THE EXPERIMENTAL STUDY ON THE RELATION BETWEEN THE GASTROINTESTINAL MOVEMENTS AND THE ABSORPTION OF THE PROTEIN AFTER GASTROINTESTINAL SURGERY, USING THE RADIOACTIVE IODOCASEIN

by

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(Received for publication Oct, 10, 1958)

INTRODUCTION

Recently, the major surgical operations such as gastrointestinal operation have undertaken with comparative ease, owing to the latest progress of the surgical technique and of anesthesia, and to the discovery of the various kinds of antibiotics. However, the surgical operation, usually, gives not a little disturbance to the vital body, and the treatments before and after operation —— the problem of the nutrition after operation in particular —— have much influences upon the convalescence of the patient after the surgical operation, and then this problem has been attracting notice and investigated by numerous authors in this decade, and especially the early feeding through a mouth has been emphasized to be one of the most important treatments following surgical operation.

Asano[1] reported the interrelation between the gastrointestinal movements and absorption after gastrointestinal operation, using isotope P^{32}, i. e. the absorption of P^{32} is absent when the gastrointestinal movements stop and the absorption is significant when the movements are vigorous, and then there is the correlation between the gastrointestinal movements and absorption. Later on, Watanabe[2] reported likewise the interesting facts by the study on the same problem, using isotope Na^{24}. It has been recognized that P and Na are the inorganic substances which play the important part for metabolisms, but it seems to be more important and interesting to investigate the absorption of protein following gastrointestinal surgery and to study the relation with the gastrointestinal movements.

The absorption of protein has been investigated in various ways for the long time, but it was determined only by the measurement of the nonprotein nitrogen, [3] by the volume of protein in blood, by the protein that remains in the intestinal canal when the definite time has elapsed after the ingestion of the protein materials, or by the biochemical analysis of faeces.[4][5] The examination of the digestion and absorption with faeces is the method to calculate the rate of digestion and absorption by the measurement of the elements that are not absorbed and appear in the faeces. This method is still universally employed today, but many doubts

have remained, because the components of faeces themselves are not yet fully understood. HOSAKA reported that the components of faeces are not only the remnants of foods that are neither digested nor absorbed, but it contains a large quantity of the excrements from the intestinal canal. Therefore, the determination of the digestion rate from such faecal material can not be considered to be correct.[6] DENT and SCHILLING[7] noticed the fact that the intestinal emzymes are able to break protein down into amino-acid, and the level of amino-acid in blood rises following the intake of a protein meal. They applied the technique of the paper partition chromatography for the analysis of the blood samples, which were withdrawn from the portal and jugular vein periodically, using the London canula to study the absorption of casein, human serum and dog serum following gastrectomy.

As the application of isotopes has been recently popularized, BAYLIN, SANDER, ISLY and SHINGLETON[8] have made clear the function of the absorption of healthy men and dogs by means of measurement of the iodoradiations in the venous blood, using the radioactive iodohumanserum albumin. SHARP, LASSEN, SHANKMAN, GEBHART and HAZLET[9] have made reserches of the absorption of protein in man, using a yeast protein tagged N^{15}. While, there are very few of the periodical observation of the absorption of the protein following the gastrointestinal surgery, and, moreover, the absorption of protein after surgery by the application of isotope —— in particular, the relation between gastrointestinal movement and absorption —— has not been investigated at all. Formerly, KOIWAI[10] and TANAKA[11] studied the gastrointestinal movement in detail, using abdominal window. Recently, Asano and Watanabe used this abdominal window, based upon TANAKA's method studied the gastrointestinal movement and absorption. On the other hand, many kinds of pigmental markers have been used for the study of the physiology of the gastrointestinal tract. The absorption from the stomach in men and dogs have been studied in this way by HOLZ and SCHREIBER[12]; FREUND and STEINHART;[13] REYNELL and SPRAY.[14] GOODMAN, LEWIS, SCHUCK and GREENFIELD[15] have used the evans blue to observe the intestinal transit in animals. REYNELL and SPRAY used phenol red to observe the absorption and transit simultaneously in the gastrointestinal tract of rats. ASANO and WATANABE used methylene blue for the measurement of the intestinal transit after the gastrointestinal surgery hinted from this idea.

In this study, the radioactive iodocasein was synthesized by labeling the radioactive iodine to casein and studied the influences of anesthesia and surgical operation upon the absorption, with special reference to the correlation between gastrointestinal movement and absorption.

METHOD

Material: Mongrel dogs were used which weighed approximately 10 kg. Food was withheld from the morning of the day before until the end of each experiment.

Radioactive iodocasein was synthesized by modifying the UGAMI and IGARASHI's method[16] for the test meal of this experiment. The method of synthesis is omitted in this paper because it was previously reported in detail.[17] 100 μc of radioactive

iodocasein was used in each case.

Method of Ingestion: 100 μc of radioactive iodocasein in the tepid distilled water was given to the dogs by stomach tube. For the study to observe the absorption of duodenal canal, the upper median incision was applied and the duodenal incision was made by the length of about 5 mm, and rubber tube inserted through which the test meal was ingested. WITZEL's nutritional enterostomy was added to investigate the absorption in the distal parts from the entero-enteroanastomosis following gastrointestinal surgery.

Laparotomy: Ether anesthesia by Ombredanne's apparatus was used in most cases, but occasionally the local anesthesia with 0.5% novocain solution was also used. Laparotomy was carried out by the upper median incision, and the gastrectomy, gastrojejunostomy and WITZEL's enterostomy were performed.

Observation of the intestinal movement:[18] Abdominal window was applied according to the technique which was deviced by TANAKA formerly. But, this procedure was employed only in a few cases, because the result of such experiment has been described in detail by TANAKA and KOIWAI. As a marker phenol red was used, which was proved to be hardly absorbed. And the distribution of the marker along the gastrointestinal tract can be utilized to evaluate the intestinal transit. 1-7 times/min. of the gastrointestinal movements were expressed as (+); 8-12 times/min., as (++); and more than 13 times/min., as (+++).

Blood sample: 1 cc of venous blood was withdrawn at 5, 10, 15, 30 min and 1, 1.30, 2, 2.30, 3, 3.30, 4, 5, 6, 8, 10, 12, 15, 18, 21, 24 hours following the test meal for analysis of blood radioisotope content. The radioisotope content was calculated in a GEIGER-MÜLLER tube. The total blood volume was assumed to be 7.7% of body weight. Using the measured radioactivity of the 1 cc. sample and the calculated total blood volume, the total radioactive I^{131} blood level was determined and expressed as a percentage of the ingested material. The detector was positioned 2 cm. above from the surface of the sample container. All samples were counted for sufficient time to give statistical accuracy to the data.

