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Intestinal Pain

Participation of other visceral sensations

by

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It is difficult to describe the nature of intestinal pain. What does it depend upon? The author has had an idea that a primary intestinal afferent by noxious stimuli provokes several effects in some other organs and tissues, from which afferents accompanied with the primary afferent are perceived as intestinal pain.

According to the author et al, the primary intestinal afferent by painful stimuli evokes contraction of the abdominal wall muscle through visceromotor reflex, and intestinal pain is composed of both afferents from the abdominal wall and the intestine[7)8)10)].

Is there any relation between the intestine and other visceral organs, similar to that between the intestine and the abdominal wall?

I. MESENTERICO-RENAL REFLEX

There are many reflexes among visceral organs, but there is a difference between reflexes in normal conditions and those by noxious stimuli like pain.

It is the hepatorenal reflex which is well known as one of the reflexes to noxious stimuli. The reflex brings severe effects on the body[2)].

It is investigated here, the neural connection between the intestine and the kidney.

i) Methods

Five cats (2.0-3.0 kg) were anaesthetized with Nembutal (50 mg/kg) and immobilized with succinylcholine chloride. Respirator was administered.

The cat was laid on the left side and the right abdominal wall was removed. The mesenteric nerve was exposed and cut. The central cut end was hooked on the conventional stimulating electrode and the root of the central stump was grounded. The right renal nerve[2)] was exposed and cut. The central cut end was desheathed and hooked on the recording electrode for which a platinum wire (0.2 mm in diameter) was used. As the indifferential electrode a platinum plate (1 × 1 cm) was placed in an adequate tissue of the body. Blood pressure was led to the electronic manometer through the femoral artery.

Changes in the renal efferent impulses as well as blood pressure by the mesenteric nerve stimulation were observed in the dual beam oscilloscope with the 4-stage, differential C-R amplifier.

The same observation was done with the sciatic nerve stimulation.

Influences of these stimulations were observed before and after removal of the aortic nerve, sinus nerve or subdiaphragmatic vagotomy.

ii) Results

Tonic discharges of the renal nerve were inhibited immediately after stimulation of the mesenteric nerve for some seconds (Fig. 1). The inhibition for not less than 10 seconds was produced by the mesenteric nerve stimulation (10 cps, 10 sec, 10 to 20 V case by case), while there were inhibitions for not more than 0.5 seconds with the sciatic nerve stimulation (the same voltage as in the mesenteric nerve).

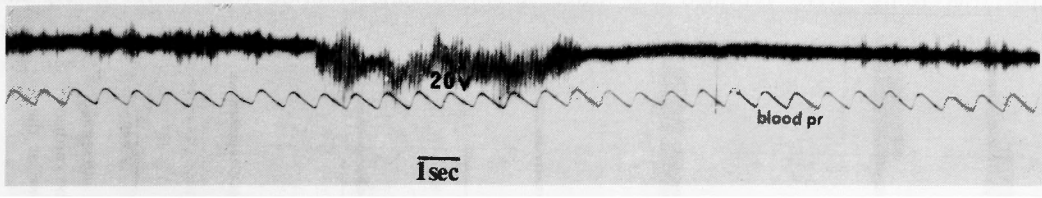


Fig. 1 Efferent discharge of the r-renal nerve and the femoral blood pressure, influenced by the mesenteric nerve stimulation. Entanglement at the middle of the trace is an artifact during stimulation.

In the former, increase in blood pressure was accompanied, except 1 case without change, and in the latter there were 3 cases of severe fall and 2 cases of no change in blood pressure.

Blocking of the sinus nerve and the aortic nerve did not bring disappearance of the inhibition but shortened duration of the inhibition to some extent.

Vagotomy erlongated duration of the inhibition rather than being effectless.

II. MESENTERICO-VAGAL REFLEX

It is discomfort in the chest or difficulty in breathing which imposes a severe nature to abdominal pain, for example, during intestinal operation with local anaesthesia of the abdominal wall or intestinal colic. The above complaints may be also induced by enhancement of the vagal tonus.

