

A RADIOGRAPHIC STUDY OF THE EFFECT OF  
FOOD, EXERCISE, AND TRANQUILIZERS ON  
GASTROINTESTINAL MOTILITY OF THE CANINE

by

JOHN DAVID RHOADES

B.S., University of Missouri, 1958  
D.V.M., University of Missouri, 1961

---

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Surgery and Medicine

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

1964

Approved by:

  
Major Professor

LD  
268  
T4  
1964  
147  
C2  
FIRST WAVE

TABLE OF CONTENTS

INTRODUCTION ..... 1

REVIEW OF LITERATURE ..... 3

    The Stomach ..... 3

    Effects of Drugs ..... 6

    The Small Intestine ..... 7

    Contrast Agent ..... 8

MATERIALS AND METHODS ..... 9

    Experimental Animals ..... 9

    Contrast Agent Used ..... 9

    Procedure ..... 10

    Film Processing ..... 12

    Radiographic Technique ..... 13

    Radiographic Equipment Used ..... 14

    Tranquilizer ..... 15

RESULTS AND DISCUSSION ..... 15

    Total Number of Radiographs ..... 15

    Emptying Time of the Stomach ..... 16

    The Small Intestine ..... 20

    Entrance Time into the Colon ..... 22

    Comparison of the Series ..... 25

    Effects of Tranquilizer ..... 29

SUMMARY ..... 30

ACKNOWLEDGMENTS ..... 34

LITERATURE CITED ..... 35

APPENDIX ..... 37

## INTRODUCTION

Radiography of the alimentary tract of the canine is one of the important diagnostic aids in small animal medicine. The lack of contrast with surrounding soft tissues and the inability to define the structures clearly has led to the use of contrast agents which improve radiographic detail.

The passage of a contrast agent through the alimentary tract is a dynamic process. The ideal method of study would be the ability to observe the passage of the contrast agent as it is taking place. This can be accomplished by means of a fluroscopic examination. Materials used in fluroscopy, while adapted for use in man, are not always effective in outlining the alimentary tract of the canine. For instance, the contrast agent used to outline the esophagus in man may stay in that structure for 10 minutes, (Douglas and Williams, 1963), thus allowing for time to observe the structure completely. In dogs the material passes rapidly through the esophagus being retained only in the grossly abnormal patients. The major objection to the use of fluroscopy in the canine is the inadequacy of safety measures. Man is a co-operative patient and this allows for a much safer procedure both for the patient and the operator. In order to insure complete safety to the veterinary radiologist and surgeon, the patient would have to be anesthetized. The administration of the contrast agent to the anesthetized patient would then be a difficult procedure. Complete lead shielding as well as lead-glass shielding and proper equipment are absolutely necessary for

fluroscopic examinations. Since it is difficult for most establishments to meet these requirements, fluroscopy is not widely used.

In Veterinary Medicine the usual procedure is the use of x-ray producing equipment with the exposure and development of film. The questions which arise are how soon after the administration of the contrast agent should films be exposed and what length of time should be allowed between exposures to best reveal the activity of the stomach and intestines. Additional information is needed as to the effects of food, exercise, and certain drugs on the movement of the contrast material through the digestive tract. Recommendations vary as to when the films should be taken following administration of the contrast agent. It has been recommended that films be exposed at 5 minutes, 30 minutes, 90 minutes, and 4 hours (Douglas and Williamson, 1963). Carlson (1961) suggests that exposures should be made at 2 to 4 hour intervals until the contrast agent has reached the colon. Schnelle (1950) indicates the stomach to be empty from 3 to 7 hours post administration. These variable opinions indicate guides or procedures for the veterinary radiologist to follow comparable to those used in human medicine are lacking in veterinary medicine. The purpose of this study is to attempt to formulate a set of standards to be used in the study of the alimentary tract of the canine.

If this stated objective can be accomplished, it will enable the veterinary radiologist to budget the use of his equipment and time in producing a timely and correct diagnosis.

