A MOTOR REFLEX FROM THE URINARY BLADDER TO THE COLON

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The pelvic nerves contain motor fibers to the colon. These nerves serve also as efferent pathways in motor responses such as the gastro-colonic reflexes (4), ileo-colonic reflexes (5) and the sensory colonic reflexes (6) which have been reported in our previous papers.

If the central end of a dissected pelvic nerve is stimulated, contractions of the colon are produced when the pelvic nerve of the opposite side is intact. This fact suggests to us the existence of a motor reflex from the urinary bladder to the colon, of which both the afferent and efferent pathways are formed by the pelvic nerves.

In the present paper, the responses of the colon, caused by stimulation of the urinary bladder and the nervous pathways for this reflex will be reported.

METHODS

Unanaesthetized spinal dogs (the spinal cord was transected between the cervical and thoracic regions 24 or 48 hours previously) were used. Sometimes, dogs anaesthetized with ouropan-soda were used. The movements of the distal colon were registered on the kymograph by the method of balloon tambour system. The urethra was ligated near the neck of the bladder, and sustained digital compression of the bladder was used as a stimulus, which caused the intravesical pressure to rise to about 80-100 mm Hg.

RESULTS

Experiment 1: When the intra-vesical pressure was made to rise abruptly, increase in contractions of the colon was produced after a few seconds latency.

Fig. 1. Unanaesthetized spinal dog. Nervous supplies to the colon were intact. From the top downward: movements of the distal colon, signal (bladder was compressed), time 6 secs. (Explanation of curves below is the same).

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as seen in fig. 1. Sometimes, this continued for several minutes after withdrawal of the stimulation. This phenomenon was obtained in anaesthetized dogs as well as in unanaesthetized dogs. This motor response disappeared after bilateral section of the pelvic nerves.

Experiment 2: However, the above results were not always obtained in animals which had intact nervous supplies to the colon. On the contrary, motility of the colon was inhibited in most cases and its tone was decreased immediately after vesical compression. The inhibition was continued during vesical stimulation, but a few seconds after withdrawal of the stimulus, an intense motor response of the colon was produced as seen in fig. 2.

![Fig. 2](image2.png) Unanaesthetized spinal dog. Nervous supplies to the colon were intact.

Experiment 3: The bilateral hypogastric and lumbar colonic nerves were previously severed. In this example (fig. 3), the motor response of the colon was obtained by the digital compression of the urinary bladder. The contractions continued after cessation of vesical stimulation. The inhibitory effects have never been observed in this case.

![Fig. 3](image3.png) The same animal as in fig. 2 was used. The lumbar outflows were transected.

Experiment 4: In fig. 4, the lumbar outflows and the left pelvic nerve were denervated previously. The abrupt rise of intra-vesical pressure also produced remarkable contractions of the distal colon. Then, after severing the right pelvic nerve, the motor response of the colon due to vesical stimulation completely disappeared.
Experiment 5: In this experiment, the afferent nervous pathways of the motor reflexes were investigated.

A: When the central end of the dissected pelvic nerve was stimulated by induced current, contraction of the colon occurred (the pelvic nerve of the opposite side was intact). In this case, an inhibitory effect was not attainable, even when the lumbar outflows were intact. However, when the pelvic nerve of the opposite side was severed, the motor response of the colon was completely abolished.

The afferent impulses of the pelvic nerve are transmitted to the sacral cord through the posterior roots from S₁ to S₃ and the efferent impulses leave the cord through the sacral anterior roots (S₁–S₃). It was shown in each experiment that the central stimulation of the sacral posterior roots from S₁ to S₃ and the peripheral stimulation of the cut end of the sacral anterior roots from S₁ to S₃ both cause contraction of the colon. (The peripheral stimulation of the posterior root and the central stimulation of the anterior root had no motor effects on the colon).

B: All roots of the lumbar and sacral regions were severed from the cord except the left sacral roots from S₂ to S₅. The central stimulation of the cut end of left S₃ caused contraction of the colon, when the left pelvic nerve was intact, as seen in fig. 5.

In the next experiment, excluding only the left S₂, all sacral roots were transected. The central stimulation of the cut end of posterior root S₂ also caused contraction of the colon (S₂ anterior root was intact).
These experiments show that the impulses are transmitted ipsi-laterally and hetero- and homo-segmentally.

