<sub>2</sub> in donkey (MANSOUR, 1980). The cervical enlargement is restricted in the cervical segments as in cat from C<sub>5</sub> to C<sub>7</sub> (SHURMANN, 1951).

The lumbar enlargement extends from L<sub>6</sub> to S<sub>1</sub> in camel, however, it extends from L<sub>2</sub> to S<sub>1</sub> in indian buffalo (SHARMA/RAO, 1971) and donkey (HIFNY/AHMED/MANSOUR, 1982), from L<sub>4</sub> to S<sub>1</sub> in sheep (GOLLER, 1957) and from L<sub>4</sub> to S<sub>2</sub> in Egyptian buffalo (ABU-ZAID, 1982). The lumbar enlargement is restricted in the lumbar region as in horse from L<sub>2</sub> to L<sub>6</sub> and from L<sub>4</sub> to L<sub>6</sub> in cattle (SEIFERLE, 1939).

The camel possesses the longest spinal cord among the large domesticated animals with an average of 213.60 cm, however, in horse it ranges between 180-200 cm and in cattle 160-180 cm as recorded by SEIFERLE (1975). The spinal cord in indian buffalo reaches 138.67 cm as reported by SHARMA/RAO (1971), while in old Egyptian buffalo it reaches 188.65 cm as measured by ABU-ZAID (1982). However, the length of the spinal cord in cat reaches 40 cm and in man 42-45 cm as stated by SEIFERLE (1975).

## REFERENCES

- Abu-Zaid, S.M.S. (1982): Some gross anatomical studies on the prenatal and postnatal morphological features on the spinal cord of the water buffalo (*Bos bubalis* L). Thesis, Ph.D., Faculty of Vet. Med., Cairo Univ.
- Clair, L.E. and H.J. Hardenbrook (1956): Lumbarepidural anaesthesia in cattle. *J. Amer. Vet. Med. Ass.*, 129: 405-409.

## SPINAL CORD IN CAMEL

- Dellmann, H.D. and R.C. McClure (1975): Central nervous system in: Sisson and Grossman's, The anatomy of the domestic animals, Vol. I, II, rev. by Getty, R. 5th ed. W.B. Saunders Comp., Philadelphia, London, Toronto.
- Fletcher, T.F. and R.L. Kitchell (1966): Anatomical studies on the spinal cord segments of the dog. Amer. J. Vet. Res., 27, 121.
- Goller, H. (1957): Topographie und segmentaler Feinbau des Rückenmarkes des Schafes (*Ovis aries*) Diss. München.
- Habel, R.E. (1951): The topography of the equine and bovine spinal cord. (Abstr. of an article by E. Seiferle). J. Amer. Vet. Med. Ass., 118.
- Hifny, A., A.K. Ahmed and A.A. Mansour (1982): Anatomy of spinal cord segments of donkey (*Equus asinus*). Assiut Vet. Med. J., Vol. 10, No. 19, 15.
- Hollinshead, W.H. (1958): Anatomy for Surgeons, the back and limbs, Vol. 3. Harper & Row Publ., New York, Evanston, San Francisco, London.
- Jenkins, T.W. (1972): Functional mammalian neuroanatomy, 1st ed. Lea and Febiger, Philadelphia.
- Mansour, A.A. (1980): Some morphological features of the spinal cord in donkey. Thesis, M.V.Sc., Faculty of Vet. Med., Assiut Univ.
- McCleod, W.M. (1958): Bovine Anatomy, 2nd ed. Burgess Publ. Co., Minneapolis, Minnesota.
- Seiferle, E. (1939): Zur Rückenmarktopographie von Pferd und Rind. Zschr. Anat. Entw. Gesch. 110.
- Seiferle, E. (1975): Nervensystem in: Nickel, Schummer und Seiferle, Lehrbuch der Anatomie der Haustiere Bd. IV. Verlag Paul Parey, Berlin und Hamburg.
- Sharma, D.N. and G.S. Rao (1971): Anatomy of the spinal cord segments of buffalo (*Bubalis bubalis*). Acta Anatomica 79.
- Thiel, G. (1941): Die topographie der Rückenmarkssegmente des Hundes. Diss. Hannover.
- Thomas, C.E. and C.M. Combs (1962): Spinal cord segments. A- Gross structure in the adult cat. Amer. J. Anat. 110.
- Thomas, C.E. and C.M. Combs (1965): Spinal cord segments. B- Gross structure in the adult monkey. Amer. J. Anat., 116.