How is the relation between the intestine and other organs through the vagal nerve?

i) Methods

a) The three cats were anaesthetized with Nembutal (50 mg/kg) and a respirator was administered in a constant rate. The cat was laparatomied in a median line. A catheter was inserted in a duodenal part of the mesenteric artery for injection of acetylcholine chloride ('Ach' for short, 0.2 mg, 1 cc) to the intestine. A balloon was set in an intestinal segment and led to the manometer. Blood pressure in the femoral artery was also led to the manometer. After closing the wall, the left vagal nerve was exposed and cut at the neck. At the central cut end, several functional single fibers were prepared.

Change in the efferent impulse of each fiber by Ach injection was recorded simultaneously with intsetinal contraction or blood pressure before and after blocking of the intercostal nerves (Th 7-Th 13).

Electrodes and other recording apparatus were the same as in (I).

b) Five cats (2.0-3.0 kg) were anaesthetized with Nembutal (20 mg/kg) and the respirator was administered at a constant rate. The cat was laparatomied in a median line. Around the mesenteric nerve, a pair of copper wires (0.7 mm in diameter) was tied as the stimulating electrode which was insulated against the other tissues. An earthing ele-

ctrode was placed more centrally, towards the ganglion. After closing the wall and decerebration at the supracollicular level, the cat was laid on the right side and the left thoracic wall was removed. A branch of the vagal nerve was prepared and cut. The central cut end was set on the recording electrode (the same as (a)).

The evoked potentials in the vagal branch, by the mesenteric nerve stimulation enough to provoke only the abdominal wall contraction, were recorded repeatedly (0.5 cps). Recordings were repeated also after succinylcholine chloride (S.C.C. for short) in-

