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Research Report

Embryological study of the spinal dura and its attachment into the vertebral canal

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Abstract

Background: This observational study reviews the development of the spinal dura and its attachment into the vertebral canal.
Methods: Microscopic investigations have been carried out on sections of a 27-mm crown-rump length (CRL) embryo, a 100-mm CRL fetus and a nearly 7-month-old fetus.
Results: The results appear very consistent with those present in the literature. The 27-mm CRL embryo's dura lamella still appears strongly attached to the vertebral body as well as to the laminae. Dorsally it forms part of the membrana reuniens dorsalis. Only on upper thoracic and cervical levels several sections clearly show a releasing anterolateral dura lamella; however, a close attachment remains in the very center. On sacral canal level, sections of the 100-mm CRL fetus clearly show connective tissue strands in the laterocaudal direction, linking the dural sac and the surrounding sacral canal. In almost every region, the abdominal sections of the 7-month-old fetus show a linkage between dura mater and posterior longitudinal ligament. This linkage fluctuates from fibrous structures to a wide and mostly stratified attachment providing a close contact between both structures. In the intervertebral foramen region, several sections show a structure of connective tissue, covering the foramen laterally from the spinal ganglion and having contacts with laminae and disci.
Conclusions: The attachments perceived between spinal dura and its surroundings may be considered to be the remains of an original unitary tissue, which will differentiate into full-grown ligamental structures according to the unique functional heritage of the individual. These epidural ligaments may have to play an important physiological and pathophysiological role in the human body.

Keywords: Meninges; Dura mater; Epidural space; Spinal ligaments; Posterior longitudinal ligament; Spinal roots; Osteopathy; Osteopathic medicine; Neural crest

1. Introduction

Monkhouse's[1] allegation about medical students' knowledge of anatomy being "lamentable" is no news, Trolard having pronounced the same severe sentence in 1899 during his opening-speech for the 'Congres International des Anatomistes' in Paris.[2] They both concur that knowledge of anatomy is the very basis for responsible and efficient medicine. Specifically in respect of the anatomy of the epidural region, however, we have found no consistency between the distinct descriptions of it in textbooks or articles, in spite of the evident clinical importance of that region.[3] Moreover, medical literature provides us with sparse and mostly contradictory information about the existence of dural insertions,[4] that is if they are really insertions; not to mention their origin. In a comparative literature study[5] concerning the precise anatomical descriptions regarding the vascularization

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of the spinal column and the contents of the medullar canal, the author concluded that in general the older anatomical works are more detailed and complete than recent ones. One should almost suppose that contemporary works are intentionally restricting anatomical knowledge and excluding some anatomical facts. This phenomenon really becomes a problem if terminology gets mixed up as was the case for the dorsolateral dural ligaments of Hofmann.[6,7] So it would appear that most older anatomical works paid some attention to the so-called epidural ligaments.[6,8–11] Renewed interest only arose after a series of clinical and anatomical studies providing these ligaments with a part in the pathogenesis of nerve root compression resulting from protruded discs in the vertebral canal.[12–14] There was even a study conducted about the anatomical role of the anterior epidural ligament (Trolard's ligament) in anterior intraspinal epidural carcinomatous infiltrations.[15] There are few studies concerning epidural ligaments during fetal development.[16–19]

The present study is the continuation of a former, anatomical one,[4] in which 48 cadaver dissections showed the spinal dura as a well-fixed envelope inside the lumbosacral canal: laterally, segmental fixations were found enveloping the nerve roots and their dural sleeve (Hofmann's ligaments, Forestier's opercula and their reinforcements);[6,20] dorsally, by the dorsomedial septum; ventrally, by a network of filaments, or ligaments, or filaments and median septa (Trolard's ligaments),[8] which were found to be systematically present in almost 94% of all cases.[4]

The purpose of this study was to investigate whether these fixations are developing structures or whether they are adhesions or ingrowths, as stated by Parke and Watanabe[14] and whether they develop in adult life. This study examined the development of the spinal dura and its attachment into the vertebral canal, using fetuses at different stages of development.

2. Methods

Three human fetal cadavers were used: (A) one 27-mm crown-rump length (CRL) human embryo, (B) one human fetus having a CRL of 100 mm, and (C) a 7-month-old human fetus. The 27-mm CRL embryo and the 7-month-old fetus (A and C) were provided by the Erasmus Academic Hospital of the Université Libre de Bruxelles, from the collection of human embryos, and the 100-mm CRL fetus (B) was provided by one of the authors. Microscopical investigations were carried out on stained sections of the specimens. These comprised 1170 horizontal sections of the 27-mm (CRL) embryo (A), colored with a 10% solution of formalineosin–hematoxylin. 335 frontal sections of the pelvis of the 100-mm CRL fetus (B), colored with eosin–hematoxylin, were used for this study. Furthermore, 46 abdominal sections preserved in resin, which corresponded to the levels between the discs D9–10 and L2–3, of the 7-month-old fetus (C) were studied.

The microscopes used were a light-microscope Leitz-Wetzlar with attached photo equipment, a Jenalumar-Zeiss and a stereoscopic Heerbrugg Wild. All serial sections made were analyzed using the following methodology: reconstruction of the sections through visual inspection; visual inspection of each section, using one of the previously mentioned microscopes; identification of the structures of interest; description and photography of the regions of interest.

3. Results

3.1. The 27-mm CRL embryo

On the dorsal side of its vertebral body, A showed a dense structure of connective tissue that we henceforth shall call the embryonic dura mater (EDM) (Fig. 1). Sacrally, this connective tissue structure looked slightly thicker in the center. Laterally, in the ganglionic region the EDM made contact and showed offshoots toward the ganglion. Except for some scarce, thin connective tissue attachments, there was hardly any central contact between the EDM and the pia mater, which was clearly present around the medulla spinalis. On almost every section level we found an attachment to the spinal ganglion, starting from the lateral end of the EDM and enclosing the ganglion entirely.

In the lumbar region, the EDM had a thick structure and attached itself centrally to the vertebral body across the entire width of the ventral median fissure. Laterally, it released the vertebral body.

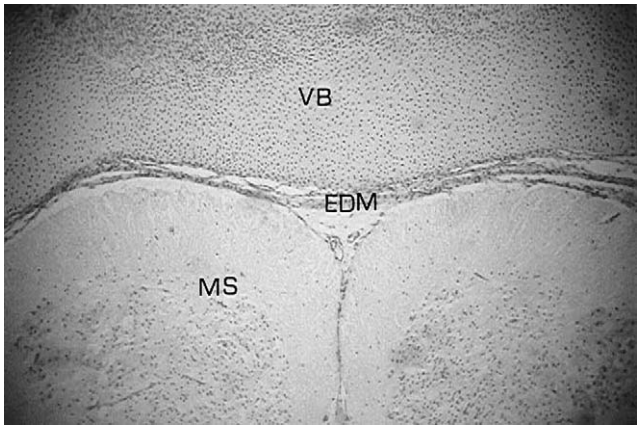

Fig. 1. Horizontal cervical section of the vertebral column of a 27-mm CRL embryo. MS, medulla spinalis; VB, vertebral body; EDM, embryonic dura mater.