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The development of the epidural space in human embryos

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The epidural space is seen in embryos at stage 17 (41 days) on the periphery of the primary meninx. During stage 18 (44 days) the dura mater proper appears and the epidural space is located between this meninx and the perichondrium and contains blood vessels. During the last week of the embryonic period (stages 20–23) the epidural space is evident around the circumference of the spinal cord. On the posterior surface it is found between the dura mater and the mesoderm of the dorsal body wall.

Key words: human neuroembryology, primary meninx, epidural space

INTRODUCTION

The epidural space lies between the spinal dura mater and the periosteum of the vertebral canal. This periosteum is formed by the outer endosteal layer of the dura mater. The epidural space contains loose connective tissue, venous plexuses and adipose tissue, which is particularly evident in the lumbar region [8]. There is some evidence that it is only a potential space [2].

Most papers devoted to the development of the meningeal spaces deal with such spaces in the skull [1, 3, 4, 6, 7].

The development of the epidural space in the vertebral canal was observed by Sensenig [9] in embryos at 30 mm C-R length. Lüdinghausen and Dziallas [5] found the space in foetuses of 180–280 mm C-R length.

The aim of the present study is to describe the formation of the epidural space in staged human embryos.

MATERIAL AND METHODS

The study was performed in 47 human embryos of 12 to 30 mm C-R length, from stage 17 to stage 23 (Table 1). All the embryos were sectioned in the horizontal, frontal, and sagittal planes and stained according to various methods (chiefly Mallory, haematoxylin and eosin and with silver salts). In some embryos graphic reconstructions were prepared at each of the stages investigated.

RESULTS

The primordium of the epidural space appears in embryos at the end of the 6th week (stage 17). In these embryos a more cellular zone appears on the periphery of the primary meninx, which is observed close to the vertebral bodies covered by the perichondrium (Fig. 1). In some places between the perichondrium and this zone there are irregular spaces containing blood vessels. These spaces may be considered the early epidural space.

In embryos at the beginning of the 7th week (stage 18) the condensed cellular layers appear in the most peripheral part of the primary meninx (Fig. 2, 3). These layers are present in the cervical and upper thoracic portions of the vertebral canal.

The external condensed layer fuses with the perichondrium of the vertebral bodies and the internal layer forms the primordium of the dura mater. Between the two layers the epidural space is observed.

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Table 1. C-R length, developmental stage and age of the embryos investigated

Catalogue No.	C-R length [mm]	Developmental stage	Age [days]	Plane of section
B-70	12.0	17	41	Horizontal
A-12	12.5	17	41	Horizontal
B-180	13.0	17	41	Sagittal
B-64	13.5	17	41	Frontal
PJK-2	13.5	17	41	Horizontal
PJK-14	13.5	17	41	Sagittal
B-68	14.0	17	41	Horizontal
A-1	14.0	17	41	Horizontal
B-129	14.0	17	41	Sagittal
B-122	14.5	18	44	Frontal
Bł-4	15.0	18	44	Horizontal
B-128	15.0	18	44	Sagittal
B-65	16.0	18	44	Horizontal
B-66	16.5	19	46	Horizontal
Bł-5	17.0	19	46	Horizontal
Z-13b	17.0	19	46	Frontal
Bł-10	17.5	19	46	Horizontal
B-123	17.5	19	46	Sagittal
X-19	17.5	19	46	Sagittal
KA-2	18.0	19	46	Horizontal
B-112	18.0	19	46	Sagittal
A-10	18.0	19	46	Horizontal
PJK-1	19.0	19	46	Sagittal
KA-3	19.0	19	46	Sagittal
PJK-28	19.0	19	46	Horizontal
PJK-13	19.0	19	46	Horizontal
B-99	19.5	20	49	Horizontal
Bł-2	20.0	20	49	Sagittal
Bł-1	20.5	20	49	Horizontal
PJK-27	21.0	20	49	Horizontal
B-126	22.0	21	51	Horizontal
B-170	22.5	21	51	Horizontal
B-127	23.5	21	51	Sagittal
A-4	23.5	21	51	Frontal
PK-61	24.0	21	51	Sagittal
WR-II	25.0	22	53	Horizontal
ZJ-2	26.0	22	53	Sagittal
Z-3	26.5	22	53	Horizontal
B-114	27.0	23	56	Sagittal
WW	28.5	23	56	Frontal
B-177	28.5	23	56	Horizontal
A-4	29.0	23	56	Horizontal
A-2	29.0	23	56	Frontal
A-71	29.0	23	56	Horizontal
A-3	29.0	23	56	Horizontal
Kub-2	29.5	23	56	Horizontal
B-184	30.0	23	56	Horizontal