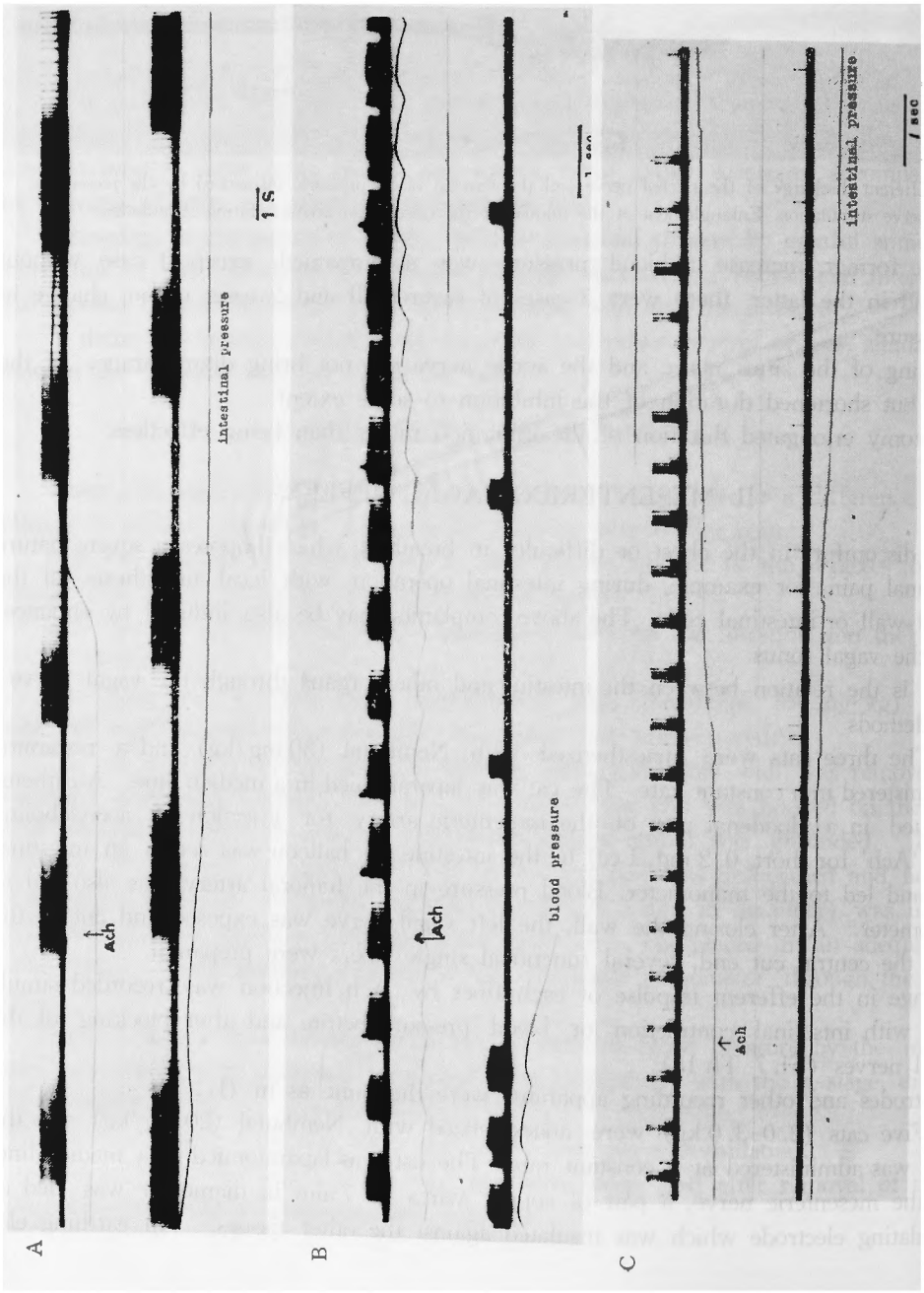


Fig. 2 A : a unit discharge in the bronchial branch of the vagal efferent with intraluminal pressure of the intestine. B : a unit discharge in the cardiac branch with the femoral blood pressure. C : a unit discharge in the cardiac branch with intraluminal pressure of the intestine. Enhancement of the tonic discharge is the response at the intestinal contracting state or the rise in blood pressure preceding the general action of acetylcholine.

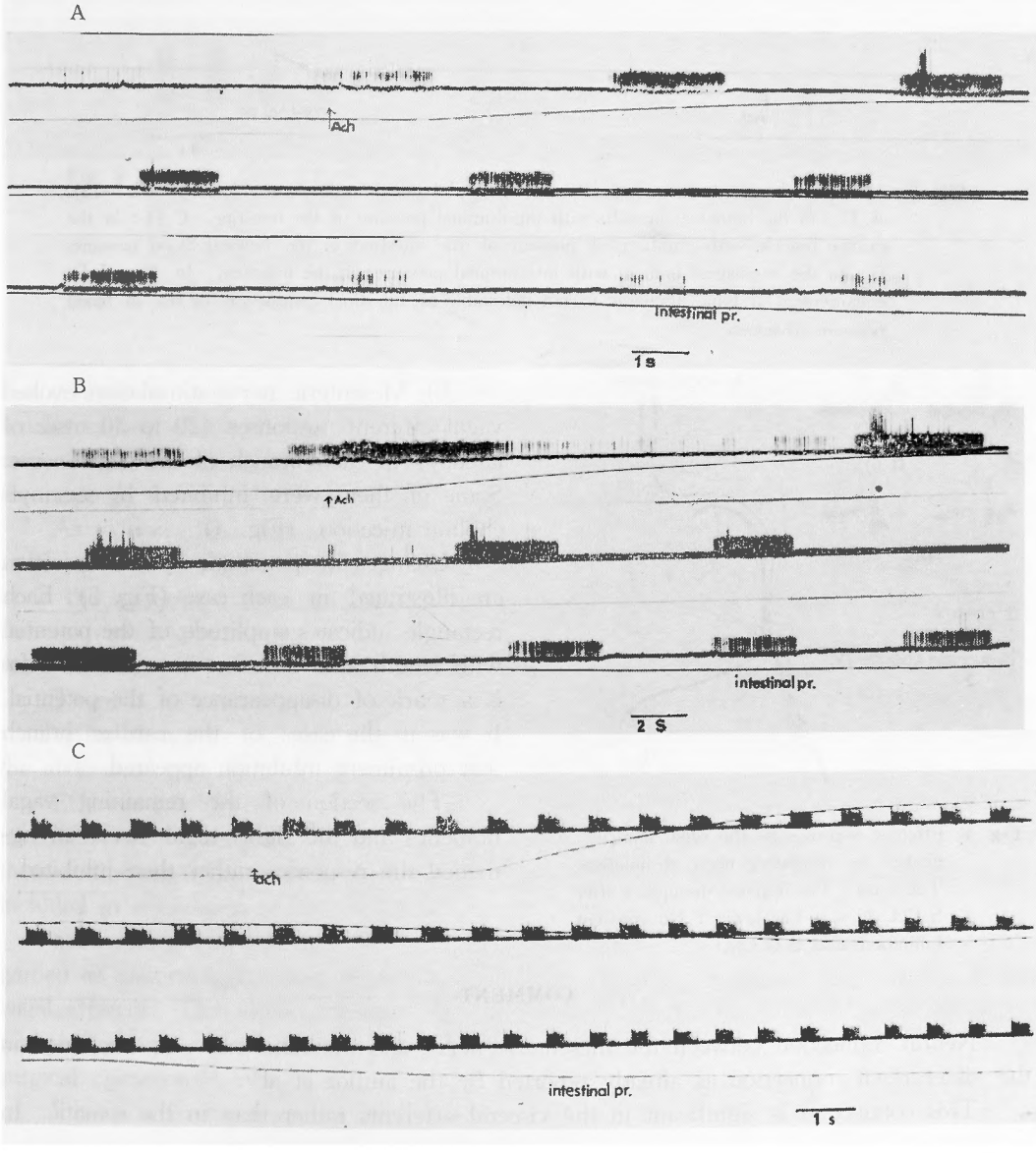
jection i.v..