## REVIEW OF LITERATURE

## The Stomach

The empty stomach is completely hidden from palpation and observation by the liver and diaphragm cranioventrally and the intestinal mass caudally (Miller, 1955). According to Schnelle (1950) the stomach is located on a plane extending from the level of the 9th or 10th rib posteriorly. A small part lies in apposition to the diaphragm. The greater curvature parallels the 12th rib. It lies almost entirely to the left of the median plane (Miller, 1955). The pyloric portion runs from left to right (Schnelle, 1950). During the process of filling, the fundus expands at a more rapid rate than any other part thus the organ rotates in a ventrocaudal direction (Miller, 1955). The extremities of the stomach, pylorus and cardia, move the least (Miller, 1955).

Gastric emptying is thought to be dependent on the pressure gradient within the stomach and the relaxation of the pylorus (Jamieson and Kay, 1959). Two factors contributing to the pressure is the over all tonus of the gastric muscle and the intra-antral local pressure developing in front of the advancing peristaltic wave. Most authors accept the verdict that the pressure changes resulting from antral peristalsis are the chief causes of gastric emptying (Jamieson and Kay, 1959). Measurement of intralumen pressures in the area of the pylorus has revealed that the basal pressure of the pyloric antrum usually exceeds the basal pressure of the duodenal bulb (Brody, Werle, Mechan, and Quigley, 1940).

According to the laws of hydraulics, materials in the stomach tend to move from a region of higher intraluminal pressure to a region of lower pressure (Werle, Brody, Ligon, Read, and Quigley, 1940). This is accomplished in two phases. The first phase is evacuation of the stomach. The second phase shows the evacuation still persisting until the intra-antral pressure is terminated or the pyloric sphincter is closed.

It has been demonstrated that fats inhibit the activity of the stomach. Quigley, et. al., (1941), demonstrated that fats when fed to dogs inhibit the activity of the antrum, sphincter, and duodenal bulb. Cream with a 25-30% butterfat content was used in 75 dogs. Egg yolk which contained approximately 33% lipids was used in 10 dogs. Inhibition started in 1.5 to 2 minutes and was complete in 4 minutes in the antrum and sphincter. Recovery usually began in 15 minutes and was complete in 20 minutes. It was shown that greater amounts of lipids prolonged the effects so that complete recovery was delayed as long as 30 minutes. However, when barium sulfate was added to cooked cornmeal<sup>1</sup> and given via a gastric cannula (Quigley, et. al., 1941), evacuation of the stomach frequently began during the feeding phase.

Recent observations have shown that the inhibitory effect only occurs when the fat comes in contact with the mucosa of the upper small intestine (Jamieson and Kay, 1959). It is postulated that the fat causes the release of an "inhibitory hormone" chalone. Olive

---

<sup>1</sup>25 grams of cornmeal and 80 grams of BaSO<sub>4</sub> with q.s. water to make 500 cc.

oil was found to inhibit gastric motility for as long as 2 hours when given on an empty stomach. Fried fats which are altered by heat may cause increased gastric motility and cause pain increase in the presence of gastric ulcers (Jamieson and Kay, 1959).

According to Schnelle (1950) starches leave the stomach faster than meat and ground meat leaves faster than large pieces of meat.

Gastric discomfort occurs only when the distention pressure of the stomach greatly exceeds the physiological limits (Jamieson and Kay, 1959). A sense of repletion and fullness may come from the fullness of other visera and the belly as a whole. Radiological examination of the stomach indicates it to be more active when full and less active when empty.

The passage of a contrast agent through the pylorus may be delayed for several hours in nervous dogs (Douglas and Williamson, 1963). According to Golden (1941) rats resisting examination revealed an erratic pattern and later without resisting revealed normal patterns. Holmes and Ruggles (1937) found the normal emptying time of the stomach of the adult human varies from 3 to 6 hours. Schnelle (1950) indicates that in the canine emptying begins 5 to 10 minutes after the intake of food and begins to subside in 2 hours with the stomach empty in 3 to 7 hours.

Sympathetic innervation of the stomach is now believed to have little influence on gastric motility except indirectly by altering blood flow (Jamieson and Kay, 1959). Injected adrenalin or sudden fright briefly arrests gastric movements. Vagotomy results in gastric retention.

## Effects of Drugs

Epinephrine intravenously promptly inhibits the movement of the stomach and intestine (Jones, 1959). The walls of the intestines relax but the alimentary tract sphincters constrict retarding the movement of the ingesta.

The use of adrenergic blocking drugs permits the parasympathetic innervation of the gastro intestinal tract to predominate resulting in increased motility (Jones, 1959).