Table (1)  
Segment length (in cm)

S.L.*	Mean	Range	S.L.*	Mean	Range
C <sub>1</sub>	05.50	04.65-06.50	L <sub>1</sub>	06.30	05.00-07.10
C <sub>2</sub>	11.00	09.00-13.30	L <sub>2</sub>	06.10	04.85-06.90
C <sub>3</sub>	14.90	12.80-17.00	L <sub>3</sub>	05.30	04.40-06.00
C <sub>4</sub>	16.10	12.70-18.35	L <sub>4</sub>	04.90	04.15-05.35
C <sub>5</sub>	16.50	12.20-19.50	L <sub>5</sub>	04.40	03.75-04.75
C <sub>6</sub>	13.20	10.95-16.80	L <sub>6</sub>	03.20	02.40-03.80
C <sub>7</sub>	08.90	07.40-09.55	L <sub>7</sub>	01.95	01.60-02.60
C <sub>8</sub>	05.50	04.40-06.15			
T <sub>1</sub>	04.60	03.70-05.30	S <sub>1</sub>	01.50	01.15-01.70
T <sub>2</sub>	04.80	03.90-05.70	S <sub>2</sub>	01.30	00.95-01.45
T <sub>3</sub>	05.90	03.70-07.00	S <sub>3</sub>	01.10	00.90-01.20
T <sub>4</sub>	06.80	04.55-07.70	S <sub>4</sub>	00.95	00.85-01.05
T <sub>5</sub>	07.40	05.36-08.65	S <sub>5</sub>	00.85	00.60-00.90
T <sub>6</sub>	07.30	05.24-08.75	Ca <sub>1</sub>	60.75	00.70-00.90
T <sub>7</sub>	07.60	05.35-08.80	Ca <sub>2</sub>	00.70	00.65-00.90
T <sub>8</sub>	07.25	05.40-07.95	Ca <sub>3</sub>	00.70	00.65-00.80
T <sub>9</sub>	07.50	04.50-09.25	Ca <sub>4</sub>	00.65	00.55-00.75
T <sub>10</sub>	07.20	04.70-07.95	Ca <sub>5</sub>	00.60	00.40-00.60
T <sub>11</sub>	07.25	05.10-08.70			
T <sub>12</sub>	07.15	05.25-07.80			

\* Segment length



## SPINAL CORD IN CAMEL

Table (2)  
Transverse diameter (in cm)

T.D.*	Mean	Range	T.D.*	Mean	Range
C 1	1.30	1.10-1.40	L 1	1.00	0.95-1.10
C 2	1.25	1.00-1.50	L 2	1.04	0.95-1.20
C 3	1.25	1.00-1.50	L 3	1.14	1.05-1.30
C 4	1.24	1.05-1.50	L 4	1.19	1.10-1.30
C 5	1.30	1.05-1.50	L 5	1.20	1.10-1.30
C 6	1.44	1.15-1.60	L 6	1.36	1.20-1.45
C 7	1.60	1.35-1.70	L 7	1.38	1.10-1.50
C 8	1.66	1.40-1.80			
T 1	1.54	1.35-1.65	S 1	1.26	1.00-1.45
T 2	1.36	1.30-1.45	S 2	0.98	0.80-1.20
T 3	1.10	0.95-1.25	S 3	0.70	0.65-0.80
T 4	1.05	0.90-1.20	S 4	0.56	0.45-0.70
T 5	1.04	0.85-1.20	S 5	0.49	0.35-0.60
T 6	1.00	0.80-1.20	Ca 1	0.45	0.40-0.50
T 7	0.98	0.80-1.10	Ca 2	0.40	0.35-0.45
T 8	0.99	0.85-1.10	Ca 3	0.40	0.35-0.45
T 9	0.99	0.85-1.10	Ca 4	0.27	0.25-0.40
T 10	0.98	0.75-1.10	Ca 5	0.23	0.20-0.35
T 11	0.99	0.85-1.10			
T 12	0.99	0.85-1.10			
T 12	0.98	0.90-1.00			