ii) Results

a) In the vagal efferents synchronous with heart rate or respiration, there appeared the responses[9] by Ach in contracting state of the intestine or rise in blood pressure (Fig. 2).

Fig. 3 shows the responses in the cardiac, bronchial and esophageal branches after blocking of the intercostal nerves. Inhibition of the responses in the tonic discharges of the cardiac and the bronchial branches could be found after blocking, prominently in the former.

The section of the right vagal nerve strengthened the responses rather than inhibited.



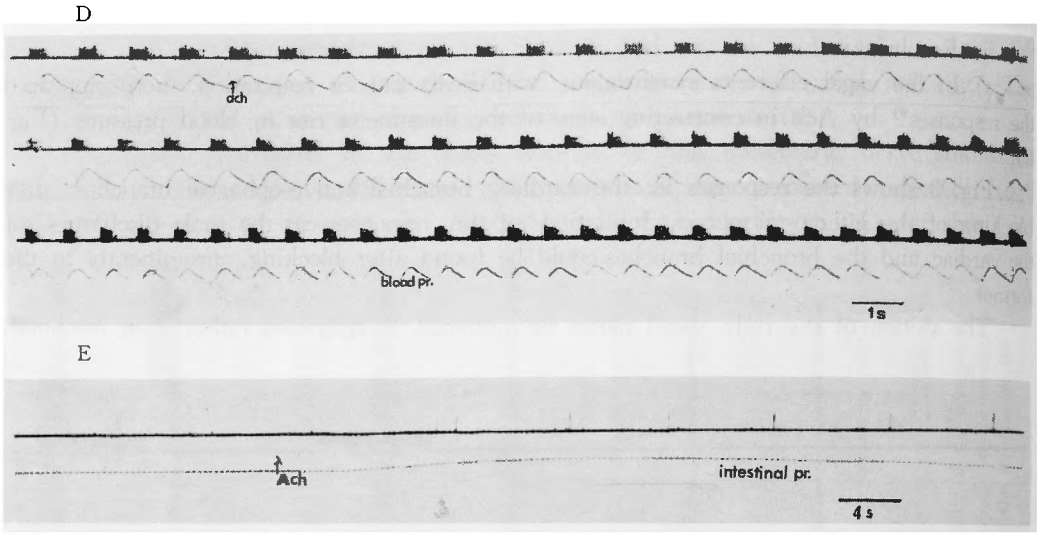


Fig. 3 A unit discharge of the vagal efferent after abdominal wall nerve blocking (Th 7-13). A, B : in the bronchial branch, with intraluminal pressure of the intestine. C, D : in the cardiac branch, with intraluminal pressure of the intestine or the femoral blood pressure. E . in the esophageal branch, with intraluminal pressure of the intestine. In C and D, enhancement of tonic discharge is not detectable as intestinal contraction or rise in blood pressure advances.