RESULTS OF THE EXPERIMENT

1. Preliminary experiment

To study the absorption after gastrointestinal surgery using the radioactive iodocasein, it is necessary to investigate the area where the absorption takes place and the speed of absorption under normal condition. Moreover, it is much important to investigate the appearance of absorption in each area of digestive tract under the influences of ferment hinderer or anesthetics. The following experiments were carried out to observe the absorption in each area under various conditions.

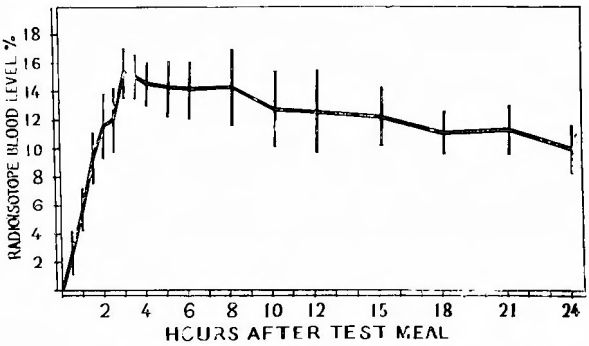
A. Absorption under normal condition of an empty stomach

a) Absorption from the gastrointestinal canal

In order to obtain the standard values of the radioisotope content in blood after the ingestion of a test meal of radioactive iodocasein, the experiments were carried out on healthy dogs. Ten dogs were used for this test.

For the investigation of the absorption from the gastrointestinal canal under the most physiological condition, it is needless to say that the test meal should be given through mouth of the experimental animals, but it is difficult, as a matter of fact, to make them eat the proper quantity of test meal at any time desired. Then, to perform the administration of test meal as physiological as possible, and to diminish the technical error as possible, 100 μc of the radioactive iodocasein in 50 cc of water was ingested by the stomach tube. Each experiments were continued throughout the 24 hour-period. The average blood radioisotope level and the

Fig. 1 Absorption of I^{131}-casein from the gastrointestinal canal.



Average normal curve with standard deviation at points indicated. After about 3 hours, the radioisotope blood level reached to the maximal point.

standard deviation for each point of observation are shown in Fig. 1. The blood radioisotope content appeared in the blood sample with 5 minutes after ingestion of the test meal, but its quantity was very small. After 30 minutes, the radioisotope content increased to the level above 2.5% and then the curve began to rise pronptly from this point. After about 3 hours. the level reached to the maximal point, and then decreased gradually up to 24 hours after ingestion.

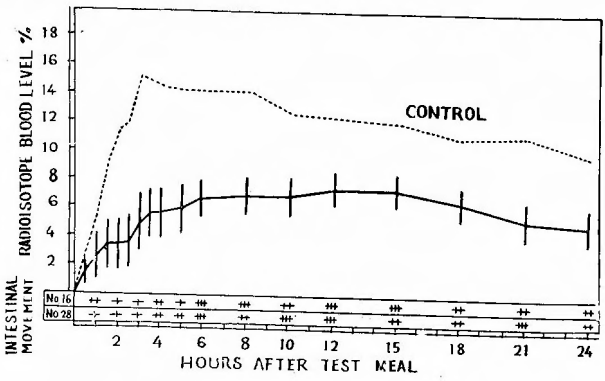
b) The influence of the monoiodoacetic acid on the absorption of the iodocasein from the gastrointestinal canal and the gastrointestinal movements.

Monoiodoacetic acid[19] belonging to the alkylating agents in the thiol or sulfhydryl reagents is recognized generally to check the protein absorption by the chemical reaction to the so-called "fixed SH-groups" within the protein and enzymes. This experiment was undertaken in order to evaluate the effect of monoiodoacetic acid on digestion and absorption of the radioactive iodocasein.

By the same method as in the case of normal controls, the test meal added 0.01 mol of monoiodoacetic aid was ingested by the stomach tube. In three cases the resin window was arranged on the abdominal wall four days before this experiment and the intestinal movements were observed through the window. The results were showed in Fig. 2. From this data, the reduction and the delay in height of the blood radioisotope levels following ingestion was confirmed. Namely, the absorption after 6 hour-period is about 6% and the maximum of average curve is below 8% in spite of the vigorus peristaltic movements. When 0.01 mol of the monoiodoacetic acid was administered simultaneously with the test meal,

the absorption was reduced to approximately 50%, compared with the normal control. The gastrointestinal movements were observed in detail in one case as follows:

Fig. 2 The influence of the monoiodoacetic acid on the absorption of the iodocasein from the gastrointestinal cannal, and the gastrointestinal movements. Average curve of control is broken line at points indicated.



Dog No. 16

Hours after test meal	Gastrointestinal movements (frequency per min.)	
5 min.	Gentle peristaltic wave of the intestine	4
30 min.	Intestinal peristalsis	5
1 hour	Gastric peristalsis	3
	Intestinal peristalsis	12
2-3 hours	Intestinal peristalsis	8
4 hours	〃 〃	9-10
5 hours	〃 〃	6
6-8 hours	〃 〃	14-16
	Rhythmic segmentation	3-4
	Stomach was out of sight through the window.	
10 hours	Intestinal peristalsis	10
12-15 hours	〃 〃	12-14
18-24 hours	〃 〃	9-10
	Segmentation was not recognized.	

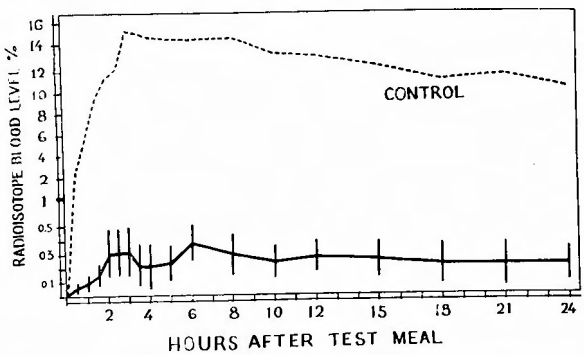
B. The experiment on the absorption from the different part of the gastrointestine

a) Absorption from the stomach

i) Absorption of the radioactive iodocasein:

In order to evaluate the absorption from stomach, the pylorus was closed with Petz's clamp through upper median incision under local anesthesia of 0.5% novocain solution, and the communication between the stomach and duodenum was shut out completely. Then, the test meal was ingested directly into the stomach through tube. As shown in Fig. 3, the absorption from the stomach was very little during the 24 hour-test period. The radioisotope blood level was not over 1% on the average. Five dogs were used, but two of them vomitted one part of the test meal 2 hours after ingestion.

