

MICROMETRICAL OBSERVATIONS ON THE CENTRAL CANAL OF SPINAL CORD IN GOAT FOETUSES*

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ABSTRACT

Micrometrical observations on the central canal of goat at various stages of prenatal development were studied using 52 foetuses of various ages. By second month, the cross-section of central canal was elongated and narrow especially in the cervical region. The reduction in the size of central canal was marked between third and fourth month. All regions exhibited a size reduction of central canal towards the end of gestation. During fourth and fifth month of gestation, the position of the central canal was a little dorsal in the cervical, cervical enlargement, thoracic and lumbar regions of the spinal cord but ventral or central in lumbar enlargement and ventral in sacral regions, helping to maintain a caudal flow of CSF.

INTRODUCTION

The position of the central canal is believed to be central in the spinal cord as per earlier reports in domestic animals (Dellmann and Mc Clure, 1975). But the studies on the developmental changes in the position of the central canal in goat at the micrometrical level are very scanty. So this study was undertaken to illustrate the micrometrical observations on the central canal of goat at various stages of prenatal development.

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MATERIALS AND METHODS

The study was conducted on 52 goat foetuses of different ages. The age was calculated using the formula derived by Singh *et al.* (1979), for goat foetuses, $W^{1/3} = 0.096(t - 30)$, where, W = Body weight of the foetus in g and t = Age of the foetus in days. The foetuses were grouped into five age groups corresponding to five months of gestation. The fixative used was 10 per cent neutral buffered formalin (NBF). Embryos and small foetuses upto 50 days of gestation were fixed as such in the fixative for 48 to 96 hours. In foetuses from 50 days to 90 days, the vertebral column with spinal cord inside was fixed. In foetuses above 90 days, the spinal cord was exposed by laminectomy, dissected out and was cut into pieces of two to three segments each and processed. These specimens were dehydrated and embedded in high melting paraffin (MP 58-60°C). Serial sections of 5 μ m thickness were made. Histological techniques like Ehrlich's haematoxylin and eosin (H & E) staining, Holzer's method for glial fibres, Van Gieson's method for collagen, Holmes silver nitrate method for axis cylinders and myelin sheaths, Sevier-Munger method, phosphotungstic acid haematoxylin (PTAH) method and Aldehyde-Thionine-PAS method for neural tissues (Luna, 1968) were employed. The micrometrical observations were recorded by using an ocular micrometer. The data collected were analysed

statistically following Snedecor and Cochran (1985).

RESULTS AND DISCUSSION

During the first month of gestation, the ependymal layer of the neural tube was thin at the basal plate but thick in the alar plate all along the length of the neural tube except at the coccygeal region, where its thickness was equal at both alar and basal plates (Table 1).

Average height, width and ependymal layer thickness of central canal are presented segment-wise and region-wise in tables 2 and 3. By second month, the cross-section of central canal was elongated and narrow especially in the cervical region. It was wider and longer at the first cervical segment, but decreased in size at C2 and C4 segments. The C1 segment followed the same pattern during later stages of gestation also. The ependymal layer thickness showed a regional variation during second month, with the minimum thickness at the sacral region in the precoccygeal cord. During later stages, it did not show much variation in thickness between regions. By the fifth month, a reduction was noticed in the ependymal thickness at all regions (Table 3).

The reduction in the size of central canal was marked between third and fourth month. The height of the central canal decreased from 15.097 per cent of total spinal cord height at third month

through 5.380 at fourth, to 3.780 per cent at fifth month at the cervical region. The corresponding values were 13.235, 6.351 and 4.611 per cent at cervical enlargement; 15.476, 7.267 and 5.110 per cent at thoracic; 16.030, 7.286 and 5.680 per cent at lumbar; 15.502, 7.391 and 5.483 per cent at lumbar enlargement; 20.080, 16.190 and 13.321 per cent at sacral and 49.020, 29.676 and 25.470 per cent at coccygeal region. It indicated a size reduction at all regions towards the end of gestation.

