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Innervation of the human cervical and thoracic vertebrae at eight postovulatory weeks

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The nerves to the cervical and thoracic vertebrae were traced in 10 serially sectioned human embryos. It was found that the vertebral bodies receive nerve fibres from the trunks of the spinal nerves, anterior branches and meningeal branches of the spinal nerves, and from the sympathetic trunks. Slender twigs from the trunk of the spinal nerve arise close to the spinal ganglion and terminate in the posterior and lateral surfaces of the vertebrae. Fibres from the anterior branches of the spinal nerves terminate in the lateral and anterior surfaces of the vertebrae. Thin rami from the sympathetic trunk reach the anterior surface of the vertebrae. (Folia Morphol 2009; 68, 2: 84–87)

Key words: human embryonic period, vertebral column, innervation

INTRODUCTION

Vertebrae, similarly to long and flat bones, have a complex autonomic and sensory innervation, and bone cells have receptors for several neuropeptides (NPY, CGRP, VIP, SP) present in the nerves in bones [1–3, 6].

The common clinical observations that many inflammatory, neoplastic, endocrine, and vascular bone diseases as well as fractures and hereditary disorders give rise to pain give evidence that many of the nerves in bone are sensory.

The vast literature concerned with the innervation of the vertebral column is devoted mainly to the lumbar part and especially to the intervertebral discs, facet joints, and ligaments [5, 7, 8, 10, 16, 19–21].

It was found that in back pain following intervertebral disc injury there is a rapid atrophy of the deep back muscle (multifidus). This atrophy is due to reduced motoneuron excitability from segmental inputs [12].

Innervation of the cervical and thoracic region of the vertebral column has been studied far less often than the lumbar part [9].

The findings of the innervation of the vertebral column in human adults raise the question as to whether the embryonic and foetal vertebral column has a similar nerve supply, and what are the sources of such innervation.

The aim of the present study is to trace nerve fibres to the cervical and thoracic vertebrae in human embryos aged 8 weeks, with special reference to the origin and distribution of these nerve fibres.

MATERIAL AND METHODS

Innervations of the cervical and thoracic vertebrae were studied in 10 embryos at developmental stages 21–23 (eight weeks). The embryos belonged to the collection of the Department of Anatomy of the Medical University in Poznań. Serial sections of embryos were made in the sagittal, coronal, and transverse planes. The thicknesses of the sections were 5 and 10 μm. The stains included haematoxylin and eosin, Mallory, and cresyl violet, and every fifth section was treated with Bodian's protargol. All transverse sections of one embryo at stage 21 were treated with silver.

RESULTS

In all the investigated embryos, the thoracic and cervical regions occupied the greatest percentage

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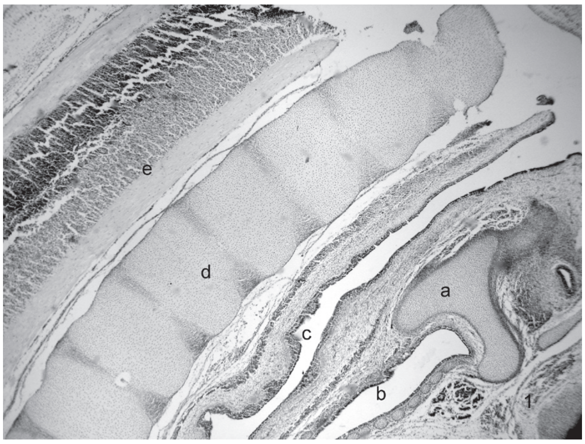

Figure 1. Sagittal section through the neck of an embryo at stage 22. H+E. × 40; a — cricoid cartilage, b — trachea, c — oesophagus, d — vertebral column, e — spinal cord.