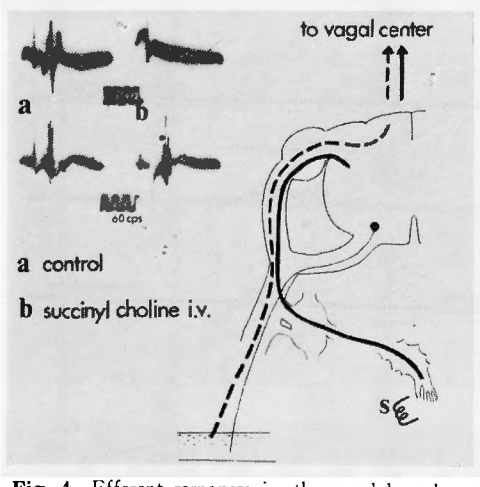


Fig. 4 Efferent responses in the vagal branches, evoked by mesenteric nerve stimulation. The upper : The response disappears after S. C. C. (i. v.). The lower : No apparent inhibition after S. C. C. (i. v.).

b) Mesenteric nerve stimulation evoked vagal efferent responses (20 to 30 msec of latency) in each branch of the vagal nerve. Some of them were inhibited by succinylcholine injection. (Fig. 4)

Changes in potentials by the injection are illustrated in each case (Fig. 5). Each rectangle indicates amplitude of the potential with length and duration in width. A dot is a mark of disappearance of the potential. It was in the cases of the cardiac branch that prominent inhibition appeared.

The section of the remaining vagal branches and the right vagal nerve strengthened the responses rather than inhibited.

COMMENT

Neural connection between the mesenteric nerve and the renal nerve is contained in the viscerorenal connection as already reported by the author et al[8].

This connection is significant in the visceral afferents rather than in the somatic. In

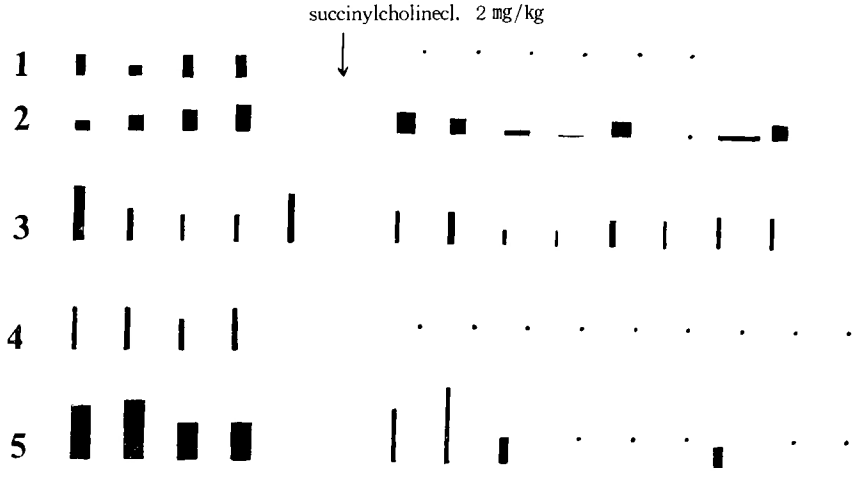


Fig. 5 Diagram of changes in evoked responses of the vagal efferents by repeated mesenteric nerve stimulation before and after S.C.C.(i.v.). 1, 4, 5 : in the cardiac branch. 2 : in the bronchial branch. 3 : the esophageal branch. Frequency of stimulation : 0.5 cps. A dot indicates no apparent potential. A rectangle indicates amplitude of potential with length and duration in width.

that connection, there seemed to be something other than the pressor reflex though the renal response was accomanied by the rise of blood pressure in most cases, because the response did not disappear with the removal of main baroceptors and there was found the response in the case of no change in blood pressure.