Fig. 3 Absorption of the radioactive iodocasein from the stomach

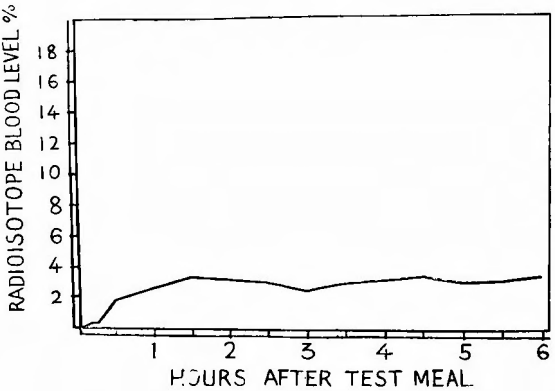


Average curve of control is broken line at points indicated.

ii) Absorption of the carrier-free iodine^{131} and casein:

The radioactive iodocasein was not absorbed from the stomach as described above. This experiment was undertaken to observe whether or not the radioactive iodocasein is decomposed to carrier-free iodine^{131} and casein by the hydrolysis in the stomach, from the viewpoint of the absorption. Namely, the mixed solution of 100 μC of I^{131} and 3 g of casein in distilled water was ingested into the stomach which was shut out operatively from the duodenum at the pyloric portion.

Fig. 4 Absorption of the carrier-free I^{131} and casein from the stomach



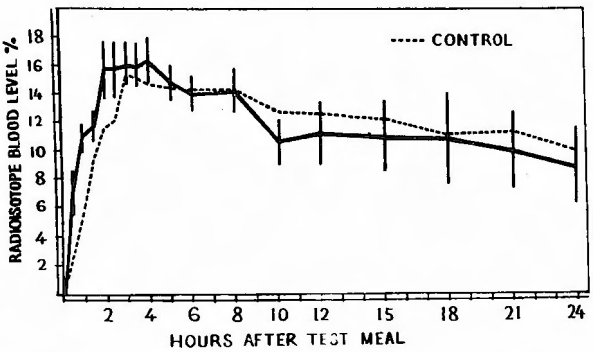
The radioisotope blood level at 1 hour and 30 min. after ingestion was 3.4% as shown in Fig. 4. The absorption of the mixed solution was excellent, compared with that of radioactive iodocasein alone from the stomach and the difference between both absorption was apparently recognized.

b) 1) Absorption from the duodenum

In order to evaluate the absorption from the intestinal canal, the test meal was ingested into duodenum directly. The small upper median incision was performed under local anesthesia of 1% novocain solution and the small incision of about 5 mm. was made at 2 cm. lower part from bulbus duodeni. Through this wound the test meal was ingested directly into the duodenum by tube and the

wound was closed by routine procedure. While, the radioactive iodocasein is not dissolved completely in distilled water, such surgical procedure was forced to assure the ingestion. As shown in Fig. 5, the blood radioisotope levels at 30 min. after test meal is 7% and the average curve reises more rapidly than normal controls. When the test meal was ingested directly into duodenum like this, the maximal point of radioisotope level appeared in the blood within two to four hours. Namely, the intestinal absorption is better and more rapid in spite of the influence of the surgical poocedure for ingestion.

Fig. 5 Absorption from the duodenum.



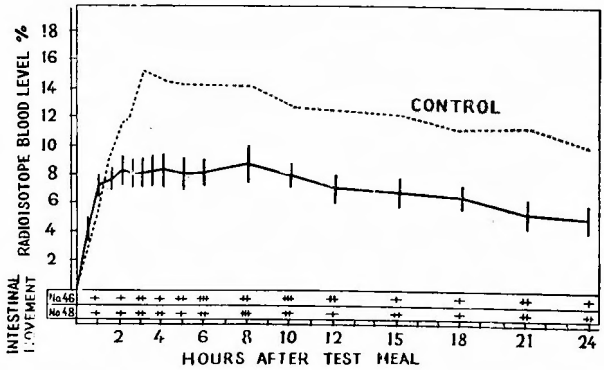
Average curve of control is broken line at points indicated. The average curve reises more rapidly than normal controls.

2) The influence of the monoiodoacetic acid on the absorption from the duodenum and the gastrointestinal movements.

The test meal involved 0.01 mol of monoiodoacetic acid was ingested into the duodenal canal by the same method as described above.

The average curve during one hour-period is better than normal control, but after 2 hours the significant diminution in radioisotope blood levels was recognized. However, the absorption is better, compared with the absorption from gastrointestinal canal following the test meal involved 0.01 mol of the monoiodoacetic acid.

Fig. 6 The influence of the monoiodoacetic acid on the absorption from the duodenum and the gastrointestinal movements. Average curve of control is broken line at points indicated.



Two of the six cases were arranged with the resin abdominal window four days before this experiment, and the vigorous intestinal movements were seen during the test period. Namely, after the ingestion of the test meal the intestinal movements increased its frequency and tonus and the peristaltic movements became stronger, compared with those before ingestion.

C. The influence of the monoiodoacetic acid upon the gastrointestinal movements.

The experiment as described above was performed to study the influence of the monoiodoacetic acid on the abrorption, and moreover, this experiment was undertaken to observe the influence of the monoiodoacetic acid on the gastrointestianl movement in particular.

The dogs were arranged with the resin abdominal window four days before the experiment. 0.01 mol of the monoiodoacetic acid was used. Three points of the intestine under the abdominal window were determined as the standard conveniently, and the intestinal movements were observed at these standard points. The dogs were killed immediately after the experiments and these points (A, B and C) were measured from the TREITZ's ligament. The intestinal movements were observed in case No. 75, and the results were as follows:

Dog No. 75, ♀, weight 9 kg.

40 cc. of 0.01 mol solution of the monoiodoacetic acid was ingested through the mouth.

Time of the observation	Intestinal movements at A. B and C point (frequency per min.)
1 hour before ingestion	Gentle peristalsis A, 8; B, 9; C, 8
30′ 〃 〃	〃 A, 16; B, 13
Just before ingestion	Gentle peristalsis A, 16
5′ after ingestion	〃 A, 10
10′ 〃	A, 10; The intestinal canal, redden; The tonus became strong. B, Peristalsis of the gentle tonus, 7
15′ 〃	A, 7; Rythmic segmentation became strong.
20′ 〃	A, Peristalsis, 12; B, 14; The movements were both peristalsis and rythmic segmentation. Point A was out of the sight gradually and point B appeared in view.
30′ 〃	The smooth peristalsis, A, 9; B, 11.
1.0′ 〃	A, B, 9-10
1.30′ 〃	A, 10; B, 11
2.0′ 〃	A, B, 10
3.0′ 〃	B, 11
3.30′ 〃	Gentle peristalsis, A, 5; B, 8; C, 9
4.0′ 〃	A, Out of the sight; B, Peristalsis and rythmic segmentation, 10; C, Rythmic segmentaion, 10
5.0′ 〃	Gentle peristalsis, B, 10; C, 9
6.0′ 〃	B, Gentle irregular peristalsis, 9

The dogs were slaughtered after six hours and the autopsy was done. The position of point A, B and C was 60 cm., 130 cm. and 165 cm. respectively from the TREITZ's ligament.

