Angulated Course of Spinal Nerve Roots

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According to the classic description found in standard books of anatomy and other medical literature, the roots of the spinal nerves in the adult adjust to a more or less characteristic pattern for each spinal region. To reach their corresponding intervertebral or sacral foraminae, courses of the upper spinal nerves run horizontally; the lower nerves slant more obliquely downward and laterally; and the lowest nerves, below the first lumbar, run nearly straight downward in the vertebral canal forming the cauda equina. No changes in the direction of the nerves are described between the intradural and extradural portions of their course.

During many dissections, we have found that the description above is not always accurate. In the majority of cases, a variable number of spinal nerve roots, generally the lower cervical and the upper thoracic ones, followed an angulated course. In these cases, the nerves ran downward in the dural sac, but after perforating the dura mater, altered their course and proceeded upwards. We have found very few other reports in the literature describing this variation.

Material and Methods

This study is based on the dissections of 50 cadavers (adult, white and Negro, males and females).* The dissections were either performed anteriorly by removing the bodies of the vertebrae after the pedicles had been cut, or posteriorly after laminectomy. The examinations were made with the bodies in positions of decubitus ventralis or dorsalis with the head in a natural intermediate position (neither extension nor flexion) on the dissecting table.

Observations and Description

In 38 bodies (76%) of the cases, there was obvious angulation of some of the spinal nerve roots. The affected nerves were generally between C-3 and T-9. The frequency of the angulation increased from nerve C-3 to T-3, and from there decreased until nerve T-9. The higher degree of angulations were observed most frequently in nerves T-2 and T-3 (Fig. 1). The angulation of the nerves became more accentuated with hyperextension of the head.

The case showing the most marked deviation in the course of the roots was that of a 60-year-old man. From C-1 to C-4 the roots followed their normal horizontal or slightly descending course through the dural sac. The roots of nerves C-5 to T-6 ran their slanting, descending course until they reached the dura. At the point where they perforated this membrane, each root changed its direction and started to run upward and laterally forming a superiorly facing angle (Fig. 2). The angulation increased progressively from nerve C-5 to nerve T-3, the latter displaying the maximal acuteness of angulation, about 30°. From here on until nerve T-6, the angulation decreased gradually. After reaching their intervertebral foraminae, the angulated nerves changed their course again and ran laterally and downward; thus, each nerve formed a second angulation, straddling the inferior pedicle of the foraminae (Fig. 2). From T-7 down, the nerves resumed their normal straight oblique course with no further angulations at the dural sac.

Discussion

Baldwin was the first to call attention to the angulated course of the thoracic nerve roots. More recently, Reid described this anatomical feature in 71% of 80 specimens.
Shapiro in his myelographic studies described and illustrated comparable angulations as the normal course for spinal nerve roots from the eighth cervical to the midsacral area. According to his observations, the angulation reached 45°.

An irregularity in the growth rate of the dural sac during fetal life could condition the angulated course of the nerves. It is well known that until the third month the spinal cord fills the entire length of the spinal canal, and the spinal nerves pass horizontally from their origin straight through the dural sac to their corresponding intervertebral foraminae. From the fourth month of embryonic life, the vertebral column grows and elongates at a faster rate than the spinal cord. Since the cord is anchored above to the endocranial part of the nervous system, the roots of the spinal nerves start to run in an oblique direction from their segment of origin to the corresponding level of exit from the vertebral column. This oblique course becomes more marked with increasing age, reaching its maximum in the adult. If the straight course of these roots is to be maintained, the development of the dural sac must be uniform along its entire length and its rate of growth intermediate between the fast-growing bony spine and the slow-growing spinal cord. The segmental growth of the dura would then adjust to such a degree that the roots will proceed without interference during the relative ascent of the spinal cord in the vertebral canal. If this does not happen (i.e., if some segments of the dural sac fail for some reason to develop at the corresponding intermediate rate between the vertebral column and the spinal cord) the straight course of the nerves is interrupted, and the roots appear angulated with the apex of the angle at the very point where the nerve crosses or perforates the dura. This process may continue with the growth of the individual, thus explaining the greater frequency of this variation in adults.

The existence of these angulations could be of some practical importance. They may contribute to diagnostic errors in the location of a lesion affecting spinal nerves, such as herniated disc, osteophyte, tumor, hemorrhage, trauma, etc. The angulated spinal nerve roots would appear more exposed to trauma than normal straight roots (see Fig. 3), either at the point of perforation of the dural sac or where the nerve straddles the corresponding pedicles of the vertebra.

![Graph showing distribution of angulated nerves. Nerves T-2 and T-3 are most frequently affected.](image-url)