Even though the position of the central canal is believed to be central in the spinal cord, different developmental stages exhibited variation to this principle. The region-wise average for distances of dorsal median sulcus at dorsal surface and ventral median fissure at ventral surface to central canal is shown in table 4. The percentage of these distances to total spinal cord height is shown in table 5. The percentage of dorsal median sulcus to central canal distance (DMS to CC distance) was more than the percentage of ventral median fissure to central canal distance (VMF to CC distance) during second and third month of gestation. The maximum DMS to CC distance percentage was at the sacral region during fourth and fifth month, but it was minimum at sacral region at second and third month. It indicated a more ventral shifting of the central canal towards the end of gestation in the sacral region. In other regions, the upper end of central canal started approximately from the

Table 1. Micrometrical data at the first month of gestation (Mean \pm S.E), m

Parameter	Regions						
	Cervical	Cervical enlargement	Thoracic	Lumbar	Lumbar enlargement	Sacral	Coccygeal
Lumen height	466.667 \pm 33.133	486.875 \pm 29.760	459.222 \pm 30.022	436.875 \pm 23.622	455.000 \pm 25.593	317.500 \pm 11.726	165.000 \pm 10.062
Lumen width- upper	95.000 \pm 3.162	84.375 \pm 2.745	66.667 \pm 6.180	75.000 \pm 6.708	77.500 \pm 2.500	65.000 \pm 3.536	52.500 \pm 7.500
Lumen width- lower	90.000 \pm 33.317	80.625 \pm 12.006	22.500 \pm 2.165	43.125 \pm 9.997	55.000 \pm 11.402	45.000 \pm 6.124	15.000 \pm 0.500
Ependymal thickness - alar plate	110.000 \pm 6.325	103.125 \pm 14.013	76.111 \pm 7.158	95.625 \pm 7.986	125.500 \pm 20.736	65.000 \pm 2.500	63.000 \pm 7.348
Ependymal thickness - basal plate	57.500 \pm 8.139	50.625 \pm 7.986	51.667 \pm 6.180	39.375 \pm 8.475	55.000 \pm 11.402	43.333 \pm 3.909	63.000 \pm 7.348

Table 2. Segment-wise height and width of central canal and ependymal layer thickness in the precoccygeal spinal cord (Mean + S.E), μm