D. The experiment on the influence of the anesthesia upon the absorption

from the different part of the gastrointestinal tract, and its movements

The anesthesia is one of the most essential part in the surgical field. Especially, according to the recent advance of the anesthesiology, gernall anesthesia has been undertaken easily in modern surgery. While the influence of the anesthesia upon the gastrointestinal movements was reported by KOIWAI formerly, no report has been made on the relation between the gastrointestinal movements and the absorption of protein in the anesthesia. Therefore, this study was undertaken to observe the relation between the gastrointestinal movements and absorption of protein.

a) Absorption from the gastrointestinal tract under ether anesthesia, and its movements.

The experimental animals were anesthesized by OMBREDANNE's mask with ether after the subcutane injection of 1 cc of atropine sulfate. At time when the third stage of anesthesia was obtained, the test meal was ingested quickly into the stomach by tube. The anesthesia was continued four hours, then, both absorption and gastrointestinal movements were observed for twenty-four hours. Three in six dogs were put with the abdominal window four days before this experiment. The gastrointestinal movements were not seen entirely during the maintenance of ether anesthesia. The peristaltic movements were recovered gradually in a hour or so after the discontinuance of anethesia. However, the recovery of the rate of the absorption —— the blood radioisotope levels —— was very slow and the complete recovery was seen about ten hours after the discontinuance of the anesthesia, i. e. the rate of the absorption became excellent by degrees, in parallel with the recovery of intestinal movements.

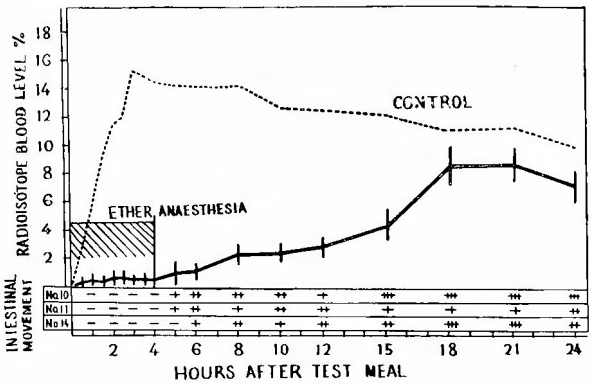
Intestinal movements were observed in case No. 10, No. 11, as follows:

Hours after test meal	Gastrointestinal movements
4. 0′	Tonus of the stomach and intestine were not observed. Gastrointestinal movements not yet recovered.
4.10′	The gastric movement did not observed, but intestinal strain was recovering.
4.18′	Gentle peristaltic waves of the intestine were observed in No. 11.
4.22′	No. 11, began to bark No. 10, Gentle peristalsis of the intestine was observed. Gastric tonus was observed.
4.30′	Gastric peristalsis, No. 10, 4; No. 11, 5. Gentle peristaltic waves of the intestine were observed distinctly.
5. 0′	Intestinal peristalsis No. 10, 7; No. 11, 6
6. 0′	〃 〃 No. 10, 11; No. 11, 9-11
8. 0′	〃 〃 No. 10, 12; No. 11, 7

Thereafter, the intestinal peristalsis in both No. 10 and No. 11 became vigorous gradually as shown in Fig. 7. Gastric movement two hours after the discontinuance of anesthesia could not observed, because the stomach rose upward and outward from the view through the abdominal window due to the increase of the gastric tonus.

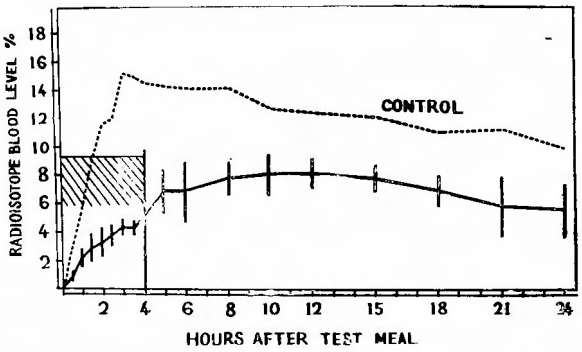
b) The intestinal absorption when the test meal was ingested directly into

Fig. 7 Absorption from the gastrointestine under ether anesthesia and the gastrointestinal movements



Average curve of control is broken line at points indicated.

Fig. 8 The intestinal absorption when the test meal was ingested directly into the duodenal canal during the maintenance of anesthesia



Average curve of control is broken line at points indicated.

the duodenal canal during the maintenance of anesthesia

When the depth of the ether anesthesia by OMBREDANNE'S mask entered into the third stage, the local incision was done and the test meal was ingested into the duodenal canal by the tube in the same way as described above.

The radioisotope blood levels of this experiment was shown in Fig. 8. After the ingestion of the test meal, some degree of the absorption was observed during the four-hour period of anesthesia, and, after the discontinuance of anesthesia, the radioisotope blood level recovered gradually as similar as in the case when the test meal was ingested into the stomach during the anesthesia, but its level is lower than the normal controls.

II. ABSORPTION AFTER GASTROJEJUNOSTOMY AND THE GASTROINTESTINAL MOVEMENTS

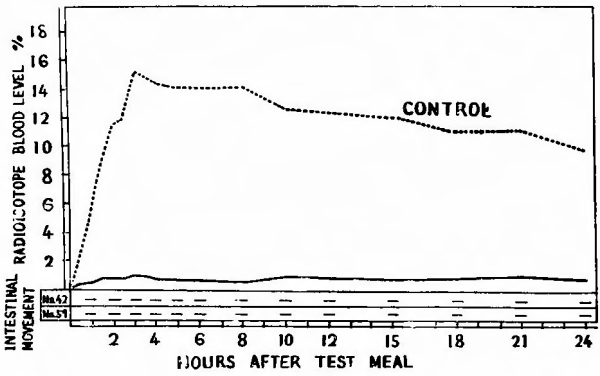
Gastrojejunostomy was performed under ether anesthesia. The stomach and the first portion of duodenum were mobililized, and the latter was divided from

the stomach by clamps, and the duodenal stumps was closed. The jejunum was anastomosed to the anterior wall of the stomach. Then, BROWN's entero-entero anastomosis was added. At the end of the operation, the abdominal window was arranged to observe the gastrointestinal movements under the direct vision.

A. Absorption immediately after gastrojejunostomy, and the gastrointestinal movements.

When the dog awaken from the anesthesia, 100 μc of the radioactive iodocasein was ingested through stomach tube. The gastrointestinal movements were not seen for twenty-four hours. The absorption was little as shown in Fig. 9. The detailed experimental data are shown in Tabie 1.