Parasympathomimetic drugs greatly increase the activity of the gastro-intestinal tract (Jones, 1959). Parasympatholytic drugs such as atropine will block the action of the parasympathomimetic drugs on the gastro-intestinal tract but will not completely inhibit the action of the vagus nerve.

The phenothiazine derivative tranquilizers possess inhibitory action on the gastro-intestinal tract (Irwin, 1958). They have a greater effect on vomiting of infectious or chemical origin. The action is produced by blocking the chemoreceptor trigger zone located on the floor of the 4th ventricle which has a direct connection with the vomiting center of medulla.

The primary site of action of opium and its derivatives is the central nervous system (Jones, 1959) and the secondary site is the smooth muscle primarily of the intestinal tract. The propulsive action or motility of the entire tract is markedly depressed, thus delaying the passage of food and resulting in a constipating effect.



## The Small Intestine

The loops of the small intestine occupy the ventrocaudal portion of the abdominal cavity when the other hollow visera are relatively empty (Miller, 1955). The duodenum is the most fixed part of the small intestines; beginning at the pylorus it runs dorsocranial for a short distance, then continues caudoventrally (Miller, 1955). Caudally the duodenum turns upon itself running cranial toward the stomach where it joins the jejunum (Miller, 1955). The jejunum and ileum form the bulk of the small intestine and are arranged in numerous loops and coils of no definite pattern (Miller, 1955).

There are several different types of movement in the intestinal tract (Dukes, 1955). Their total effect produces a mixing function, brings contents in contact with mucous membranes for absorption, and moves food from place to place in the bowel.

The small intestine exhibits a well-marked gradient of activity as it is traced from the duodenum to the caecum and colon (Jamieson and Kay, 1959). Two types of movement, rhythmic segmentation and peristalsis, are exhibited. Rhythmic segmentation is characterized by a series of constriction rings which perform a kneading and mixing function. This rarely occurs in the duodenum. Peristalsis is characterized by a traveling constriction ring always moving in a cranio-caudad direction. Reverse peristalsis does not occur in health but does occur in nausea and vomiting.

The time taken for a contrast agent to pass through the small intestine and reach the large bowel may vary from 2 to 12 hours (Douglas and Williamson, 1963). In the human it has been shown

that food traverses the small intestine in 8 to 12 hours (Jamieson and Kay, 1959). High residue diets tend to pass more rapidly where low residue diets tend to move slower.

The normal shadow of the small intestine is usually continuous and the lumen is even in width except where a contraction happens to be taking place (Golden, 1941). The peristaltic constriction rings are usually short and the intestinal wall promptly relaxes behind them.

#### Contrast Agent

In radiography and fluroscopy of the gastro-intestinal tract, the basic opaque agent is barium sulfate (Files, 1956). Bismuth (Schnelle, 1950) can also be used but does not outline the wall of the intestinal tract as well as barium sulfate.

Barium sulfate U.S.P., is a fine white bulky powder not absorbed from the intestinal tract (Jones, 1959). Barium is obtained by precipitation from barite, vacuum dried, and pulverized to produce a fine, white substance of a molecular weight of 233 (Files, 1956).

Barium sulfate can be mixed with specially processed cereals (flavored with vanilla or chocolate) in order to more nearly approximate the normal motility of food taken into the stomach (Files, 1956).

In the average sized dog weighing from 25 to 30 pounds about 5 to 25 grams of barium sulfate mixed with water to the consistency of cake frosting should be used (Carlson, 1961).

According to Seward (1951) the use of a cold mixture will

result in increased peristalsis and thus produce movement through the intestinal tract at a more rapid rate.

## MATERIALS AND METHODS

### Experimental Animals

Eight dogs were used in the investigation. There were 7 females and 1 male in the group. Two Beagles were aged, 2 were approximately 1 year of age, and the remaining 4 were  $4\frac{1}{2}$  months old and litter mates.

The dogs were numbered consecutively from 1 through 8. Dogs number 1 and 2 were mixed breeds, number 3 and 4 were aged Beagles, and numbers 5, 6, 7, and 8 were the  $4\frac{1}{2}$  month old litter mates. Dog number 1 weighed 23 pounds; number 2, 21 pounds; number 3, 39 pounds; number 4, 32 pounds; with the remaining 4 weighing an average of 14 pounds each.

The dogs were kept in wards 5 and 6 of Dykstra Veterinary Hospital.