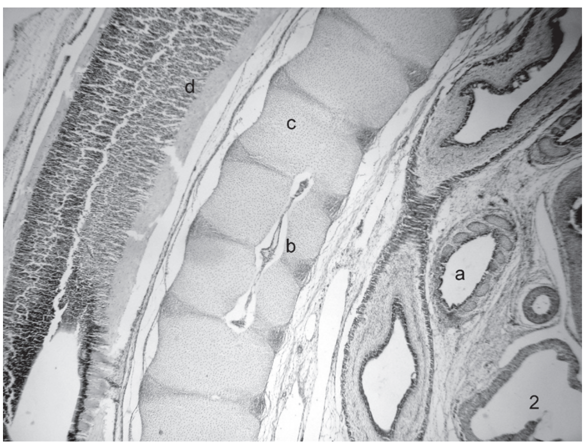

Figure 2. Sagittal section through the thorax of an embryo at stage 23. H+E. × 40; a — principal bronchus, b — notochord, c — vertebral column, d — spinal cord.

Figure 3. Transverse section through the thorax of an embryo at stage 23. H+E. × 40; a — spinal cord, b — spinal ganglion, c — vertebral body, d — oesophagus, e — sympathetic ganglion, f — spinal nerve, g — meningeal branch.

Figure 4. Transverse section through the thorax of an embryo at stage 21. Impregnated with Bodian's protargol. × 40; a — spinal cord, b — vertebral body, c — grey communicating ramus, d — white communicating ramus, e — (arrow) branch from the spinal nerve to vertebra, f — anterior branch of the spinal nerve giving off ramus to vertebra (arrow), g — posterior branch of the spinal nerve, h — ramus from the sympathetic trunk to vertebral body (arrow).

of the developing vertebral column. The cartilaginous bodies of the vertebrae formed gentle arches, slightly concave anteriorly (Figs. 1, 2). The notochord ascended through the centra, a little anteriorly. It showed localized cellular aggregations at the level of the intervertebral discs, whereas within the vertebral bodies it formed narrow streaks (Fig. 2). The neural processes (future vertebral arches) were incomplete and extended along the sides of the spinal cord (Fig. 3). They were united by collagenous fibres.

The spinal ganglia descended close to the intervertebral foramina and lay partly on the pedicles (Fig. 3). The spinal nerves were very short and were located within the intervertebral foramina. All branches originating from the spinal nerves were well seen (Fig. 4). Sympathetic trunks descended on the anterolateral surfaces of the vertebrae.

Nerve fibres to the vertebral bodies arose from the:
- trunk of the spinal nerve;
- anterior and posterior branches of the spinal nerve;
- meningeal branch;
- sympathetic trunk.

Two or three slender twigs originated from the trunk of the spinal nerve, close to the spinal ganglion and passed to the posterior and lateral surfaces of the vertebra (Fig. 5). The anterior branch of the spinal nerve gave off rami, which could be traced in

Figure 5. Transverse section through the cervical part of an embryo at stage 21. Impregnated with Bodian's protargol. × 100; a — branches from the trunk of the spinal nerve to vertebral body, b — spinal cord, c — vertebral body, d — trunk of the spinal nerve, e — spinal ganglion.

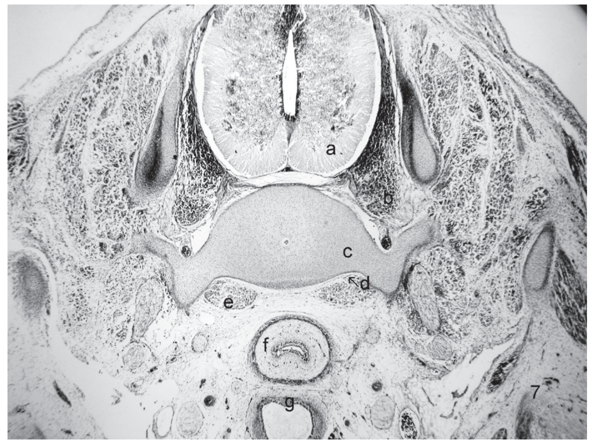

Figure 7. Transverse section through the cervical part of an embryo at stage 21. Impregnated with Bodian's protargol. × 40; a — spinal cord, b — spinal ganglion, c — vertebral body, d — ramus from sympathetic ganglion to vertebral body, e — sympathetic ganglion, f — oesophagus, g — trachea.