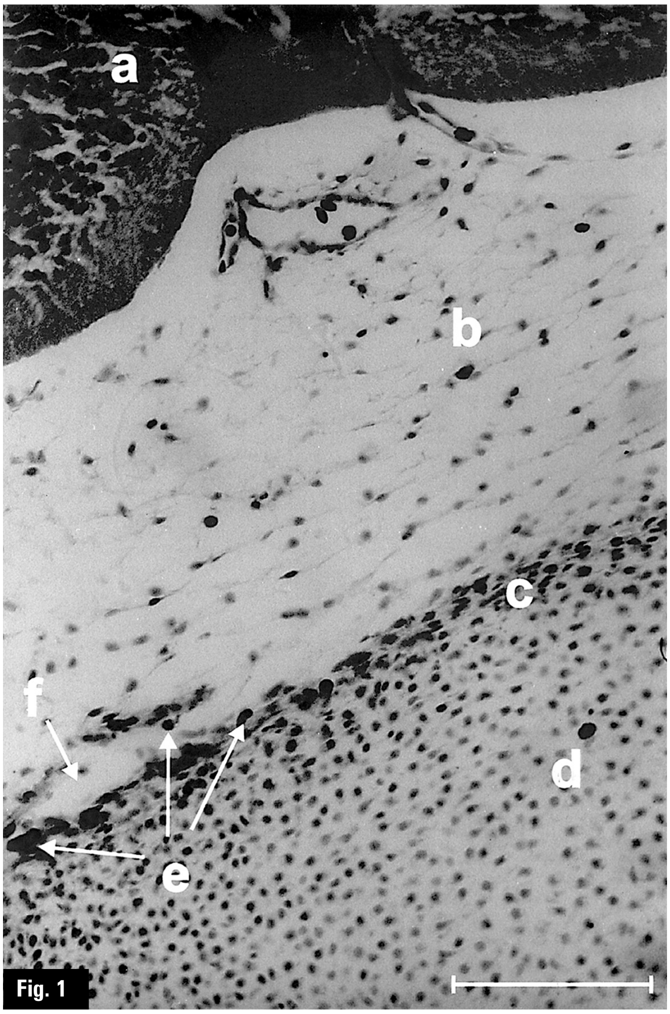
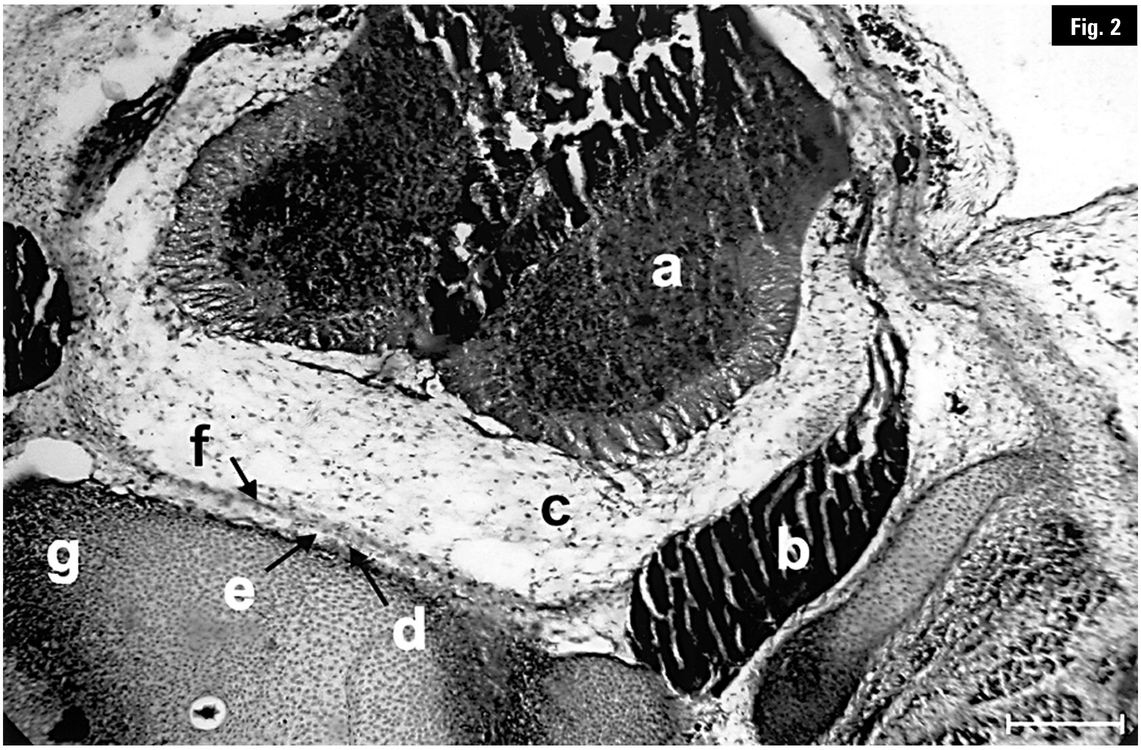