The 2 aged Beagles had prominent mammary tumors present. Dog number 8 was affected with chorea as a result of having had canine distemper.

### Contrast Agent Used

Barium sulfate was selected as the contrast agent to be used. It is a white, bulky non-absorbable powder and passes through the

intestinal tract unchanged. Veri-o-Pake<sup>1</sup> containing approximately 96.7% U.S.P. barium sulfate (x-ray grade) was used thereby eliminating presence of irritating gums, resins, or cathartics.

#### Procedure

A total of 6 different radiographic series were conducted with each dog. The series were designated by using the letters of the alphabet A through F.

In series A the animals were fasted for 24 hours previous to the administration of the barium sulfate.

In series B the animals were fasted for 24 hours, then fed just prior to the administration of the barium sulfate.

Series C was conducted with the animals being fasted for 24 hours and exercised vigorously for 20 minutes prior to administration of the barium sulfate.

In series D the animals were fasted for 24 hours and exercised vigorously for 20 minutes prior to the administration of a barium sulfate food mixture.

Series E was conducted with the animal fasted for 24 hours then a tranquilizer<sup>2</sup> was given intravenously prior to the administration of the barium sulfate. The animals were allowed to reach a maximum state of tranquilization before administration of the

---

<sup>1</sup>Veri-O-Pake, General Electric Company, Milwaukee, Wisconsin.

<sup>2</sup>"Sparine"; Wyeth Laboratories Inc., Philadelphia, Pennsylvania.

barium sulfate. This averaged approximately 5 minutes following the administration of the tranquilizer at a rate of 1 milligram per pound of body weight.

Series F was conducted with the animals fasted for 24 hours, then fed and given tranquilizer before the administration of the barium sulfate. The same procedure used in the administration of the tranquilizer in series E was employed in series F.

All dogs were fasted 24 hours prior to each series. The purpose was to assure that the animals would have an appetite when the series called for food to be given. A high quality protein diet<sup>1</sup> was used in all series which called for food and no animal refused to eat when called upon to do so.

The barium sulfate powder was mixed with water to form a consistency which would equal that of whipped cream. This was accomplished by adding an estimated 12 to 15 milliliters of water to 1 ounce of the dry powder. The smaller dogs received about one-half ounce of the mixture and the larger dogs received approximately three-fourths of an ounce. It was administered by placing it in the dog's mouth and forcing him to swallow.

A minimum interval of 5 days was maintained between each series in order to prevent the constipating effect which could possibly result from the continuous use of the barium sulfate.

Two survey radiographs were taken to ascertain the condition of the digestive tract prior to the administration of the

---

<sup>1</sup>"Prescription Diet P/d"; Hill Packing Company, Topeka, Kansas.

radio-opaque substance. These consisted of a ventral-dorsal exposure and a lateral exposure with the right side of the animal toward the film.

After administration of the barium sulfate, the animals were rotated in an attempt to distribute the barium sulfate evenly in the stomach. This was accomplished by rolling the dog over onto his back several times. As soon as this was completed, a second survey radiograph was taken. Succeeding radiographs were taken at 30 minutes, 60 minutes, 120 minutes, 180 minutes, 240 minutes, and 300 minutes post barium administration. In those instances where the barium sulfate had reached the colon in less than 300 minutes, the series was terminated before the 300 minute film was exposed.

For exposure of films the animals were placed in a lateral recumbency on their right sides. The lateral recumbent position was used until the 240 minute interval was reached. At this time additional radiographs were taken with the animals in a ventral-dorsal recumbency. These 2 views were taken at each succeeding time interval until the series was terminated.

#### Film Processing

At each time interval the films were developed and a reading of the wet radiograph was obtained before the next exposures were made. General Electric Super Mix Developer<sup>1</sup> and General Electric

---

<sup>1</sup>"G.E. Super Mix Medical X-Ray Minimum Exposure Developer"; General Electric Company, Milwaukee, Wisconsin.

Super Mix Fixer<sup>1</sup> were used in the film processing. The developing time and temperature were as recommended by the General Electric Company based on a general rule in which a developing temperature of 68° F. required 4½ minutes development time. When the developer temperature was higher than 68° F., the development time was shortened and if the developer temperature was lower, the development time was lengthened according to the degree of temperature variant.

