

repeatedly with a 10% solution of X-ray films in acetone until the surface remains smooth after drying. The writer uses discarded "safety" films, freed of emulsion with a brush and warm water. These dissolve quickly in acetone. Three more layers of stockinette are drawn over the cast, each being painted individually in the same manner. After drying for a day, the mask is cut off in front of the steel tube and behind the cast. The cast is removed piecemeal with chisel and hammer. The 4 inside layers of stockinette which were not painted are pulled out. Several rounds of 2-inch bandage can be wrapped about the posterior end of the mask, and painted on, to remove slight corrugations due to the ribs of the stockinette (Fig. 1, left). The inside of the mask is also painted with the X-ray film solution. Leaks which can be demonstrated under pressure occur only between the steel tube and the first layer of stockinette. They are readily closed by applying shellac after cutting off the mask so that the steel tube extends out about one-fourth of an inch. After the mask has stood above a warm radiator for a day it is practically odorless.

A No. 12 rubber stopper fits the steel tube, and through it the large inlet and outlet tubes pass. Posteriorly an air tight connection to the neck of the dog is made by means of a bandage of 6-inch dental dam.<sup>1</sup> Applying a gel of gum ghatti<sup>2</sup> or tragacanth to the clipped neck of the animal enables one to obtain a satisfactory connection without applying the bandage too tightly.

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### Spread of Poliomyelitis Virus Along Nerve Fibers of the Sympathetic System.\*

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Flexner and Lewis<sup>1</sup> were the first to show that poliomyelitis could be produced in monkeys by the intranasal instillation of the virus. Faber<sup>2</sup> states that the virus is absorbed by way of the olfactory bulb

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<sup>1</sup> Boothby, W. M., and Sandiford, I., *Am. J. Physiol.*, 1923, **66**, 93.

<sup>2</sup> Gaebler, O. H., *J. Exp. Med.*, 1933, **57**, 349.

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<sup>1</sup> Flexner, L., and Lewis, P. A., *J. Am. Med. Assn.*, 1910, **54**, 1140.

<sup>2</sup> Faber, H. K., *Medicine*, 1933, **12**, 83.

along the base of the brain, thence proceeding to the medullary area and to the cord. After intracerebral injection, the spread of the virus would presumably be along the same route after it reaches the base of the brain. The axones are the main transmitting structures (Hurst<sup>3</sup>) and the spinal fluid plays no part in the spread (Jungeblut and Spring<sup>4</sup>). Monkeys may contract poliomyelitis after intraperitoneal and subcutaneous injections of massive doses of virus,<sup>5</sup> but, to my knowledge, never after the injection of the small doses that produce the disease when the virus has been intracerebrally and intrasciatically injected or intranasally instilled. The intrasciatic, intracerebral, intraperitoneal and subcutaneous routes are highly artificial portals of entry. When the virus is intranasally instilled, it enters the system through a natural portal of entry, and the spread along nerve fiber connections can easily be traced to the brain. Many workers believe that the nasal area is the usual and natural portal of entry in the human.

The following experiments were performed to show that the virus may spread by way of the sympathetic fibers in monkeys experimentally infected with poliomyelitis.

Our purpose was to isolate the cord carrying the virus from its axones, and thus to leave the sympathetic system as the only means of communication between the upper cord and the injected peripheral nerve.

Transabdominal operations were technically impossible and the operations to expose the sympathetic chain posteriorly were usually followed by death of the animal. The only feasible method was to cut out the cord at some strategic point so that all the communications between the somatic nerves and upper cord would be destroyed and then to inject a peripheral nerve, which in these experiments was the sciatic.

In man, the small and large sciatic, gluteal and pudic nerves originate from fibers which come from lumbar V to sacral IV. There are connecting branches between lumbar IV, lumbar V and the femoral plexus. The latter is formed from nerve branches which come from lumbar segments II to IV. Small filaments from lumbar I and II combine to form the genitocrural nerve and there is a communicating twig from the last thoracic to lumbar I.

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<sup>3</sup> Hurst, E. W., *J. Path. and Bact.*, 1930, **33**, 1133.

