ANATOMICAL CONSIDERATIONS IN SURGERY OF THE SPINAL CORD
A STUDY OF VESSELS AND MEASUREMENTS OF THE CORD
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Quite often in the course of a surgical attack on the spinal cord, features of the gross anatomy occupy the thoughts of the neurosurgeon tackling the particular problem of the moment. These anatomical questions arose frequently during the course of 120 tractotomies and 55 operations for spinal-cord tumors performed in the past 5 years. Textbooks of anatomy and illustrative articles written on the subject in the past 76 years did not present sufficient information. Examination of the autopsy material of 30 injected spinal cords showed that additional studies were needed to clarify many aspects of the surface anatomy of the spinal cord.

In this study particular attention is paid to the anterior spinal artery, its course and branches, and to measurements of the spinal cord. Precise knowledge of these subjects is of practical value in spinthalamic tractotomies, rhizotomies and operations for tumors of the spinal cord as well as traumatic and vascular afflictions.

MATERIALS AND METHODS

The basis of this study is 30 presumably normal spinal cords injected in the body to outline the vessels of the cord.

The material of injection was Neoprene* latex solution colored red for arteries, and blue for veins. The method of injection was as follows: The brain is tilted backward after the first six cranial nerves and the carotid arteries have been severed. A catheter is introduced into the basilar artery just above the junction of the vertebral arteries, and the vessel is ligated around the catheter. The vertebral arteries are catheterized in the neck and ligated around the polyethylene catheter. The cut ends of the carotid arteries as well as the posterior cerebral arteries are occluded with silver clips. Another catheter is introduced into one of the largest lumbar arteries supplying the cord between T10 and L5 regions.

One may wonder why it is necessary to inject through four catheters instead of one from the lumbar or lower thoracic area as performed by Tanon. Unfortunately it is essential because of the numerous vessels (vertebrals, posterior inferior cerebellar arteries, intercostal, lumbar, iliolumbar and lateral sacral arteries) that supply the cord and its nerves. We have found that the injection must be done through at least

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* Kindly supplied by E. I. Du Pont de Nemours & Co., Inc., Elastomers Division, Organic Chemical Department, Wilmington, Delaware.
the four vessels described above to obtain a good filling of the vessels of the spinal cord. Otherwise the dye will regurgitate into the larger abdominal and thoracic vessels before filling all the branches of the spinal arteries.

Neoprene latex solution penetrates into vessels as small as 25 microns in diameter provided that postmortem clots have been washed out of these vessels. This is accomplished in the following manner: Each catheter is irrigated with cold tap water until the return is clear. This usually takes about 30 minutes. Then a 5 per cent concentration of acetic acid and hydrochloric acid solution is injected to dissolve any clots in the vessels. After 10 minutes of irrigation with this solution, tap water is used again until the returns are clear. This takes another 20 minutes.

Injection of the latex is best accomplished by using veterinary syringes. While an assistant holds the three catheters occluded with his fingers, the injection is started from the vertebral artery, using 5 cc. of latex solution. Then a silver clip is placed around the catheter to prevent any backflow, and injections through the other catheters are made rapidly in succession. The entire 20 cc. should be injected within 5 to 6 minutes. During the injection only slight to moderate pressure should be exerted on the plunger. If there is leakage from the vessels near the pons, a few drops of saturated aqueous solution of potassium alum are squirted onto the area. This procedure solidifies the latex solution and prevents further leakage. It takes about 60 minutes or longer for the latex solution to solidify in vessels of 2 to 3 mm. in diameter. This process can be accelerated by the injection of a few drops of the same alum solution through each catheter immediately after the completion of the injection of latex.

The brains and the spinal cords were removed in many of our specimens without detaching one from the other. This can be done without difficulty if the dura mater around the foramen magnum, C1 and C2, is dissected free.

If the veins are also to be injected, it is better to use another spinal cord and inject the veins accompanying the arteries described above. However, in a few instances it was possible to inject arteries and veins in the same body and demonstrate them on the spinal cord adequately. One must remember that during the injection of arteries, fluid in the capillaries can escape only through the veins or vice versa.

Certain measurements, such as the distance between the intervertebral foramen and the point of entrance of the sensory root to the spinal cord, were taken on the body after the laminae were unroofed and the dura mater was opened. Other measurements were taken when the fixation of the brain and spinal cord was completed. The brains and the spinal cords were suspended in 10 per cent formalin solution, preserving their natural configuration.

RESULTS

A. Vessels. The studies by Adamkiewicz, Kadyi, Bolton, and others of the vessels of the spinal cord form the basis of our knowledge today. From these studies we have learned that the tractus arteriosus anterior supplies a two-thirds cross-sectional area of the cord including the corticospinal tracts. Of great practical importance are the variations in the course of the tractus arteriosus anterior, which have been inadequately described even in the more recent studies. There is no disagreement as to the origin of the tractus arteriosus anterior, which comes off as individual branches, one from each side, near the junction of the vertebral arteries, details of which can be