### Radiographic Technique

The small animal technique chart in the Radiology section of the Department of Surgery and Medicine at Kansas State University was used. The width of the animals on a plane through the 2nd lumbar vertebra was measured in centimeters laterally and ventral-dorsally. This measurement was applied to the technique chart in order to obtain the K.V.P. settings. The constant factors used were a 36 inch focal film spot distance; 100 milliamperes, Royal Blue film<sup>2</sup>, and High speed screens.<sup>3</sup> The exposure times used were 1/30 and 1/60 of a second. These times were determined according to the small animal technique chart.

---

<sup>1</sup>"G.E. Super Mix Fixer, Speed Type for X-Ray Film"; General Electric Company, Milwaukee, Wisconsin.

<sup>2</sup>"Royal Blue Medical X-Ray Film"; Eastman Kodak Company, Rochester, New York.

<sup>3</sup>"Dupont Stainless Intensifying Screens"; General Electric Company, Milwaukee, Wisconsin.

## Radiographic Equipment Used

The diagnostic x-ray machine in the Radiology section of the Department of Surgery and Medicine at Kansas State University was used. This was a General Electric mobile 200 diagnostic X-Ray Machine.<sup>1</sup>

The machine has a maximum of 200 milliamperes with a K.V.P. range of 40 to 100 K.V.P.'s. The focal spot film distance used in this investigation was 36 inches.

The size of the film used for the large dogs was 11 inches by 14 inches. Film size for the smaller dogs was 8 inches by 10 inches. Royal Blue<sup>2</sup> Medical X-Ray film was used throughout the investigation.

High speed screens<sup>3</sup> were used in all the cassettes.<sup>4</sup> A grid<sup>5</sup> was used to absorb scatter radiation in the dogs which measured over 12 centimeters.

---

<sup>1</sup>"Model No. 11 CK 4-1"; General Electric Company, Milwaukee, Wisconsin.

<sup>2</sup>"Royal Blue Medical X-Ray Film"; Eastman Kodak Company, Milwaukee, Wisconsin.

<sup>3</sup>"Dupont Stainless Intensifying Screens"; General Electric Company, Milwaukee, Wisconsin.

<sup>4</sup>"Molded Cassettes"; General Electric Company, Milwaukee, Wisconsin.

<sup>5</sup>"Lysholm Grid"; General Electric Company, Milwaukee, Wisconsin.



Protective clothing consisting of lead lined aprons and gloves was used by all who participated in the taking of the radiographs. A film badge was utilized to measure possible scatter radiation.

### Tranquilizer

The tranquilizer used was Promazine Hydrochloride.<sup>1</sup> This tranquilizer was selected for use because of its widespread usage and safety in small animal medicine. A standard dosage of 1 milligram per pound of body weight was used and administered intravenously.

## RESULTS AND DISCUSSION

### Total Number of Radiographs

An average of 11 radiographs were taken of each dog in each of the six series resulting in a total of 528 radiographs taken to complete the investigation.

The time necessary to complete the experiment was 3 months. This allowed approximately 5 days rest between individual series for each dog. By allowing this amount of time between series there were no instances of any clinical intestinal disorders at any time during the investigation.

---

<sup>1</sup>"Sparine"; Wyeth Laboratories Inc., Philadelphia, Pennsylvania.

## Emptying Time of Stomach

Table 1. The individual emptying time of the stomach in Series A.

Dog Number	:	1	2	3	4	5	6	7	8
Time <sup>1</sup>	:	60	120	120	60	60	120	60	60

Series A was conducted with the animal fasted for 24 hours prior to administration of the barium sulfate.

In 5 out of 8 of the dogs as indicated by Table 1. the stomach was empty by 60 minutes. In the 3 remaining dogs the barium sulfate had moved out of the stomach by 120 minutes.

The average emptying time of the stomach in Series A was 82 minutes. This does not imply that the barium sulfate remained in the stomach until this time. The stomach was considered empty when only a trace of barium sulfate was observed in the stomach and the majority of the barium was in the small intestine.

Dogs number 2 and 3 resisted handling very vigorously, thus contributing to their delayed emptying times of the stomach. With this in mind, an attempt was made to allow the remaining dogs to become more familiar with being handled and with their surroundings before any of the remaining series were initiated.

<sup>1</sup>The time is given in minutes.