Figure 1. Cross-section of embryo at stage 17. a — spinal cord, b — primary meninx, c — perichondrium, d — vertebral body, e — blood vessels, f — primordium of the epidural space. H+E. Scale bar: 100 μm.

Figure 2. Cross-section of embryo at stage 18. a — spinal cord, b — spinal ganglion, c — primary meninx, d — external layer of dura mater, e — epidural space, f — internal condensed layer forming dura mater proper, g — body of vertebra. H+E. Scale bar: 100 μm.



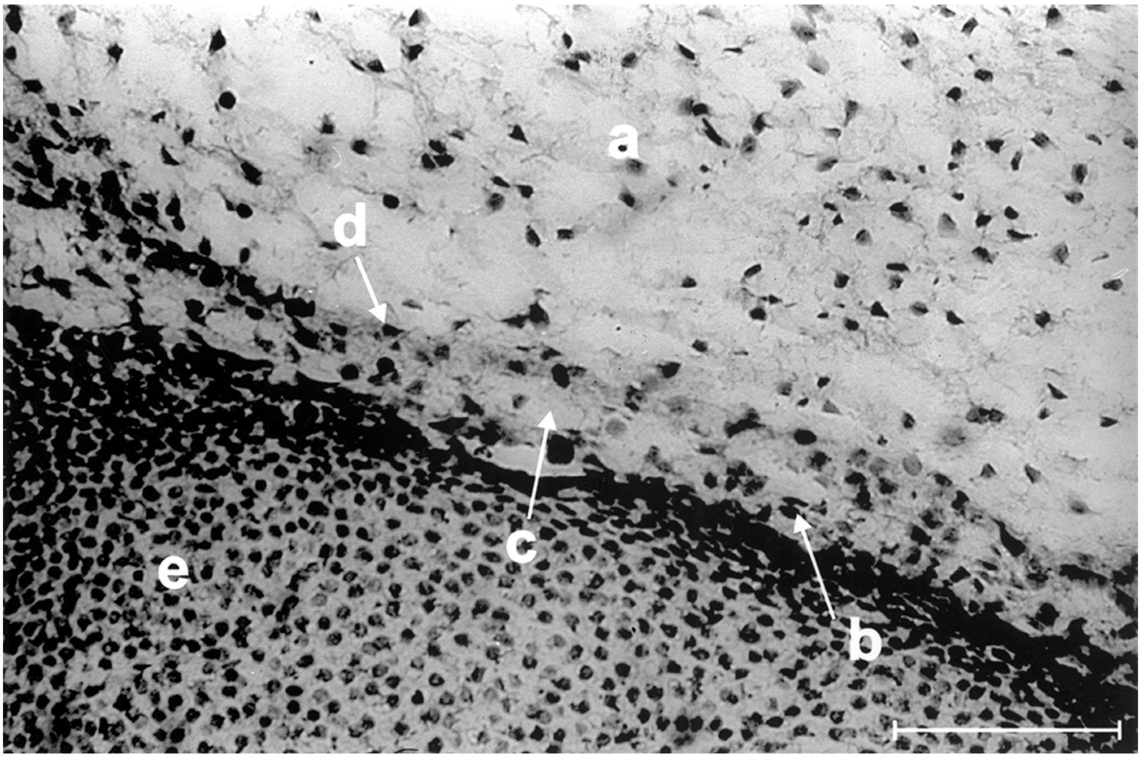


Figure 3. Cross-section of embryo at stage 18. a — primary meninx, b — external layer of dura mater, c — epidural space, d — internal layer of dura mater, e — body of vertebra. H+E. Scale bar: 100 μm.