\* Transverse diameter

Table (3)  
The number of nerve rootlets

No. of nerve	Nerve rootlets	Ventral root	Dorsal root	No. of nerve	Nerve rootlets	Ventral root	Dorsal root
C				L			
1	24	14	10	1	42	25	17
2	30	17	13	2	40	24	16
3	34	21	13	3	38	22	16
4	34	22	12	4	38	22	16
5	40	22	18	5	40	25	15
6	44	26	18	6	46	30	16
7	52	33	19	7	52	33	19
8	70	42	28				
T				S			
1	66	40	26	1	50	30	20
2	26	14	12	2	32	22	10
3	28	17	11	3	30	18	12
4	28	17	11	4	26	16	10
5	30	16	14	5	20	12	8
6	34	18	16				
7	36	22	14	Ca			
8	36	22	14	1	16	10	6
9	38	21	17	2	16	10	6
10	40	22	18	3	12	7	5
11	44	26	18	4	10	6	4
12	44	27	17	5	8	5	5

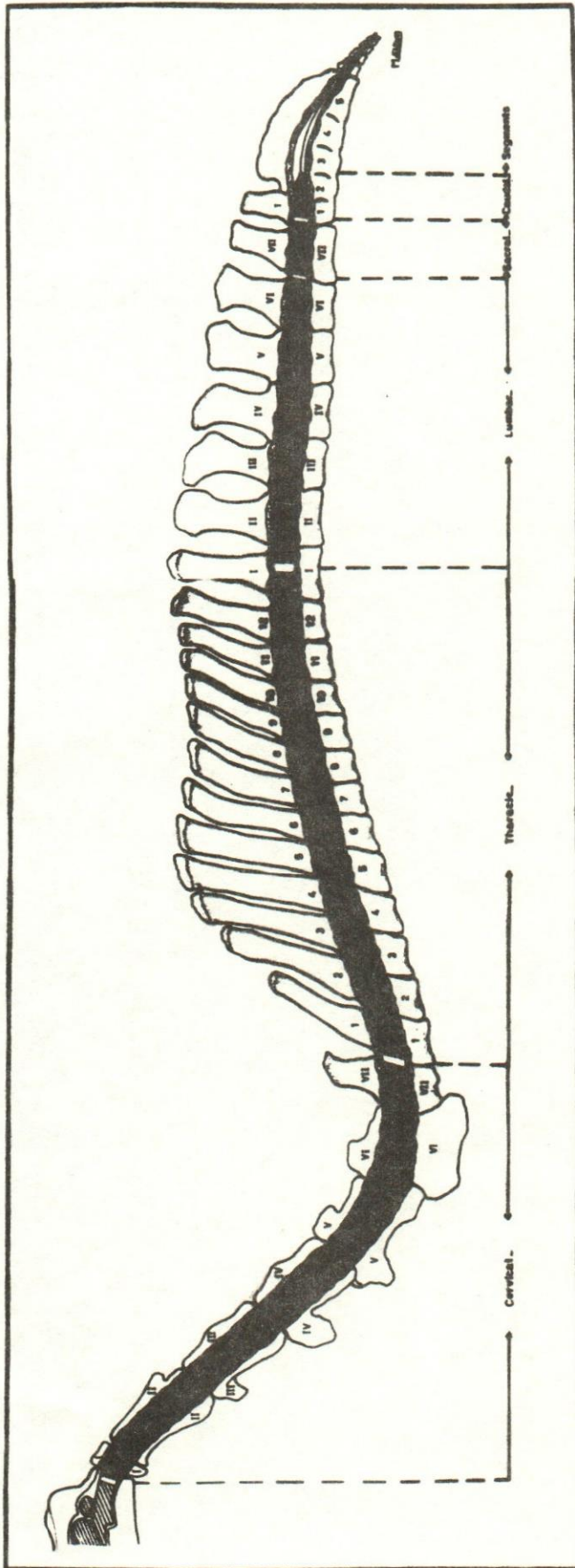
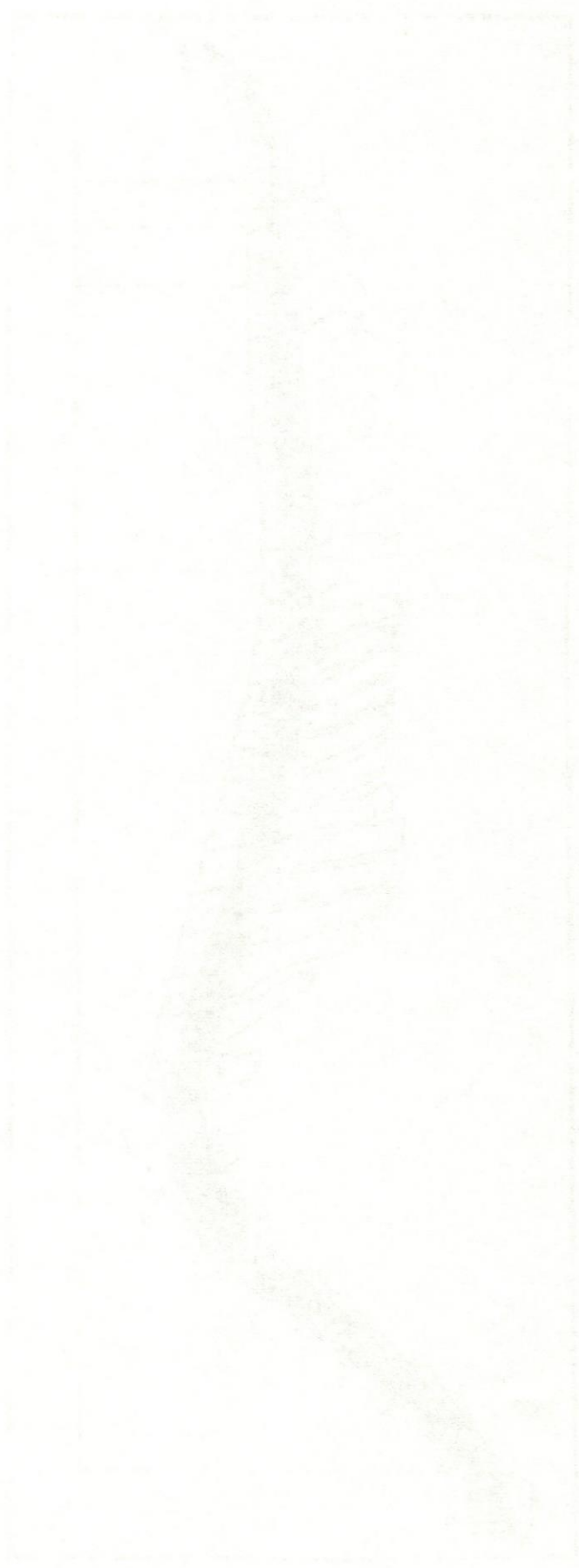


Fig. (1): Sagittal section of the vertebral column showing the relationship between the spinal cord segments and the vertebrae