C: All roots of lumbar and sacral regions were dissected excluding the left S2 posterior and right anterior roots from S1 to S3. The left pelvic nerve was severed. By central stimulation of the left S2 posterior root, contraction of the colon was obtained as seen in fig. 6.

In examples where the left S2 posterior root and right S2 anterior root were left intact while all the other roots and the left pelvic nerve were severed, central stimulation of the left S2 posterior root caused contraction of the colon.

In another experiment, the left S1 (or S3) posterior and right S2 anterior root were left intact, and the other roots were severed from the cord. By central stimulation of the left posterior root of S1 (or S3), contraction of the colon was obtained.

These experiments show that the impulses which ascend the posterior roots to the spinal cord, are transmitted hetero-laterally and homo- and hetero-segmentally in the cord and then passed to the pelvic nerve through the anterior roots.

**DISCUSSION**

1) The inhibition of movements of the small intestine, caused by distention of the urinary bladder has already been reported by King (3) and others (2, 7). Colon motility is also similarly inhibited as shown in Exp. 2. This inhibitory reflex was abolished after denervation of the lumbar outflows (see Exp. 3).

2) In general, motor response of the colon which had intact nerve supplies, was not observed during the rise of intra-vesical pressure, but was produced after withdrawal of the stimulus (Exp. 2). During stimulation, inhibition only was obtained. This fact seems to suggest that in this example the inhibitory effect, due to lumbar outflows, is more contributory than the motor effect which is due to the pelvic nerves. However, in some cases such as shown in Exp. 1, motor response obtained in animals with intact nerve supplies. This was probably so since in these animals the pelvic nerves were more contributory than the hypogastric nerves. Garry and Gillespie (1) stimulated *in vitro* an artificial “mixing” of the pelvic and lumbar outflows and observed that a stimulus of intermediate frequencies gave a biphasic response; *i.e.*, first, contraction, then,
inhibition. However, the results of the direct stimulation to nerves can not be immediately applied to our findings by vesical stimulation.

That the motor effects are not an after-effect of inhibition can be understood from the following facts. 1) That the motor effect is obtained after section of the colonic and hypogastric nerves (Exp. 3); 2) that it is abolished when the pelvic nerve is severed, and 3) that the inhibitory effect due to peripheral stimulation of the colonic nerve is succeeded by no motor effect.

3) It is undoubtedly demonstrated that the afferent pathways of the motor reflex run in the bilateral pelvic nerves. However, when the pelvic nerve of one side was left intact, the reflex also occurred as shown in Exp. 4. This is also clarified in the experiment of the homo-lateral sacral roots (see Exp. 5.B). At the same time, the impulse which ascended the pelvic nerve of one side, was transmitted to the opposite side of the sacral roots as shown in Exp. 5.C (hetero-lateral, homo- and hetero-segmental).

Thus, the motor reflex pathways may be concluded as being as follows: the afferent impulse in the pelvic nerves enter the sacral cord through the posterior roots (S1 – S3) and the efferent impulse pass through the anterior roots of the one or both pelvic nerves to the colon.

4) The physiological significance of the vesico-colonic motor reflex may be considered as follows: Colon motility is somewhat inhibited at the initial stage of micturition, then remarkable contractions of the colon follow. That is, micturition antecedes defecation. However, when the tone of the pelvic nerve increases or when the tone of the colonic nerves decreases, both micturition and defecation may occur simultaneously.

CONCLUSION

By the abrupt rise of the intra-vesical pressure, colon motility is initially inhibited, then excited remarkably. After transection of the hypogastric and lumbar colonic nerves, the inhibitory effect on the colon was abolished and only the motor effect was obtained. The motor effect is abolished by bilateral section of the pelvic nerves, but when pelvic nerve of one side is intact, the motor reflex occurs. In the motor reflex, the afferent pathway from the bladder and the efferent pathway to the colon are both formed by the pelvic nerves. The afferent fibers pass through the S1 – S3 posterior roots to the sacral cord and leave the cord through anterior roots to the pelvic nerve. In the spinal cord, the impulse is transmitted ipsi- and hetero-laterally and also transmitted homo- and hetero-segmentally.

REFERENCES