Seg-ments	Group II			Group III			Group IV			Group V		
	Central canal		Ependyma thickness	Central canal		Ependyma thickness	Central canal		Ependyma thickness	Central canal		Ependyma thickness
	Height	Width		Height	Width		Height	Width		Height	Width	
C1	152.500± 4.330	120.000± 25.981	30.012± 6.078	262.500± 16.870	90.000± 1.826	37.500± 3.354	160.000± 2.887	90.000± 1.826	30.000± 2.236	165.000± 7.678	210.000± 17.321	26.250± 1.677
C2	127.500± 3.433	60.000± 8.660	30.000± 0.365	247.500± 10.227	90.000± 3.651	30.000± 0.913	130.000± 5.774	75.000± 4.017	30.000± 0.365	127.500± 4.952	172.500± 21.651	26.250± 1.677
C4	127.500± 3.433	60.000± 0.015	30.000± 6.078	187.500± 3.819	90.000± 1.461	30.000± 2.236	135.000± 0.577	90.000± 5.447	30.000± 0.146	141.250± 9.612	181.250± 13.975	22.050± 0.201
C6	180.000± 0.012	67.500± 4.330	22.500± 3.354	217.500± 16.869	120.000± 5.774	25.000± 2.236	195.000± 2.309	135.000± 5.447	30.000± 0.365	180.000± 6.952	176.250± 6.149	22.500± 0.020
C8	187.500± 3.819	60.000± 4.472	35.000± 4.472	231.500± 19.503	120.000± 2.887	37.500± 2.737	180.000± 1.155	105.000± 1.095	30.000± 0.183	141.250± 9.529	215.000± 15.652	28.800± 0.438
T2	197.500± 3.096	67.500± 3.819	35.000± 8.944	231.500± 19.503	105.000± 2.887	37.500± 2.737	150.000± 4.041	105.000± 7.303	30.000± 0.730	212.500± 5.881	165.000± 15.652	28.800± 0.358
T5	232.500± 4.425	82.500± 1.443	33.000± 5.367	221.500± 15.046	105.000± 02.039	33.750± 0.456	165.000± 3.464	90.000± 16.432	32.400± 0.803	197.500± 2.141	142.500± 16.771	22.500± 3.354
T7	227.500± 12.633	67.500± 4.330	15.000± 0.210	232.500± 4.425	75.000± 3.464	31.000± 0.913	135.000± 1.555	75.000± 5.477	30.000± 1.461	197.500± 2.141	121.250± 12.857	18.300± 1.476
T12	225.500± 0.100	45.000± 3.354	22.500± 3.354	225.000± 0.200	105.000± 0.577	22.000± 0.730	135.000± 5.774	90.000± 2.191	30.000± 1.095	187.500± 3.819	127.500± 10.062	20.100± 2.281
L1	225.000± 20.207	67.500± 10.062	22.500± 1.118	240.000± 13.904	88.000± 6.351	30.000± 0.671	165.000± 2.887	105.000± 1.461	30.000± 3.286	180.000± 2.887	157.500± 23.479	26.000± 1.789
L2	262.500± 3.819	75.000± 6.708	30.000± 0.010	240.000± 13.904	113.000± 4.619	30.000± 0.010	135.000± 1.732	105.000± 0.730	22.500± 0.913	187.500± 3.819	142.500± 30.187	26.000± 2.191
L3	262.500± 23.550	75.000± 6.708	30.000± 0.365	212.500± 3.819	105.000± 1.155	30.000± 0.365	135.000± 5.771	90.000± 3.651	22.500± 3.651	187.500± 3.774	146.250± 18.447	29.250± 5.019
L4	192.500± 5.881	90.000± 0.000	30.000± 2.191	225.000± 20.453	90.000± 4.041	30.000± 2.191	180.000± 5.196	105.000± 3.651	30.000± 0.548	187.500± 3.430	187.500± 23.478	30.000± 1.555
L6	200.000± 22.435	97.500± 3.354	18.000± 2.012	257.500± 4.958	88.000± 2.887	30.000± 1.876	150.000± 2.309	105.000± 0.730	30.000± 2.191	195.000± 20.125	150.000± 6.708	30.000± 0.913
S2	285.000± 2.887	75.000± 0.025	18.000± 0.730	250.000± 3.651	88.000± 5.774	30.000± 0.025	210.000± 5.774	60.000± 5.447	30.000± 0.730	200.000± 1.826	100.000± 1.826	30.000± 0.913
S4	277.500± 4.333	37.500± 1.118	15.000± 1.826	250.000± 3.651	38.000± 1.732	30.000± 0.730	300.000± 11.547	75.000± 5.447	30.000± 0.671	337.500± 0.913	97.500± 0.913	26.000± 0.730

Table 3. Region-wise height and width of central canal and ependymal layer thickness in the precoccygeal spinal cord (Mean+S.E), μm

Regions	Group II			Group III			Group IV			Group V		
	Height	Width	Ependyma thickness	Height	Width	Ependyma thickness	Height	Width	Ependymal thickness	Height	Width	Ependyma thickness
Cervical	135.833± 8.333	80.000± 20.000	30.000± 4.174	232.500± 22.913	90.000± 0.000	32.500± 2.500	141.667± 9.280	85.000± 5.000	30.133± 0.133	144.583± 10.953	187.917± 11.327	24.850± 1.400
Cervical enlargement	188.333± 5.069	65.000± 2.500	30.800± 4.167	226.833± 4.667	115.000± 5.000	33.333± 4.167	175.000± 13.229	115.000± 10.000	30.000± 0.426	177.917± 20.594	185.417± 15.144	26.700± 2.100
Thoracic	228.333± 2.205	65.000± 10.897	23.500± 5.220	226.333± 3.245	95.000± 10.000	28.917± 3.548	145.000± 10.000	85.000± 5.000	30.800± 0.800	194.167± 3.333	130.417± 6.305	20.300± 1.217
Lumbar	250.000± 12.500	72.500± 2.500	27.500± 2.500	230.833± 9.167	102.000± 7.371	30.000± 0.349	145.000± 10.000	100.000± 5.000	27.083± 1.083	185.000± 2.500	148.750± 4.507	25.000± 2.500
Lumbar enlargement	196.250± 3.750	93.750± 3.750	24.000± 3.464	241.250± 16.250	89.000± 1.000	30.000± 2.034	165.000± 15.000	105.000± 0.000	30.000± 1.370	191.250± 3.750	168.750± 18.750	30.000± 1.234
Sacral	281.250± 3.750	56.250± 18.750	16.500± 1.500	250.000± 0.000	63.000± 25.000	30.000± 0.378	255.000± 45.000	67.500± 7.500	30.000± 0.701	268.750± 68.750	98.750± 0.722	28.000± 2.000