As to the sciatic nerve, there is a saying that the inhibition or acceleration in the renal nerve is decided according to the strength of stimulation[5]. But the same strength as in the mesenteric nerve stimulation was used and the result presented a good explanation for crushing syndrome by severe fall in the blood pressure without inhibition in the renal efferent.

There is no evidence for sensation from the kidney during the inhibition in the renal efferent nerve. If any sensation is produced there, it will impose other natures to the abdominal pain than the sciatic nerve stimulation.

Efferent stimulation of the vagal nerve can produce bradycardia, prolongation of P-Q in E.K.G., A-V block, bronchospasm and perhaps nausea. According to the results in (II) these complaints happen to be accompanied with intestinal colic and are considered to be included in complaints of intestinal pain.

Such relation between painful intestinal contraction[9] and vagal responses may be regarded as viscerovagal reflex because the response does not disappear by blocking of the vagal afferent. The vagal response by conventional stimulation of the mesenteric nerve interprets the possibility of vagal responses to mechanical stimulation of the intestine during surgical operations[6].

Inhibition in the response by blocking of the abdominal wall nerves or of neuromus-

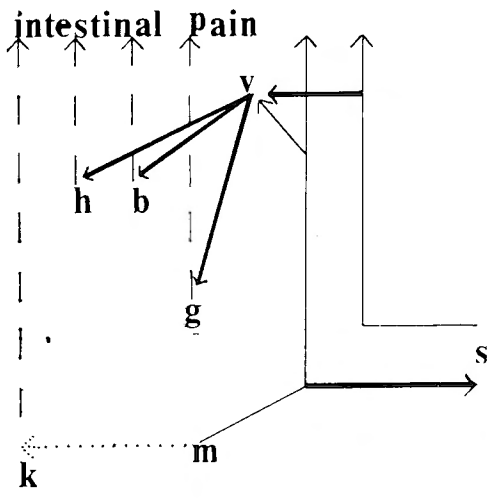


Fig. 6 Schema showing that a painful disorder in the mesenteric region produces a compound sensation as an abdominal (intestinal) pain. The mesenteric disorder stimulates other organs and tissues through several reflexs, the afferents from which are perceived, accompanied with the primary afferent from the meseenteric disorder. All of these afferents is perceived as intestinal pain. m : the mesenteric region. k : kidney. s : the abdominal wall. h : the heart. b . the bronchial region. g : the esophageal and gastric region. v : the vagal center.

cular junction with succinylcholine shows how the somatic afferent through the visceromotor reflex participates in the viscero-vagal reflex and that the blocking of the afferent from the referred somatic region eliminates two constituents…… the painful component[7] and discomfort in the chest, from the complaints in intestinal pain.

It is popular and consistent with common sense that in pain reaction, pain is accompanied with tachycardia and the sciatic nerve stimulation inhibits the tonic discharges of the vagal efferents[3][4]. There is a difference between the cardiac response by the somatic nerve stimulation and by the mesenteric nerve stimulation. Therefore, the intestinal or visceral pain is considered to have a sensation of other natures originating in the chest than the somatic pain.

In the previous paper[9] it was reported that during intestinal pain afferent excitation of C-fibers were observed more dominantly than the others. But the intestinal afferent alone has not proved to be capable of producing pain. The other reports say, it is important for producing pain that intestinal afferent provokes muscle spasm of the abdominal wall by way of the mesenterico-motor reflex[1].

It is suggested here that discomfort, sensations of severity and others during intestinal pain depend on the afferents from other organs by way of the viscero-visceral and viscero-vagal reflex as well as direct pathway of the intestinal afferent.

Fig. 6 illustrates that intestinal pain is a compound sensation from the original intestinal afferent, other organs and tissues by way of several reflexes.