Fig. 9 Absorption immediately after gastrojejunostomy and the gastrointestinal-movements



Average curve of control is broken line at points indicated.

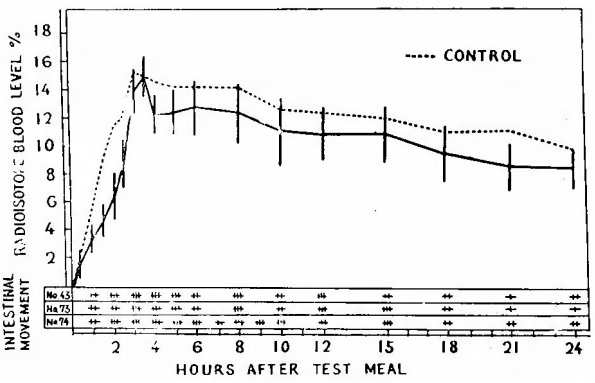
Table 1. The radioisotope blood level (%) immediately after the gastrojejunostomy

Dog No. / Sex & Weight / Time	42	49	59
	♀, 10 kg.	♂, 9.5 kg.	♀, 9.5 kg.
5′	0.2	0.1	0.3
10′	0.3	0.4	0.5
15′	0.4	0.2	0.7
30′	0.9	0.2	0.7
1. 0′	0.7	0.4	0.7
1.30′	1.3	0.3	1.0
2. 0′	0.8	0.6	0.8
2.30′	0.6	0.7	0.8
3. 0′	1.4	0.7	1.1
3.30′	1.2	0.7	1.3
4. 0′	0.9	0.5	1.0
5. 0′	0.9	0.6	1.0
6. 0′	1.0	0.4	0.7
8. 0′	1.0	0.5	0.8
10. 0′	1.6	0.5	1.1
12. 0′	1.4	0.4	0.9
15. 0′	1.3	0.3	0.6
18. 0′	1.3	0.4	0.7
21. 0′	2.0	0.3	0.5
24. 0′	1.6	0.3	0.5

B. The absorption and the gastrointestinal movements 3 weeks after the gastrojejunostomy

Water was given from the first operative day and milk and liquid diet were given for 4 days postoperatively, and then porridge and soft meal were given, thereafter, and continued until the test was undertaken three weeks after the operation. The test meal was ingested by the tube and the intestinal movements were observed through resin abdominal window through which the peristaltic movements were observed significantly. These results are shown in Fig. 10 and Table 2.

Fig. 10 Absorption and the intestinal movements three Weeks after the gastrojejunostomy



Average curve of control is broken line at points indicated.

Table 2 Radioisotope blood level (%) and the gastrointestinal movements 3 weeks after the gastrojejunostomy
Dog No. 43, 우, Weight 11.4 kg.

Hours after test meal	Radioisotope blood level (%)	Gastrointestinal movements (frequency/min.)
5′	0.7	Peristaltic wave 7
10′	0.9	I. M. 6-8
15′	0.8	G. P. 3
30′	1.6	I. M. 7
1. 0′	2.3	I. M. 7-10
1.30′	4.1	I. M. 9-11
2. 0′	5.6	I. M. 14; G. P. 3
2.30′	7.9	I. M. 14
3. 0′	12.8	I. M. 12-14
3.30′	14.0	I. M. 15; G. P. 5
4. 0′	12.7	I. M. 12-14
5. 0′	12.1	I. M. 11-13
6. 0′	11.8	I. M. 9; G. P. 4
8. 0′	12.4	I. M. 12
10. 0′	10.2	I. M. 8-10
12. 0′	10.7	I. M. 10-12
15. 0′	10.1	I. M. 9
18. 0′	9.5	I. M. (gentle) 8-9
21. 0′	8.7	I. M. 6
24. 0′	9.2	I. M. (gentle) 7-9

I. M. = Intestinal Movements G. P. = Gastric peristalsis

Adhesion of the intestine and the peritonitis were not observed through the

resin abdominal window during the test-period.

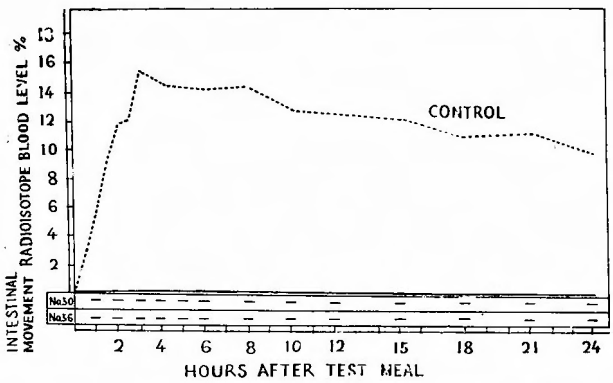
III. THE ABSORPTION AFTER GASTRECTOMY

Gastrectomy of POLYA type was performed under ether anesthesia. Three-fifths of the stomach was resected and the continuity was re-established by end to side anastomosis between the remaining part of the stomach and the jejunum. And BROWN's entero-entero anastomosis was added.

A. Absorption immediately after gastrectomy, and the gastrointestinal movements.

When the dog awaked from the anesthesia, the test meal was ingested. Intestinal tonus was decreased and the movement was absolutely absent. Stomach went

Fig. 11 Absorption immediately after the gastrectomy and the gastrointestinal movements



Average curve of control is broken line at points indicated.

Table 3 Radoisotope blood level (%) following gastrectomy

Dog No.	50	56	60
Sex & Weight	♀, 9.5 kg.	♀, 8.5 kg.	♂, 9.2 kg.
Time			
5′	0.06	0.09	0.08
10′	0.05	0.12	0.04
15′	0.04	0.08	0.05
30′	0.15	0.15	0.10
1. 0′	0.09	0.20	0.16
1.30′	0.13	0.23	0.18
2. 0′	0.14	0.18	0.15
2.30′	0.10	0.25	0.22
3. 0′	0.20	0.21	0.17
3.30′	0.14	0.17	0.17
4. 0′	0.13	0.23	0.23
5. 0′	0.14	0.16	0.20
6. 0′	0.10	0.20	0.25
8. 0′	0.10	0.20	0.19
10. 0′	0.10	0.17	0.17
12. 0′	0.06	0.23	0.21
15. 0′	0.08	0.19	0.16
18. 0′	···	0.15	0.14
21. 0′	0.05	0.09	0.08
24. 0′	0.10	0.12	0.10

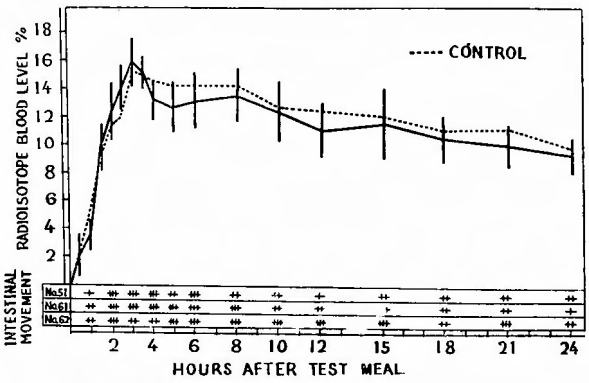
up outside from the resin window and could not observed under vision. The radioisotope blood levels were no more than about 0.2%. The results are shown in Fig.