<sup>4</sup> Jungeblut, C. W., and Spring, W. J., *PROC. SOC. EXP. BIOL. AND MED.*, 1930, **27**, 1076.

<sup>5</sup> Poliomyelitis, International Committee for the Study of Poliomyelitis, Williams and Wilkins Co., Baltimore, 1932.

In the monkey, the last thoracic occasionally gives off a small twig to lumbar I as it does in man. Lumbar I ramifies downward, connecting with lumbar II and III. In the few specimens dissected, lumbar III did not appear to connect with lumbar IV and the lower nerves.

Because there might be connections between thoracic XII and lumbar I, operative transections were always made so that this and the eleventh thoracic segment were included.

The cord was delivered through a posterior approach; the openings were the length of from 4 to 5 vertebrae, the upper one being thoracic X. The cord was sutured through, tied as best as possible at the upper and lower ends, then cut across and removed en bloc for from  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch of its length distal to the upper incision. The immediate spinal nerves above and below were cut. Since Rhoads<sup>6</sup> has shown that aluminum hydroxide inactivates a virus suspension of equal volume, the area from which the cord was taken was filled with a colloidal suspension of aluminum hydroxide and a wick packing of the same material was inserted in this space to prevent any possible spread of the virus by way of the packing from the lower to the upper part of the cord. After the operation, there was no connection between the thoracic cord and the lower unremoved segment save by way of the sympathetic ramifications.

In the second operation on the same animal, the sciatic nerve was delivered, crushed with a hemostat in several places and then injected with 1 cc. of 2% potent poliomyelitis virus along its length, the needle being inserted with a rotating irritative motion. Portions of the dose were injected directly into each of the nerve bundles that make up the trunk. There was no operation on the spinal cords of the control animals, but the sciatic nerve was exposed, stitched, tied across in 2 places high up near the ischial tuberosity and then bisected between the two ligatures. The upper ligature was later anchored, with the end jutting between the skin suture line. The distal part was crushed a few times with a hemostat and injected in the same manner as described before and with the same amount of virus. All the operations were done under complete ether anesthesia. Those monkeys (40%) who died as a result of the first operation described need not be referred to in this report.

The experiments performed in the first set of animals were as follows:

Monkey No. 60. The sciatic nerve was cut as described and the distal portions injected with poliomyelitis virus. The animal did

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<sup>6</sup> Rhoads, C. P., *J. Exp. Med.*, 1931, **53**, 399.

not develop the disease. For convenience, we called this method I. The dose was 1 cc. of a 2% virus suspension.

Monkey No. 61 was injected intracerebrally with 1 cc. of a 2% virus suspension and developed poliomyelitis. This was method II.

Monkey No. 62. The portion of the cord of this animal was removed as described and the virus was injected intrasciatically. Poliomyelitis resulted. This operation was called method III. The dose was 1 cc. of a 2% virus suspension.

Monkey No. 63. The sciatic nerve was injected directly with 1 cc. of a 2% virus suspension. The animal developed the disease. This operation was called method IV.

Other animals used as controls were injected subcutaneously or intramuscularly with twice, and some intravenously with 5 times the amount of the same strength of virus used in the cord transected animals, yet the monkeys did not develop poliomyelitis.

After each experiment following method III, cervical cord sections were taken which showed the typical changes characteristic of poliomyelitis. Cord emulsions of the virus obtained from this area produced the disease in other animals. Postmortem dissection showed that in animals treated according to method III, there were no connections between any of the thoracic and upper lumbar nerves, not to mention the lower lumbar and sacral nerves from which the sciatic trunk springs. No aberrant spinal nerve connections between the upper and lower cord were observed.

This experiment was repeated in 3 other sets of animals with the same results.

In the doses used, the virus was ineffective when given by the venous, intramuscular or subcutaneous routes and also when injected into a nerve that had no central axionic connections.

These experiments show that the virus of poliomyelitis can spread from the sciatic nerve along the connecting sympathetic nerve fibers to reach the cervical cord and produce the disease in that area.