SUMMARY

i) The mesenteric nerve stimulation inhibits the renal nerve efferent discharges and the inhibition by the stimulation to the sciatic nerve is difficult to be detected. The inhibition remains after removal of the aortic nerve and the sinus nerve or after subdiaphragmatic vagotomy.

ii) Acetylcholine to the intestine through the mesenteric artery provokes vagal efferent responses or enhances tonic discharges in the vagal efferents, preceding general actions of the drug. Some of the responses are inhibited by the bilateral blocking of the abdominal wall nerves.

iii) Some of the vagal efferent responses evoked by the mesenteric nerve stimulation

are inhibited by administration of succinylcholine chloride.

iv) In addition to the report that abdominal pain with nausea and vomiting by noxious stimulation to the intestine disappears after the bilateral blocking of the abdominal wall nerves, it is discussed that discomfort or sensations of severity during intestinal pain is produced from the viscero-visceral and viscero-vagal reflexes, besides the primary visceral sensation and that such unconfortable sensations are alleviated by inhibition of the reflexes, for example, by means of the bilateral blocking of the abdominal wall nerves.

(Presented before at the Symposium on Pain of the 24th Annual Meeting of the Japan Neurosurgical Society, Tokyo, 1965.)

REFERENCES

1) Ann M. Alderson, C.B.B. Downman, Reflex activation of intercostal nerves and trunk muscles by non-myelinated fibers of the splanchnic nerve in rabbits. J. Physiol. **150** : 463-477, 1960.
2) Hori, M., Austen, W.G., McDermoff. W.V.Jr., Hepatic anoxia and stimulation of hepatic nerves on renal hemodynamics and function. Surgical Forum XV : 108-109, 1964.
3) Iriuchijima J., Kumada M, Activity of single vagal fibers efferent to the heart. Jap. J. Physiol. **14** : 479-487, 1964.
4) Iriuchijima J., Kumada M., Efferent cardiac vagal discharge of the dog in response to electrical stimulation of sensory nerves. Jap. J. Physiol. **13** : 599-605, 1963.
5) Iriuchijima J., Text book for circulation research (in Japanese). Igaku-Shuppan Co. Tokyo. 1966.
6) Kimura C., Tsunekawa K., Kumada K., Machizuka A., Neural reflex and surgical agression (in Japanese) Saishin-Igaku **21** : 2712-2715, 1966.
7) Kumada K., Machizuka A., Significance of the referred spasms of the abdominal wall muscles during the visceral pain. Arch. J. Chir. **35** : 6, 1966.
8) Kumada K. Machizuka A., Pain and C-fiber. Neurologia Medicochirurgica 7, 141-142, 1965.
9) Kumada K., Intestinal Pain : Intestinal spasm by acetylcholine and its pain producing effect. This Journal.
10) Kumada K., Intestinal Pain : Significance of the secondary response in pontine reticular formation evoked by mesenteric nerve stimulation (to be published).
11) M.H. Evans, A. Mcpherson., The effects of electrical stimulation of visceral afferent nerve fibers on monosynaptic and polysynaptic reflex responses. J. Physiol. **150** : 105-113, 1960.

和文抄録

腸管痛：他の内臓感覚の関与

京都大学医学部外科学教室第2講座（指導：木村忠司教授）

熊　田　　馨

猫を用いて，腸間膜神経刺戟による他の2，3の臓器への影響を観察した．

1) 腸間膜神経の求心性電気刺戟によつて，腎神経遠性放電は著明に抑制されるか，坐骨神経の同様刺戟によつては抑制がみとめがたい．この抑制は若干の検討から一つの神経反射であるとかんがえられる．

2) 腸管に対するアセチールコリンの直接刺戟によつて，迷走心経の遠心性反応，或は緊張性放電の増強がみられる．この反応の或るものは，腹壁神経の遮断によつて抑制される．

3) 腸間膜神経電気刺戟による迷走神経遠心性誘発放電の或るものはサクシニールコリン投与で抑制される．

以上の結果と，すでに報告した腹痛に対する腹壁神経遮断の影響とから，腸管痛に際しての，体性領域の疼痛とは異つた特異な不快感，重症感は腸間膜神経から発する内臓・内臓反射，内臓・迷走神経反射による他臓器感覚に負う処が大であることが推論され，またこれらの不快感は体壁神経遮断によつて抑制され得ることが示される．