11 and Table 3.

B. The absorption and the gastrointestinal movements three weeks after the gastrectomy

Selecting the dog which operative course was excellent, the abdominal resin window was attached three weeks after the former operation. Peritoneal adhesion, exudation and/or any sign of the inflammation were not observed through the resin window. The stomach could not be observed as it was out of the sight from the window. Intestinal movements were vigorous. The results are shown in Fig. 12 and Table 4.

Fig. 12 Absorption and the intestinal movements three weeks after the gastrectomy



Average curve of control is broken line at points indicated.

Table 4 Radioisotope blood level (%) and the intestinal movements three weeks after the gastrectomy

Dog No.	51		61	
Sex & Weight	♀, 10.4 kg.		♀, 12.3 kg.	
Time	Blood level(%)	I. M.(frequency/min.)	Blood level (%)	I. M.(freq/min.)
5′	0.8	A, 5–6	0.4	A,7
10′	1.8	Tonus(+)	1.1	A, 6–7
15′	2.9	A, B, 6	1.3	A, 7; B, 5
30′	4.6	A, 8; B, 6	3.6	A, 8; B, 5
1. 0′	11.8	A, B, 6-8	6.3	A, 9
1.30′	14.5	A, 12	11.4	A, 12-14
2. 0′	17.2	A, 14; B, 12	14.4	A, B, 12
2.30′	15.6		15.5	A, B, 14-16
3. 0′	17.5	A, B, 12-14	15.5	A, 12;B, 13
3.30′	15.8	A, 11; B, 14	16.2	A, 13; B, 13
4. 0′	13.2	B, 14	14.7	A, 12; B, 11-13
6. 0′	15.6	A, B, 11-14	17.1	A, 14; B, 12
8. 0′	13.4	A, 11	16.5	A, 15; B, 11
10. 0′	11.4	A, 10; B, 11	14.6	A, 12-13; B, 10
12. 0′	9.3	A, 9 (gentle)	13.3	A, 12; B, 11
15. 0′	11.6	B, 11	14.3	A, B, 10-11
18. 0′	9.2	A, B, 9-11	12.1	A, 11; B, 10
21. 0′	8.6	B, 9-10	8.9	B, 8-10
24. 0′	9.2	A, 8; B, 9-10	8.1	A, 7; B, 11

I. M. : Intestinal Movements

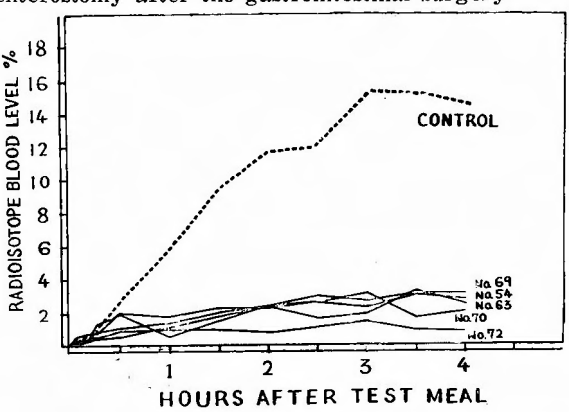
Point A. { No. 51 : 70 cm. distal from the TREITZ's ligament
No. 61 : 77 cm. distal 〃 〃

Point B. { No. 51 :120 cm. distal from the TREITZ's ligament
No. 61 :130 cm. distal 〃 〃

IV. THE EXPERIMENT ON THE ABSORPTION WHEN THE TEST MEAL WAS INGESTED DIRECTLY INTO THE SMALL INTESTINE THROUGH WITZEL'S ENTEROSTOMY AFTER THE GASTROINTESTINAL SURGERY AND THE INTESTINAL TRANSIT

Gastrectomy was performed in five cases and gastrojejunostomy was performed in six cases. WITZEL's enterostomy were performed at the distal part of about 75 cm from the TREITZ's ligament in all cases, from which a No. 14 catheter with one or two lateral opening near the end was inserted. The catheter was partly buried in a tunnel in the intestinal wall, and a small opening was made just proximal to this for its insertion into the gut, through which the catheter was inserted and brought out of the abdominal wall. The test meal was ingested through this catheter 2 or 5 hours after the operation. The observation was continued for 4-5 hours. Phenol red was used as marker. The dog was slaughtered by strychinin immediately after the experiment and the distribution of phenol red in the intestinal tract was observed to evaluate the intestinal transit.

Fig. 13 Absorption when the test meal was ingested directly into the small intestine through WITZEL's enterostomy after the gastrointestinal surgery



Average curve of control is broken line at points indicated.

To summarize the results of the experiments in this section, the detail of the several cases are presented here.

Dog. No. 72, ♀, Weight 9 kg.; Gastrectomy, BROWN's entero-entero anastomosis and WITZEL's enterostomy were performed as above mentioned.

Test meal with a marker was ingested three hours afterwards.

Hours after test meal	Radioisotope blood level (%)
5′	0. 4
10′	0. 5
15′	0.55
30′	0.94
1. 0′	0.96
1.30′	0.99
2. 0′	0.77
2.30′	1.13
3. 0′	1.39
3.30′	0.87
4. 0′	0.79

Autopsy findings: Phenol red was distributed so extensively along the intestinal wall to reach the point of about 34 cm distal from the enterostomized portion, which was 10 cm bellow the BROWN's entero-entero anastomosis.

Dog. No. 54, ♀, Weight 8.8 kg.; Test meal with a marker was ingested five hours after the gastrectomy and the WITZEL's enterostomy.

Hours after test meal	Radioisotope blood level (%)
5′	0.42
10′	0.31
15′	1.31
30′	1.87
1. 0′	0. 5
1.30′	1.46
2. 0′	2.32
2.30′	2.58
3. 0′	2.25
3.30′	3. 0
4. 0′	2.71

Autopsy findings; The phenol red in the intestine was distributed until 42 cm below the enterostomized portion. The barking and bodily movement were energetic, and the respiration of the abdominal type was recognized apparently.

Radioactive blood levels of the five cases in which gastrectomy and WITZEL's enterostomy were performed were not over 3% during four hour-period.

Dog. No. 70, ♀, Weight 10.2 kg.