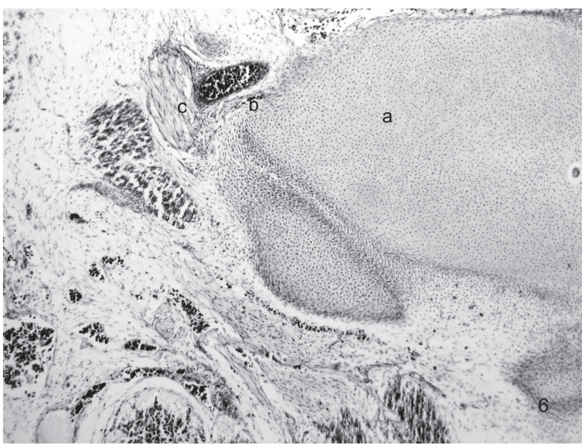

Figure 6. Transverse section through the cervical part of an embryo at stage 21. Impregnated with Bodian's protargol. × 100; a — vertebral body, b — ramus meningeus of the spinal nerve, c — anterior branch of the spinal nerve.

the superficial layer of the vertebrae (Fig. 4). These rami supplied the lateral and anterior surfaces of the vertebrae. The meningeal branch passed backwards to the vertebral canal and supplied the lateral and posterior surfaces of the vertebrae (Fig. 6). Branches arising from the sympathetic trunk originated from the sympathetic ganglia (Fig. 7) and interganglionic rami. They reached the anterior and lateral surfaces of the vertebrae and some of them accompanied the blood vessels (Fig. 4).

DISCUSSION

In the vast amount of literature relating to the innervations of the vertebral column there is a general opinion that that nerves supplying the vertebrae, intervertebral discs, ligaments, and facet joints originate from the meningeal and posterior rami of the spinal nerves. In the cervical region, the vertebral nerve contributes also to the innervations of the vertebral column [10, 11, 13]. The meningeal ramus (sinuvertebral nerve) arises from the spinal nerve just distally to the spinal ganglion, and after travelling medially, it is joined by sympathetic fibres. The nerve then passes through the intervertebral foramen into the vertebral canal where it divides into ascending and descending branches. The branches of this nerve supply the vertebral body, vertebral arch, intervertebral disc, and posterior longitudinal ligament [18].

The posterior ramus of the spinal nerve divides into medial and lateral branches. The medial branch gives off small twigs to the ligaments and facet joints.

In the present paper we described for the first time nerve fibres arising from the trunk of the spinal nerve, anterior and meningeal rami, and from the sympathetic trunk. It has to be pointed out that such osseous nerves reach the vertebral bodies during early intrauterine development.

It has been documented that nerves enter the vertebral body via the vascular foramen and by penetrating the anterior cortex to course into the marrow [4].

Jackson et al. [15] investigated nerve terminals in the lumbar region of the vertebral column and related ligaments in two foetuses, two newborns, and adults. They applied silver and cholinesterase staining. In the foetuses and newborns the cartilaginous plates of the vertebral bodies contained perivascular nerves which terminated in very thin branches and frequently formed open loops in the vascular channels of the cartilage plates. In the adults the vertebral periosteum exhibited nerve terminals of the fine free fibre and complex unencapsulated endings.

Haversian canals, periosteum, and medullary vessels are innervated. Poorly myelinated fibres are present in Haversian canals.

Recent development of immunohistochemistry has contributed greatly to the localization of various nerve-associated substances and differential identification of nerve fibres [14].

Ahmed et al. [1, 2] found NPY-, TH-, and VIP--immunoreactive nerve fibres in the vertebral bodies, periosteum, discs, dura mater, and spinal ligaments in rats. NPY- and TH-positive fibres were colocalized and predominantly located in the wall of blood vessels, whereas VIP-immunoreactive nerves mostly appeared as nonvascular.

NPY-immunoreactive nerve fibres were abundant in the bone marrow of the vertebrae and near the vertebral growth plate. Kuntz and Richins [17], investigating the innervation of bone marrow, stated that the nerve fibres fall into three main groups: 1) those which penetrate the walls of the arterioles and form delicate plexiform networks between the adventitia and the media; 2) those which surround the capillaries; and 3) those which terminate between the cells of the parenchyma.

In the performed study, using histological methods, we traced nerve fibres in the superficial layer of the cartilaginous vertebral bodies. The nerve fibres were found in the whole circumference of the vertebral body.

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