Table 2. The individual emptying times of the stomach in Series B.

Dog Number	:	1	2	3	4	5	6	7	8
Time	:	180	120	180	120	240	120	180	120

Series B was conducted with the animals fed prior to administration of the barium sulfate.

The average length of time necessary for the barium sulfate to leave the stomach in Series B was 157 minutes. There was some mixing of the food content of the stomach and the barium sulfate. The barium sulfate moved from the stomach into the small intestines leaving the bulk of the food content of the stomach behind. In all instances the bulk of the food remained in the stomach long after the barium sulfate had progressed well into the small intestines and colon.

Table 3. Individual emptying times of the stomach in Series C.

Dog Number	:	1	2	3	4	5	6	7	8
Time	:	60	120	60	60	60	120	120	120

In Series C the animals were fasted for 24 hours, then exercised for 20 minutes prior to the administration of the barium sulfate. The barium sulfate was given immediately at the end of the exercise period without allowing the animals to rest. The

average emptying time of the stomach in this series was 90 minutes. In all animals the barium sulfate had reached the pylorus of the stomach and in 2 of the animals (Nos. 2 and 6) had entered the duodenum by the time the first post administration radiographs were taken.

Table 4. Individual emptying times of the stomach in Series D.

Dog Number	:	1	2	3	4	5	6	7	8
Time	:	300	300	300	300	180	180	180	180

In Series D the animals were exercised the same amount of time as in Series C. They were then fed a barium sulfate food mixture before being allowed to rest. The barium sulfate food mixture resulted in a delayed emptying time of the stomach. The average barium sulfate emptying time of the stomach in Series D was 240 minutes. Most of the barium sulfate left the stomach leaving the bulk of the food behind.

It would be difficult to compare Series D with the other series where food was given due to the mixing of the barium sulfate with the food before administration. The pre-mixing resulted in 4 of the 8 dogs retaining significant amounts of the barium sulfate in the stomach after 300 minutes had passed.

This procedure also resulted in a poor outline of the digestive tract. The barium sulfate failed to concentrate sufficiently in any one place through the small intestine to provide good contrast.

Table 5. Individual emptying times of the stomach in Series E.

Dog Number	:	1	2	3	4	5	6	7	8
Time	:	120	120	120	180	120	120	120	60

In Series E the animals were fasted for 24 hours and tranquilized<sup>1</sup> prior to the administration of the barium sulfate. The tranquilizer was administered intravenously at the rate of 1 milligram per pound of body weight. The animals were allowed to reach a maximum state of tranquilization before the barium sulfate was administered.

The average emptying time of the stomach of barium sulfate in Series E was 120 minutes.

Tranquilization produced a delayed emptying time of the stomach over the fasted non-tranquilized animal. Aside from this, tranquilization did not alter the pattern of the passage of the barium sulfate through the digestive tract.

Table 6. Individual emptying times of the stomach in Series F.

Dog Number	:	1	2	3	4	5	6	7	8
Time	:	120	180	240	240	180	60	60	120

<sup>1</sup>"Sparine"; Wyeth Laboratories Inc., Philadelphia, Pennsylvania.

The procedure used in Series F varied from Series E in only one respect. This was that the animals were fed prior to the administration of the tranquilizer.

The average emptying time of the stomach of the barium sulfate in Series F was 150 minutes.

There was some mixing of the barium sulfate and food content of the stomach in Series F, the same as occurred in Series B. The barium moved into the small intestine leaving the bulk of the food behind as it did in previous series where food was given.

#### The Small Intestine

The barium sulfate had moved well into the small intestine before 30 minutes had passed in 7 out of 8 of the dogs during Series A. Dog number 2, however, had not progressed beyond the stomach until the end of the first 60 minute time interval. The average time interval between administration of the barium sulfate and its subsequent entrance into the small intestine was 34 minutes.<sup>1</sup>

As previously stated, dog number 2 in Series A was apprehensive of handling and presented a delayed emptying time of the stomach consequently the contrast agent was delayed in entering the small intestine.

---

<sup>1</sup>This is not a true average. This average was based on the second post administration radiograph of the barium sulfate which was at the end of the first 30 minute time period. To establish a true average it would have been necessary to make exposures at shorter time intervals after the barium sulfate administration.