No, 69, ♂, Weight 8.2 kg.

Gastrojejunostomy, BROWN's entero-entero anastomosis and WITZEL's enterostomy were performed. Test meal with a marker was ingested one hour afterwards.

Hours after test meal	Radioisotope blood level	
	No. 69	No. 70
5′	0.38	0.71
10′	0.45	0.73
15′	0.87	0.80
30′	1.09	1.93
1. 0	1.33	1.73
1.30′	1.92	2.21
2. 0′	2. 4	2.23
2.30′	2.29	2.60
3. 0′	2.69	3. 2
3.30′	3.08	1.52
4. 0′	3.14	1.97

Autopsy findings: The distance of the distribution of the phenol red bellow the enteromized point in the intestine after four hours was 34 cm. and 47 cm. respectively in the dog No. 69 and No. 70.

Dog. No. 63, ♀, Weight 8.7 kg.

Test meal was ingested two hours and a half after the gastrojejunostomy and the WITZEL's enterostomy.

The dog No. 63 was attached with the resin abdominal window through which weak peristaltic wave was observed 3-4 times per minutes after one hour and forty-five minutes from the ingestion, but such movement continued for only about four minutes.

Hours after test meal	Radioisotope blood level (%)
5′	0.18
10′	0.33
15′	0.45
30′	0.55
1. 0′	1.17
1.30′	1.78
2. 0′	2.25
2.30′	1.63
3. 0′	1.91
3.30′	3.24
4. 0′	2.59

DISCUSSION

The problemof absorption in the gastrointestinal tract has been already discussed by many authors, however, few report has appeared to date concernig the studies of protein absorption evaluated successively. BAYLIN, SHINGLETON, and others [8] studied the mode of absorption on the healthy men and dogs for six hours successively, using the radioactive iodohumanserum albumin. According to their data, the radiosotope blood level was maximum at 2 hours after the ingestion of the test meal. Using radioactive iodocasein in normal condition of dogs, the radioisotope blood level reached maximum 3 hours after the ingestion as described above. These data were nearly the same with those of SHINGLETON. The periodic difference on the curve between these two, in spite of the results from the similar method, would be the differece between the test meals used.

On the absorption from the stomach, ASANO[1] reported that the absorption of P^{32} was very slight, however, HEVESY[20] and WATANABE[2] described that Na^{24} was absorbed in large quantities. As to the absorption of protein from stomach, SHINGLETON and others reported that the absorption of radioactive iodohumanserum albumin was absolutely absent during the observation of several hours. In our test, the absorption of radioactive iodocasein was also few during 24 hours.

It has been proved that iodine is absorbed from the stomach as well as alcohol and natrium, even though its quantity is not so much as compared to the latter. When the mixed solution of the carrier-free iodine and the casein was ingested into the stomach which was occluded at the pyloric portion, the radioisotope blood level was 3.3% after one and a half hours. This value was relatively high, compared with the fact that the absorption of radioactive iodocasein alone from the stomach was below 0.5%. There are certain difference between the absorption of radioactive iodocasein and that of the mixture of the radioactive iodine and the casein. Therefore, it is considered that the radioactive iodocasein is not hydrolized easily to the carrier-free iodine and casein in the stomach, and that the I^{131} in the radioactive iodine labeled casein is attached to the molecule of casein not so loosely, but closely with some of the amino-acids in casein. In accordance with the studies of MUTZENBECHER,[21] it is proved that the added iodine acts upon tyrosine in casein, converting it to diiodo-L-tyrosine. Thereafter, REINKE and TURNER[22] studied on the same subject in detail. Furthermore, in 1949, the study of the radioactive iodocasein and diiodo^{131}-L-tyrosine was carried out by HAMILTON,[23] LEMMON, KENNETH and SCOTT.[24] It is considered that, when the radioactive iodocasein is ingested

into the gastrointestinal tract, it is decomposed into the amino-acids and the radioactive iodine is absorbed as the form of radioactive diiodo-L-tyrosine.

It has been generally known that the protein is broken down into amino-acids by the action of digestive enzymes in duodenum and then absorbed. When the test meal was ingested directly into the duodenum which was exposed by laparotomy under local anesthesia, the radioisotope blood level rose quickly; i. e., its level reached maximum at 2 hours after ingestion of the test meal, about one hour faster than normal control. It is easily understood from the marked difference between the absorption from the stomach, duodenum and small intestine that the transportation of the gastrointestinal contents, or in other words, the gastrointestinal movement is one of the most important factors for the absorption.

As described above, it was demonstrated that the absorption of protein indicated the distinctive curve at each region in the gastrointestinal canal, and moreover, there are a marked difference on the speed and the rate of the absorption at each region.

The absorption of protein is influenced not only by the gastrointestinal movement but also many factors such as temperature, blood circulation, hydrogen ion concentration, the excreation of digestive juices, enzyme activities and so on.[25)26)27)] It is not yet clearly understood that how influence these factors on the vital functions of the intestinal mucosa, but it is considered that the absorption of protein is based on the decomposition into the amino-acids and the special vital functions of the intestinal mocosa. It was also demonstrated that the absorption of protein in both the normal control and the duodenum were disturbed by 0.01 mol of monoiodoacetic acid which belongs to the alkylating agents as the impediment agent for the enzymes. It will be easily understood that, not only the smooth transportation of gastrointestinal contents but also the action of enzymes, and moreover, some vital functions of the mucous membrane of the gastrointestine are indispensable for the absorption of nutrition by reason of the fact that the absorption is disturbed by the agent in spite of the presence of the marked gastrointestinal movements.

Monoiodoacetic acid was examined by Asano and Watanabe to observe the influences of it upon the absorption, but the influence of the monoiodoacetic acid itself against the gastrointestinal movement was not observed. The frequency of the intestinal movement was not affected by the use of 0.01 mol of the monoiodoacetic acid. The movements of upper intestinal canal were vigorous and the contraction was strong at the early stage, and then the movements of the lower intestinal canal became vigorous after 20 minutes. This is because that the transportation of monoiodoacetic acid alone is much faster than casein owing to its fluidity. In addition, even if the denaturation action of the monoiodoacetic acid upon the intestinal mucosa would be undeniable, such influence would be not so serious because of the dilution by intestinal secretion.