THE UNIVERSITY OF CHICAGO  
LIBRARY

1  
2  
3  
4  
5  
6  
7  
8  
9  
10

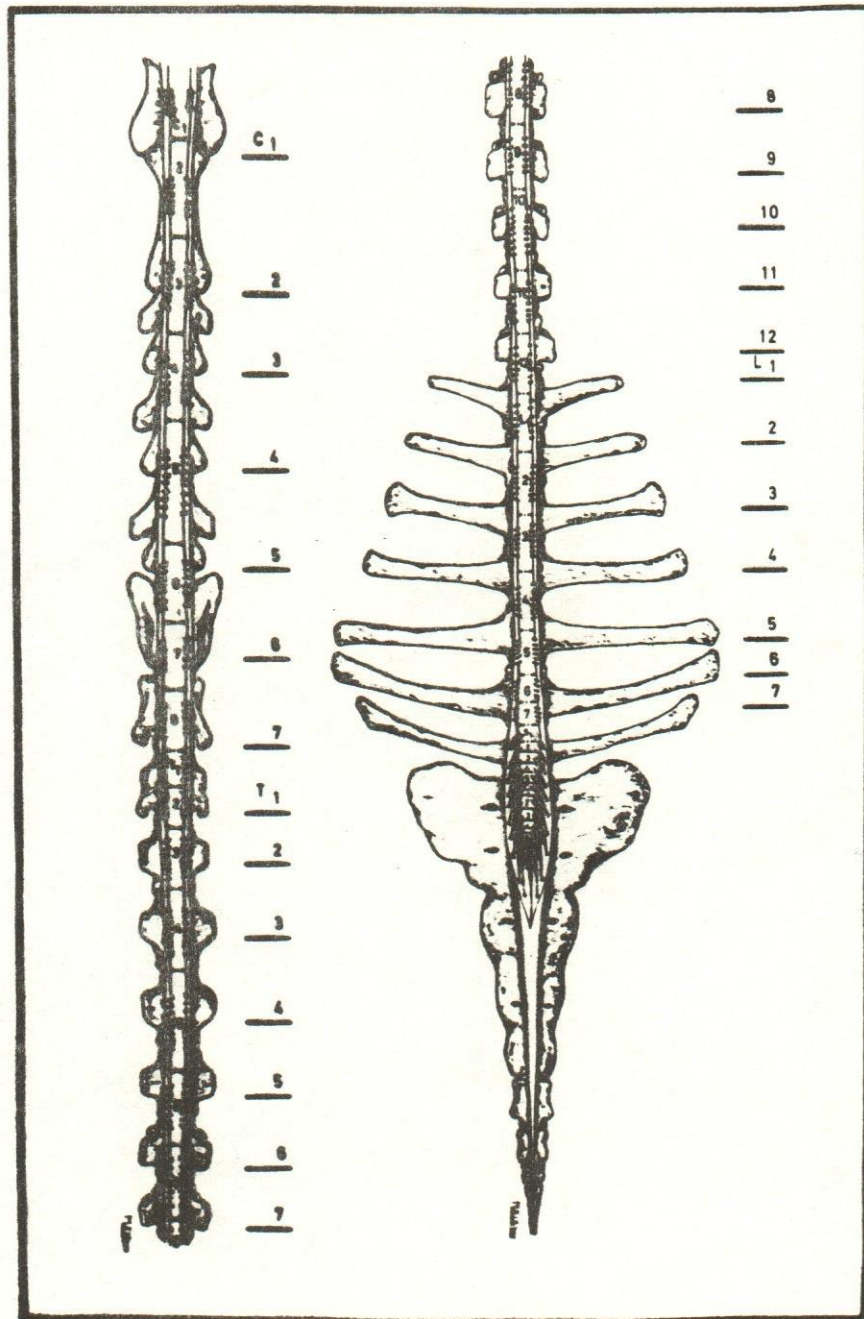


Fig. (2): Dorsal dissection of the vertebral column showing the relationship between the transverse processes of the vertebrae and the spinal cord segments. (The lines on the right represent the levels of the transverse processes)



Faint, illegible text or a caption located below the main drawing, possibly providing context or a title.