The average time of entry into the small intestine of Series B was 37 minutes. The barium sulfate was mixed with food as it passed back into the small intestine. This did not provide good contrast of the small intestine with surrounding tissues until a longer time interval has passed and more of the barium sulfate had left the stomach.

The series conducted with the animals in a fasted condition and then exercised (Series C) revealed the barium sulfate well into the small intestine of all dogs at the end of the 30 minute time period.

Series D revealed the longest delay in the entrance of the contrast material into the small intestine. The average time before the barium sulfate entered the small intestine in Series D was 45 minutes.

There were smaller amounts of the barium sulfate found in the small intestine as indicated by the 30 minute and 60 minute post administration radiographs. The barium sulfate which first entered the small intestine during this series was still well mixed with food.

It would be difficult to compare Series D with any of the other series where food was present due to the pre-mixing of the barium sulfate with the food before its administration.

The average time for the barium sulfate to enter the small intestine for Series E was 37 minutes. There were no adverse effects noted with the passage of the barium sulfate into and through the small intestine when Sparine<sup>1</sup> was the tranquilizer used.

---

<sup>1</sup>"Sparine"; Wyeth Laboratories Inc., Philadelphia, Pennsylvania.

There was less delay in the entrance of the barium sulfate into the small intestine in Series F than in Series E. The average time for the passage of the barium sulfate into the small intestine in Series F was 34 minutes. The barium sulfate was mixed with the contents of the small intestine and there were no apparent effects due to the tranquilizer on its passage.

#### Entrance Time Into The Colon

There was no attempt made to study the colon in this investigation. The end point of each series was set at 300 minutes or the time at which the barium sulfate was found to be entering into the colon. It was found that the barium sulfate had entered into the colon by 240 or 300 minutes in all dogs with the exception of one animal. Dog number 1 had a delayed entrance time into the colon in Series E and F.

The following tables give the entrance time into the colon in minutes on each dog in each of the six series.

Table 7. Barium sulfate entrance into the colon in Series A.

Dog Number	:	1	2	3	4	5	6	7	8
Time <sup>1</sup>	:	240	180	180	180	240	240	180	180

<sup>1</sup>Time is given in minutes.



The average entrance time into the colon for Series A was 202 minutes. As shown by Table 7. the barium sulfate had entered the colon in 5 of the dogs by 180 minutes and in the remaining 3 dogs by 240 minutes.

Table 8. Barium sulfate entrance into the colon in Series B.

Dog Number	1	2	3	4	5	6	7	8
Time	240	180	300	240	300	240	240	240

The average entering time of the barium sulfate into the colon in Series B was 247 minutes. The barium sulfate was still mixed with contents of the intestinal tract when it entered the colon.

Table 9. Barium sulfate entrance into colon in Series C.

Dog Number	1	2	3	4	5	6	7	8
Time	180	180	180	180	180	300	180	240

The average entering time of the barium sulfate into the colon in Series C was 202 minutes.

Table 10. Barium sulfate entrance into the colon in Series D.

Dog Number	1	2	3	4	5	6	7	8
Time	240	300	300	240	240	300	240	300

The average entering time of the barium sulfate into the colon in Series D was 270 minutes. Mixing the barium sulfate with food as in Series D slowed the movement through the small intestine to the colon.

Table 11. Barium sulfate entrance into the colon in Series E.

Dog Number	1	2	3	4	5	6	7	8
Time	180	180	300	360	300	300	240	240

The average entering time into the colon for Series E was 262 minutes. The dogs remained tranquilized throughout the length of experimental time in both Series E and F.

Table 12. Barium sulfate entrance time into the colon in Series F.

Dog Number	1	2	3	4	5	6	7	8
Time	180	240	180	420	300	240	240	300

The average entrance time into the colon of all dogs in Series

F was also 262 minutes. This was the same average as in Series E; however, the bulk of the barium sulfate was still mixed with the contents throughout the small intestine in Series F. In Series E the barium sulfate had all moved well into the posterior small intestine by this time.

#### Comparison of the Series

The information obtained from the investigation showed that best results could be gained in conducting a barium sulfate gastro-intestinal study with the animal in a fasted state and the digestive tract empty.

There was no statistical significant difference in Series A, C, and E in that the one factor in common was that the animals were fasted and the gastro-intestinal tract was empty. The pattern of the movement of the barium sulfate was essentially the same with exception of the relative length of time it took the barium sulfate to leave the stomach. Series A had an average emptying time of 82 minutes compared to 90 minutes for Series C and 120 minutes for Series E.