In regard to the influence of the general anesthesia by ether upon the absorption, Hamada[28)] reported that the absorption of glucose was not influenced, and also, Watanabe reported the facts that the influence of ether anesthesia was not observed on the absorption of Na^{24}. While, Asano reported the experimental results

that the influence of ether anesthesia on the absorption of P^{32} was so manifest that its absorption was almost absent during anesthesia, and after the discontinuance of anesthesia, its absorption recovered to the normal level quickly. When the radioactive iodocasein was ingested in the duodenal canal, a little absorption was observed during anesthesia, but, when the test meal was ingested in the stomach, its absorption was very little and its radioisotope blood level was below 1%. As ASANO's report, the gastrointestinal movement stops and the content of stomach is stagnant duing the anesthesia, and for that reason the contents was impeded the touch with the surface of mucosa. These are founded on the fact that the radioisotope blood level rises gradually with the recovery of movement after the suspension of ether anesthesia; i. e. the gentle irregular contraction arises after the suspension of ether general anesthesia and, then, the movement returns to normal by degrees. It would be considered that the long delay of the absorption of casein, in spite of the quick recovery of the intestinal movements, is not only because of its large molecules, but also because of these factors such as the slow recovery of the secretion of the digestive juice, impeded regional circulation, the activity of emzymes and the physiological functions of the intestinal mucosa and so on.

In 1934, TANAKA represented the gastrointestinal movements after the gastrointestinal operation. Recently, ASANO reported that P^{32}, indicated with fuchsin or methylen blue, did not reached until the ileocecal region at 24 hours after operation. From the result observed directly through the abdominal resin window immediately after the operation, both peristalsis and the rythmic segmentation were not recognized except the pendular movement of the intestine, and the fall of the intestinal tonus, with the congestion of the intestinal wall, was remarkable.

Absorption after the gastrojejunostomy or the gastrectomy (polya type) is very poor, when the radioactive iodocasein was used as a test meal and the recovery of the gastrointestinal movement is very late as mentioned above. These would be easily understood from this fact that both anesthesia and the operative invasion give the influence on the vital functions of the subject. From this standpoint, by the intake of protein with 24 hours after operation, it is difficult to expect the good nutritional effect.

Recently, MÜLLER-ABBOTT's double tube was applied clinically for the ingestion of carbohydrate and protein solution after 4-5 hours of the gastrointestinal operation. But, such problem should be investigated furthermore considering these experimental results.

The absorption and the intestinal movement 3 weeks after the gastrointestinal surgery were recovered to normal almost completely.

The values of blood radioisotope content in the cases of gastrojejunostomy with WITZEL's enterostomy, through which the test meal was ingested, are somewhat higher, but not so much, compared with those of gastrectomy with WITZEL's enterostomy. This difference may be owe to the grade of the operative invasion against the subjects and the lengths of time needed for operation. Absorption in the cases of gastrointestinal operation (gastrojejunostomy or gastrectomy) with WITZEL's nutritional enterostomy is better than that of gastrointestinal operation

alone, in which the test meal was ingested in the stomach immediately after operation.

CONCLUSION

The absorption of protein and the gastrointestinal movement after the gastrointestinal surgery was investigated, using the abdominal resin window and radioactive iodocasein, and also the relation between them was studied.

1) When the test meal was ingested into the empty stomach of the healthy dogs, the absorption after 3 hours showed maximal radioisotope blood level.

2) The absorption of radioactive iodocasein from the stomach was almost absent, but the absorption following the ingestion of the test meal directly into the duodenum was very excellent.

3) The gastrointestinal movement was hardly influenced by 0.01 mol solution of the monoiodoacetic acid, but the absorption of radioactive iodocasein was disturbed below 50%, compared with the normal control.

4) The gastrointestinal movement was not seen during the general anesthesia and the radioisotope blood level was also very low. The recovery of the absorption after the discontinuance of anesthesia was slower than the recovery of the intestinal movement.

5) The normal gastrointestinal movement was not seen immediately after the gastrojejunostomy or gastrectomy and the absorption of the radioactive iodocasein was little. The influence of the gastrointestinal operation upon the protein absorption was great.

6) After 3 weeks from the gastrojejunostomy or gastrectomy, the gastrointestinal movement recovered almost to the normal condition and the radioisotope blood level showed almost normal curve.

7) When the gastrointestinal operation with WITZEL's nutritional enterostomy was performed, the absorption was somewhat better than that of the gastrointestinal operation alone.

8) There is the correlation between the gastrointestinal movement and the absorption of protein.

The main points of this study was reported at 57th annual meeting of the Japanese Surgical Society and at the 43th and 44th annual meeting of the Japanese Gastro-enterological Society.

Acknowledgement. The author will express here his appreciation to Dr. TAKAMITSU SEKINE of JUNTENDO University for his kind advice and encouragement.

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筋注用

アモバルビタールナトリウム

イソミタールMは　イソミタールソーダ（国民医薬品集アモバルビタールナトリウム）に特殊な水溶剤を加えて安定とし　かつ注射時の疼痛をなくするため　ベンジルアルコールを加え無痛化した少容量の筋注用製剤である。

Isomytal

M

健保新適用　筋注6点

〔適応症〕

各種原因の不眠症。神経衰弱。ヒステリー　緊張症　恐迫神経症。神経過敏症興奮症。心的疲労復旧並びに気分転調。手術後の不安・緊張・疼痛・苦悶。

〔包　装〕

注射液＝（1 cc—0.1g）5.A，10A，50A

筋注用　催眠鎮静剤

イソミタールM注

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和 文 抄 録

放射性ヨードカゼイン使用に依る胃腸手術後の胃腸運動と蛋白吸収との関係に就いての実験的研究

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内 藤 芳 徳

胃腸手術後の吸収は，術後栄養の問題と関連し，特に手術後蛋白の吸収に就いては術後処置の中で最も重要なものの一つとされている．

成犬を用い，放射性ヨードカゼインを使用して蛋白吸収を追求し，併せて腹窓を着装して胃腸運動を観察して，その吸収と胃腸運動との関係に就いて研究を行い，次の如き実験成績を得た．

1) 正常空腹時に於ける放射性ヨードカゼインの吸収は，胃内注入後3時間で最高値を示した．

2) 放射性ヨードカゼインの胃からの吸収は殆んど無く，一方十二指腸内に直接注入せる場合著明な吸収を認めた．

3) 胃腸運動は0.01モルのモノヨード醋酸に依り殆んど影響されない．然し，放射性ヨードカゼインの吸収は，正常に比して約50%の抑制を示した．

4) エーテル全身麻酔中胃腸運動は停止し，血中アイソトープ値も甚だ低い．麻酔中止時，吸収の回復は胃腸運動の回復より遅延を示した．

5) 胃腸吻合術或は胃切除術の直後，正常胃腸運動は認められず，吸収も殆んど無い．

6) 胃腸吻合術或は胃切除術より3週間経過後では胃腸運動は殆んど正常に回復し，血中アイソトープ値も殆んど正常値を示した．

7)胃腸手術（胃腸吻合術又は胃切除術）とウィッツエルの栄養瘻を造設せる場合，その吸収は胃腸手術のみの場合より幾分良好であつた．

8) 胃腸運動と蛋白吸収との間には，相関がある事を知つた．