Multiple meningeal diverticula and cysts associated with duplications of the sheaths of spinal nerve posterior roots

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Multiple diverticula and cysts of the meninges were found during an anatomical dissection. They were associated with duplications of sheaths of the posterior roots of the spinal nerves. The diverticula and cysts appeared as simple flaccid corrugated dilatations of the sheaths, as ampullary expansions, as pediculated cysts, or as saccular dilatations of different sizes and locations. The duplication of the sheaths affected posterior roots of the thoracic nerves only. Some variations of the sheaths described in the literature are discussed. The possibility is considered that both conditions result from the same pathological factors in the embryo.

KEY WORDS • meningeal diverticula • meningeal cysts • spinal nerve meningeal sheaths • spinal nerve meningeal sleeves • anatomical abnormality

We have recently seen a case of multiple diverticula of the spinal meninges, accompanied by duplications of the meningeal sheaths of the posterior roots of the spinal nerves. It was found during the preparation of a cadaver for teaching purposes. Spinal meningeal extradural diverticula and cysts are uncommon but well documented. However, we did not find anatomical descriptions of double or triple sleeves of the posterior roots as seen here. The association of the latter with meningeal diverticula could be just a rare coincidence, or the two findings may be etiologically correlated.

Anatomical Description

General Description

The specimen was from an adult woman. It included the portion distal to C-7, namely, the spinal cord, nerves, and meninges caudal to C-8. These structures were exposed by removing the vertebral arches after the pedicles had been cut. The dura was cleaned, the meningeal sleeves of the spinal nerves carefully dissected, and the presence of diverticula and cysts recorded. The main dural sac was opened longitudinally in the midline at its posterior surface, and communications between the subarachnoid space and the diverticula were examined.

From the beginning of the dissection, the general thinness of the meningeal layers attracted our attention. The dura mater appeared as a very delicate, thin, bluish-gray semi-transparent layer through which the spinal nerve roots could be discerned (Figs. 1–5). With the progress of the dissection, two main abnormalities could be seen: dilatations and cysts of the dura mater and duplications of the posterior roots.
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Fig. 1. Artist's drawing of posterior view of the spinal cord and spinal nerves as seen after completion of the dissection shows the distribution and location of the various kinds of diverticula and cysts, and the duplications of the meningeal sheaths of the posterior roots of the nerves. The segments indicated are shown in dissection photographs in Figs. 2-5.

Fig. 2. Upper: Posterior view of segment T2-4 of the spinal cord and spinal nerves. Note the pediculated cyst attached to the angle between the sheath of the posterior roots of right T-3 nerve and the meningeal sac. Note that T-2 on both sides and T-3 on the right show double sleeves for the posterior roots. Left T-4 had triple sleeves (they do not show clearly in the picture). Most of the sleeves of these nerves also show flaccid, slightly expanded corrugated walls. Lower: Enlarged picture of right T-3 shows double sleeves of posterior roots and the pediculated cyst at the angle with meningeal sac.
Dilatations and Cysts of the Dura Mater

There were multiple dilatations and cysts of the dura mater that appeared in various places along the meningeal sac of the spinal cord itself, or at the proximal part of the sheaths of the spinal nerves. Their sizes and shapes were variable. The less marked dilatations appeared as simple, flaccid, slightly expanded corrugated walls of the proximal part of the meningeal sleeves of the posterior roots: on the right, nerves T1-3, T7, T9-12, L-1, L-3, S-1, and S-3; on the left, T1-3, T8-12, L-2, L-3, L-5, S-1, and S-2 (Figs. 1-5). Some dilatations appeared as ampullary expansions of the sleeves: on the right, T4-6 and T-8, and on the left, posterior T4-7 and T-9 (Figs. 1 and 3), often combined with flaccid corrugated dilatation. In some nerves (right T-1 and left T-5) the dilatation also affected the dura covering the ganglion itself. A few ampullary dilatations also affected the meningeal sleeves of anterior roots, T3-5 on the right and T4-7 and T-9 on the left.

Typical pediculated cysts with narrow attachment to the main dural sac were seen below nerves T-3 right (Figs. 1-4) and L-2 right, between T-8 and T-9 and between T-10 and T-11 on the left, or attached to the nerve sleeves, as at L-1 left or at the angle between the main dural tube and the nerve sleeves (T-12 left, L-1 left, and L-1 right). Saccular dilatations with broad bases of attachment were seen at the third and fourth left sacral nerve sleeves, and from the main meningeal sac between S-1 and S-2 on the right (Figs. 1 and 5). Some of the dilatations had a more or less smooth surface, while others showed an irregular surface with secondary sacculations. Their size varied from a fraction of a millimeter to more than 15 mm long and 6 mm high (S-3 left, Fig. 5). This expansion was characteristically located on the lateral superior border of the nerve. The expansion of S-4 left was also relatively big, with a similar location. In general the sacral nerves tended to develop the biggest cysts.