Table 4. Region-wise dorsal surface to central canal height and ventral surface to central canal height (Mean \pm S.E), μm

Regions	Group II		Group III		Group IV		Group V	
	DMS - CC*	VMF - CC*	DMS - CC	VMF - CC	DMS - CC	VMF - CC	DMS - CC	VMF - CC
Cervical	615.833 \pm 25.672	500.833 \pm 27.338	750.833 \pm 46.965	541.667 \pm 41.062	1162.500 \pm 27.951	1357.500 \pm 25.715	1658.083 \pm 178.209	1935.333 \pm 163.386
Cervical enlargement	800.833 \pm 46.033	465.000 \pm 31.937	840.000 \pm 64.807	635.000 \pm 56.745	1050.000 \pm 22.361	1200.000 \pm 89.443	1630.833 \pm 135.810	2032.500 \pm 137.147
Thoracic	725.833 \pm 22.227	458.333 \pm 26.257	738.333 \pm 26.667	478.333 \pm 50.525	862.500 \pm 22.822	1087.500 \pm 39.131	1269.167 \pm 34.854	1819.333 \pm 185.318
Lumbar	728.333 \pm 18.514	400.000 \pm 25.000	766.667 \pm 34.512	426.667 \pm 23.898	705.000 \pm 1.826	945.000 \pm 20.125	1264.167 \pm 69.467	1800.833 \pm 102.522
Lumbar enlargement	722.500 \pm 60.467	553.750 \pm 70.100	830.000 \pm 26.693	468.750 \pm 34.301	1155.000 \pm 69.318	1015.000 \pm 5.477	1549.750 \pm 67.387	1745.000 \pm 95.960
Sacral	527.500 \pm 12.298	220.000 \pm 9.168	675.000 \pm 33.541	285.000 \pm 38.013	1004.167 \pm 8.944	385.833 \pm 38.274	1125.000 \pm 11.180	450.000 \pm 22.361

DMS CC: dorsal median septum to central canal distance

VMF CC: ventral median fissure to central canal distance

Table 5 Region-wise average of percentage of dorsal median septum to central canal distance and ventral median fissure to central canal distance to spinal cord height

Regions	Group II		Group III		Group IV		Group V	
	DMS - CC*	VMF - CC*	DMS - CC	VMF - CC	DMS - CC	VMF - CC	DMS - CC	VMF - CC
Cervical	48.779	39.670	48.755	35.173	44.146	52.234	43.529	50.807
Cervical enlargement	53.300	30.948	49.013	37.051	38.113	43.557	42.268	52.678
Thoracic	51.235	32.353	50.484	32.707	43.233	54.511	38.635	55.383
Lumbar	52.505	28.836	53.241	29.630	37.105	49.737	38.808	55.283
Lumbar enlargement	49.066	37.606	53.333	30.120	49.677	43.656	44.437	50.036
Sacral	33.493	14.000	33.457	14.126	63.757	24.497	55.762	22.305

central point itself. Later, the VMF to CC percentage exceeded DMS to CC percentage except at lumbar enlargement and sacral regions during the fourth month and except in the sacral region during the fifth month.

These percentage ratios between different distances during fourth and fifth month of gestation revealed that the position of the central canal was a little dorsal in the cervical, cervical enlargement, thoracic and lumbar regions of the

spinal cord but ventral or central in lumbar enlargement and ventral in sacral regions. This partially agreed with the observations of Taluja et al. (1990) in goat foetuses as they observed the location of the central canal a little dorsal, ventral and approximately central in cervical, thoracic and lumbar regions respectively. This feature probably helped to maintain the caudal flow of CSF.

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