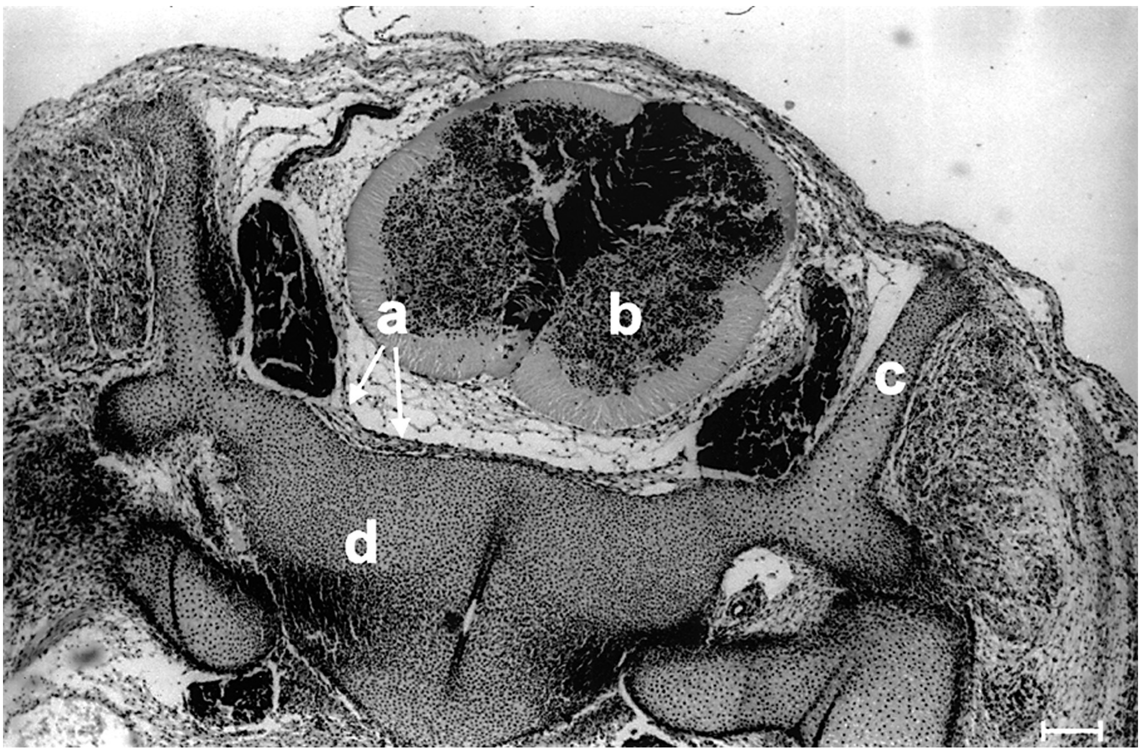


Figure 4. Cross-section of embryo at stage 19. Nissl staining. a — dura mater, b — spinal cord, c — vertebral arch, d — body of vertebra. Scale bar: 100 μm.

