

The observations suggest that this disturbance in muscular movement results from injury to structures located in the medial quarter segments of the pons and upper medulla.

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**Localization of the Mechanisms for Righting in the Brain-Stem
of the Cat.***

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Magnus and Rademaker¹ have demonstrated the dependency of the body righting reflexes from the body and of the labyrinthine righting reflexes upon the mid-brain. Their experiments indicated the dependency of these reflexes on the red nuclei. Ingram and Ranson² recently report intact righting reflexes and movements of progression after bilateral destruction of the red nuclei; our experiments, performed independently and using quite a different approach, verify and extend Ingram's and Ranson's observations.

An unoperated animal exhibits the following reactions: (1) it rights the body in falling through the air a short distance, and lights on its feet; (2) when placed on the side, the fore quarters right after the raising of the head, by a rolling, lifting motion in which the fore limbs do not participate to a great degree. The hind quarters follow the fore quarters in like manner. The head, the fore quarters, or the hind quarters will right independently if the other parts are passively fixed. As soon as righting is completed, progression proceeds. (3) If in the standing position, the hind quarters are grasped and passively rotated to one side, the head and fore quarters resist this action by a compensatory rotation in the opposite direction. (4) If the animal is suspended vertically in the air by the hips, the body hangs straight and the head is dorsi-flexed. (When struggling movements are absent.) (5) Equal resistance

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¹ Magnus, "Körperstellung", Berlin, J. Springer, 1924.

² Ingram, W. R., and Ransom, S. W., *Proc. Soc. Exp. Biol. and Med.*, 1932, **29**, 1089.

is met in bowing the body—the vertebral axis—to either the right or the left side.

The above described reactions have been found to be essentially unimpaired after the following operative procedures: (Each procedure has been carried out in 2 or more animals, and in most instances in as many as 6 to 8 animals.†) (1) Transection—or hemisection—of the brain-stem at the cephalic level of the mid-brain. Progression was at first modified in that the body was hung low, resulting from the projection of the shoulder blades above the vertebral column. Normal posture was gradually resumed. (2) Complete section of the fibers crossing the mid-line from the cephalic level of the red nuclei to the middle level of the pons by a narrow medial longitudinal lesion. (3) Unilateral section of the lateral quarter segment of the brain-stem at any level of the pons and upper medulla—thus section of rubro-spinal tract on that side. (4) Bilateral section of the lateral quarter segments of the brain-stem at any level of the mid-brain, pons, or upper medulla—bilateral section of rubro-spinal tracts in the pons and medulla.‡ In the latter cases progression was modified from the normal in that there was a medial crossing of the fore limbs in such a way that the one rubbed slightly across the medial aspect of the other. All placing reactions were absent and there was at first a dragging of the dorsum of the feet in their forward movement, indicating destruction of ascending afferents.

Unilateral removal of the mid-brain, which removes one red nucleus completely and cuts all crossing fibers from the other, or complete hemisection of the pons or upper medulla, altered righting and the distribution of tone as follows: (1) *Direct* righting from the same side of the lesion occurred in the normal manner except the reflex was hyperactive. When the reflex was very hyperactive, the body was over-righted so that the body was turned to the opposite side and rolling occasionally resulted. (2) Direct righting did not occur from the side opposite the lesion. The animal either remained lying on this side or righted *indirectly* by (a) pressing the nose against the floor, (b) extending the uppermost fore leg forward in a grasping attitude, and (c) pulling the undermost fore leg underneath the body. (3) From the righted position progression proceeded or the animal fell to the side of indirect righting. (4)

† The extent of the lesions has been checked carefully by serial section of the block of tissue containing the lesion.

‡ Serial section of the mid-brain demonstrated complete disappearance of the large cells of the red nuclei.

Vertical suspension in the air by the hips resulted in rotation of the head and fore quarters to the side opposite the lesion. (5) Unequal distribution of muscular tone on the 2 sides of the body was evidenced by (a) the tendency of the body to bow to the side opposite the lesion, and (b) a marked resistance to the passive bowing of the body to the side of the lesion.

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Injection of Peripheral Nerves from the Subarachnoid Space.

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The injection mass used by Funaoka and Yamada¹ suggested such interesting possibilities that their work was repeated and extended. For the most part their mixture of ultramarine blue 2 parts, ether 15 parts, and turpentine 30 parts was satisfactory.

The principle of inlet and outlet cannulation was adopted in all of the work. In one group 2 laminectomies were done, one in the cervical region, the other in the sacral. The dura mater was opened and relatively large glass cannulae were introduced into the subarachnoid space. The cervical cannula served as the inlet, the sacral as the outlet. For another group the inlet cannula was placed in the lumbar segment, the severed optic nerves served as outlet cannulae. The pressure was usually from 3 to 5 pounds. Fifteen dogs were used. The injections were usually begun with the animal under an anesthetic. They died as soon as the injection mass reached the brain.

In no instance was a complete injection obtained and there were variations from animal to animal. Perhaps the most constant result was the injection of the cervical lymph nodes. At one time or another many of the peripheral nerves were injected. Specifically there may be mentioned the brachial plexus and its branches as far distally as the hand; the 2 sympathetic chains and their ganglia; the phrenic nerves including their ramifications on the diaphragm; the intercostal nerves and their branches. The position of the ligatures for the cannulae prevented the injection of the nerves of the caudal extremities.

¹ Funaoka, S., und Yamada, J., *Folia Anatomica Japonica*, 1929, 7, 399.