Duplications of Meningeal Sheaths of Posterior Roots

In a number of thoracic nerves the posterior roots appeared with double meningeal sleeves proximal to the ganglion; these sleeves merged into one single sheath around the ganglion. In four nerves (T-2, T-6, T-7, T-9, and T-12), the posterior roots of the left side had double sheaths, and the posterior roots of the right side had a single sheath proximal to the ganglion, with an ampullary expansion. In the other thoracic nerves, the posterior roots had a single sheath proximal to the ganglion. In some nerves (right T-1 and left T-5), the dilatation also affected the dura covering the ganglion itself. A few ampullary dilatations also affected the meningeal sleeves of anterior roots, T3-5 on the right and T4-7 and T-9 on the left.

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Fig. 5. Posterior view of the inferior end of the dural sac. The sac is open in its upper part. Note the thinness and transparency of the dura mater, through which the nerves of the cauda equina are seen. There are big saccular dilatations of the sheaths of the third and fourth left sacral nerves and a dilatation of the meningeal sac at the right between nerves S-1 and S-2.

T-9, and T-11) the duplication of the sheaths was bilateral and symmetrical. In three nerves (T-3, T-5, and T-10) it was localized on the right, and in one (T-7) it was on the left. In one single nerve (left T-4) there was a triple set of sleeves. In no case did the anterior roots show more than one single sleeve, nor did the lumbar and sacral nerves appear with more than one sleeve in their posterior roots. In the nerve roots with double sheaths, if dilatations were present, they generally affected both sheaths. A distinct meningeal vessel could be seen ending in the walls of some of the cysts. The cavities of all the dilatations examined communicated freely with the subarachnoid cavity.

Discussion

Much confusion exists in the literature regarding the nomenclature for the various kinds of cysts of the meninges. However, the dilatations of the meninges we found in this anatomical specimen fit exactly, according to Tarlov's descriptions, the diagnosis of meningeal diverticula and meningeal cysts. They were all located proximal to the ganglia, and communicated freely with the subarachnoid space. Unfortunately, we could not obtain clinical information about the case. Beside the great variation in number, location, and size of the diverticula, perhaps the most interesting anatomical characteristic of the specimen is the duplication of the sheaths of the posterior roots. We had not noticed this kind of variation in previous dissections in the area, neither did we find it described in the standard textbooks of anatomy and neuroanatomy, nor in the current literature.

Most authors report that each of the roots of the spinal nerves, namely, the anterior and the posterior roots, independently perforates the meningeal sac and is provided with its own meningeal sleeve. With the fusion of the roots into the spinal nerve about or lateral to the spinal ganglion, both sleeves merge into a single sheath, which continues farther with the epineurium and perineurium of the nerve. Paturet mentions the possibility of finding in rare cases both roots leaving the dural sac through one single foramen and covered by a single sleeve. In such cases the foramen is elliptical in shape, with its long axis horizontally directed. Frykholm described as "dural pouches" the funnel-shaped lateral extensions of the spinal dural sac at the bottom of which the dural sheaths of the nerves emerge. He also found cases with pathological strictures at the ostea of the sleeves. Shapiro mentions that "In the cervical area, the nerve root filaments either retain their separate individuality or unite into two or more bundles before they penetrate the dura. In the thoracolumbar area, the nerve bundles join in a single trunk before passing through the dura." He does not specifically describe more than one sleeve for the posterior roots, as we found here. He believes, however, that in certain cases more than one sleeve may be present in the cervical area for the posterior roots. Dujovny states that he has seen these duplications. On the other hand, Ethelberg and Riishede describe cases where two nerves, generally L-5 and S-1, share a single sheath. These cases were generally accom-
panied by symptoms of compression of the nerves.

Apart from the academic interest from the anatomical point of view, the presence of duplications of the sheaths of the posterior roots coincident with dilatations of the meningeal sleeves gives rise to many questions. One is whether there is a correlation between these findings. The fact that both are predominantly found in the posterior roots hints at such a possibility. Embryologically, not only the posterior roots with their ganglia originate from the neural crest; the leptomeningeal membranes that contribute to the formation of the sheaths are also partially derived from the neural crest, while the dura mater is of mesenchymal origin. Thus, the development of the diverticula and the duplications of the sheaths could be caused simultaneously by the same factors. More dissections made with particular attention to the sheaths of the posterior roots in normal cases and in anatomical specimens with diverticula may throw some light on these problems. Duplications of the sheaths of the spinal nerve roots may occur more frequently than generally thought, and experimental embryology may provide further answers.

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