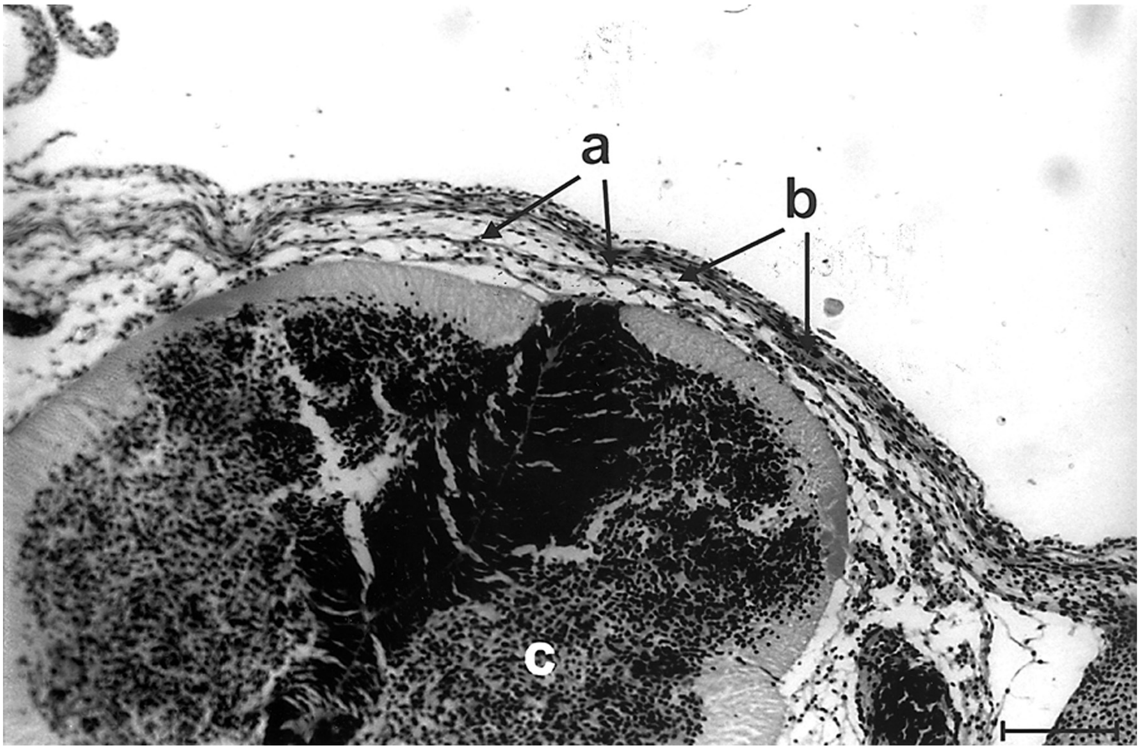
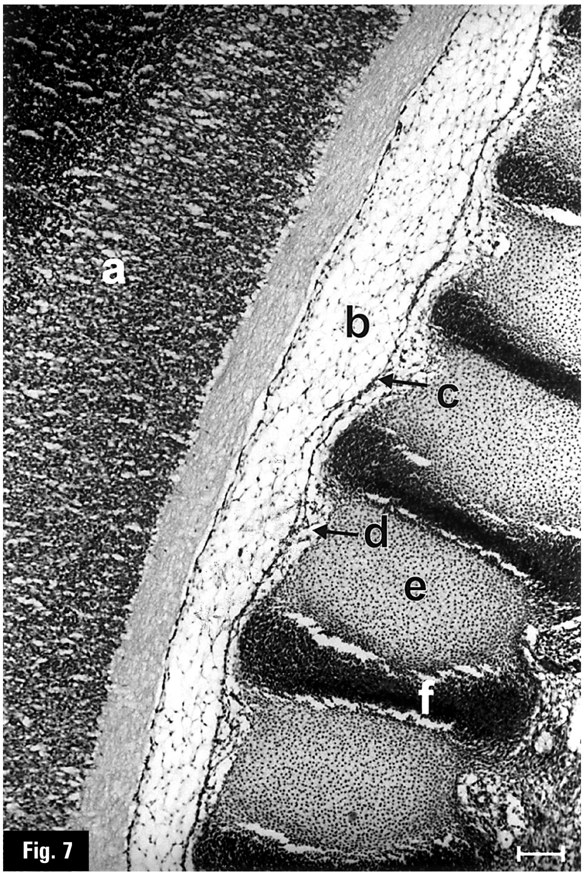
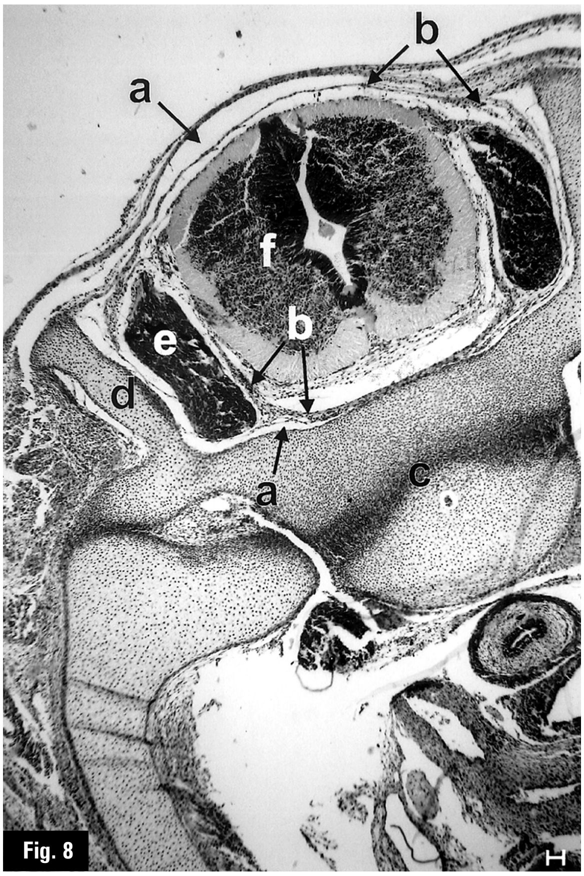


Figure 5. Cross-section of embryo at stage 19. Nissl staining. a — dura mater, b — epidural space, c — spinal cord. Scale bar: 100 μm.

Figure 6. Cross-section of embryo at stage 19. Nissl staining. a — external layer of dura mater, b — dura mater proper, c — epidural space, d — blood vessels, e — primary meninx, f — spinal cord, g — body of vertebra. Scale bar: 100 μm.





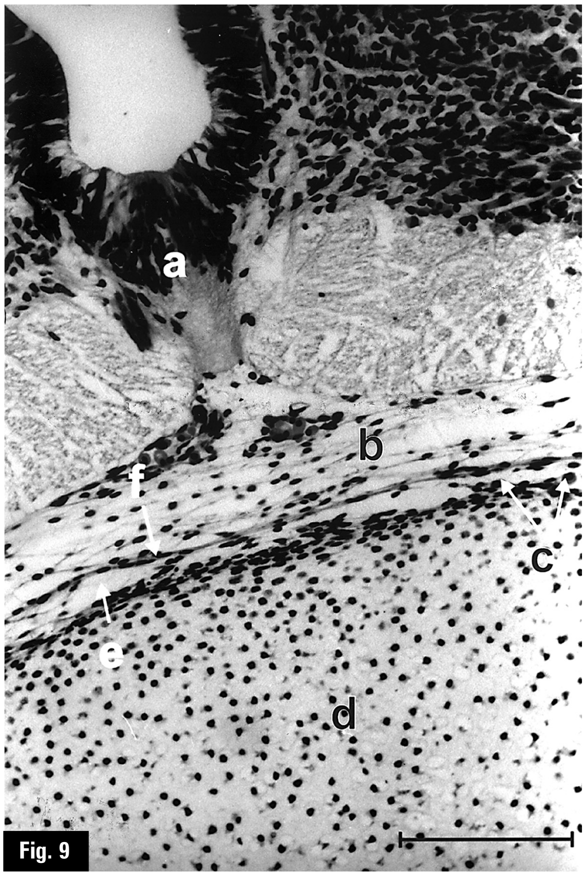


Figure 7. Sagittal section of embryo at stage 21. a — spinal cord, b — primary meninx, c — dura mater, d — epidural space, e — body of vertebra, f — intervertebral disc. H+E. Scale bar: 100 μm.

Figure 8. Cross-section of embryo at stage 22. Nissl staining. a — epidural space, b — dura mater, c — body of vertebra, d — arch of vertebra, e — spinal ganglion, f — spinal cord. Scale bar: 100 μm.

Figure 9. Cross-section of embryo at stage 21. a — spinal cord, b — primary meninx, c — blood vessels, d — body of vertebra, e — epidural space, f — dura mater. H+E. Scale bar: 100 μm.

In embryos at stage 19 the internal condensed layer forming the dura mater proper becomes thinner and more fibrous and is present around the whole circumference of the spinal cord (Fig. 4, 5). The epidural space is well developed and contains many blood vessels (Fig. 5, 6). It extends throughout the length of the vertebral canal.

During the last week of embryonic development (stages 21–23) the dura mater forms a distinct layer within the vertebral canal (Fig. 7, 8). The epidural space is wide and extends around all the surfaces of the vertebral canal. Within this space blood vessels are present (Fig. 9).

DISCUSSION

Sensenig [9] described the epidural space in embryos at the end of the 8th week (stage 23). He wrote: "In older embryos of this group the epidural cavity is forming by the separation of ventrolateral and lateral dura rudiments from the adjacent perichondrium". In the present study it was found that the epidural space is already marked in embryos at stage 17. During the 8th week this space is well formed through the walls of the vertebral canal. It contains blood vessels from the very beginning and the number of blood vessels in this space increases with age. The development of the epidural space proceeds in the rostro-caudal direction and is first observed on the ventral part of the vertebral canal. This was also noted by Lüdinghausen and Dziallas [5].

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