In all three series the barium sulfate remained concentrated as it moved through the gastro-intestinal tract. This provided good delineation of the stomach and the small intestine.

Exercise (Series C) produced little difference in the average emptying time of the stomach over the fasted non exercised animals in Series A. Three of 4 of the younger animals, however, took

considerably longer for the barium sulfate to leave the stomach in Series C. In Series E with the animals tranquilized 6 out of the 8 dogs showed the same emptying time with only 2 showing different emptying times.

It was essential to rotate the animals by rolling them over several times to assure thorough distribution of the barium sulfate in the stomach. If this is accomplished properly, the entire limits of the stomach can be outlined in the first post administration radiograph. The radiograph taken at 30 minutes after administration shows the barium sulfate concentrated in the pyloric section of the stomach and the anterior portion of the small intestine. It is felt that an attempt to distribute the barium sulfate in the stomach should not be overlooked as a prerequisite to a gastrointestinal study.

Excitement and nervousness resulting from handling provided more alteration of motility than the effects of exercise on the dogs. Dogs number 2 and 3 revealed a delayed emptying time of the stomach in Series A. Both animals resisted restraint with the result that the movement of the barium sulfate into the small intestine was altered. Radiographs of dog number 2 in Series A showed that the barium sulfate moved into the small intestine spasmodically rather than in a smooth even flowing pattern. After the dog became familiar with handling the altered pattern was not in evidence in succeeding series. These results indicate that it is very important that the animals be familiar with their surroundings and care in handling should be practiced routinely.

There was a significant statistical difference between Series A, C, and E compared with Series B, D, and F. In the series calling for food to be given (B, D, and F), the barium sulfate moved from the stomach well ahead of the bulk of the stomach contents.

Barium sulfate given with or after food did not provide a good outline of the stomach or small intestines. In most instances the barium sulfate moved throughout the digestive tract mixed with its contents, never concentrating well enough in any one area to provide good contrast.

Comparison of Series B and F revealed only 7 minutes difference in the average emptying times of the stomach. The barium sulfate was given following feeding of the animals. Series D cannot be compared because the barium sulfate was mixed with the food prior to its administration.

It would be impossible to demonstrate lesions in the wall of the stomach or to outline a foreign body in the lumen of the stomach by using the method employed in Series B, D, or F.

The motility of the stomach and small intestines was more noticeable in those instances where food was given before the barium sulfate. Peristaltic contractions of the stomach and small intestines were more pronounced in these series and were revealed quite regularly by the radiographs.

The average entrance times into the small intestine as given in the results can only be considered as relative times. If the true times were to be determined, it would be necessary to take radiographs with very short time intervals between them following

administration of the contrast agent. The second post administration radiograph taken in these series was after 30 minutes had passed. Series A, C, and E showed the barium sulfate well into the anterior part of the small intestine in nearly all dogs when the 30 minute radiograph was taken.

No significant difference was noted in the entering time into the small intestine of the barium sulfate in Series A, C, and E as compared with Series B, D, and F. The main difference was the amount of barium sulfate in the small intestine at the 30 minute time interval. In Series A, C, and E there was good delineation of the intestinal wall and excellent contrast provided by the barium sulfate. The barium sulfate was mixed with the contents of the stomach and intestines in Series B, D, and F and not concentrated well enough to provide good contrast with surrounding tissues.

Each series was to be concluded after 300 minutes had passed or the barium sulfate had reached the colon. There were 48 individual studies conducted in the investigation. In 35 of the 48 the barium sulfate had reached the colon in less than 300 minutes leaving 13 in which the average time was 300 minutes or more. The average time of the 3 series (A, C, and E) with the animals fasted and digestive tracts empty was 222 minutes. The average time of the remaining series (B, D, and F) was 260 minutes.

The main difference between the series with the animals in a fasted condition and the series where the animals had been fed was the distribution of the barium sulfate. In Series A, C, and E the barium sulfate had moved into the posterior loops of the small intestine at the same time it was entering the colon. In Series B,

D, and F the barium sulfate was still found throughout the intestinal tract in all dogs after 300 minutes. In 5 of 8 of the dogs in Series D the barium sulfate was still found in significant amounts in the stomach when it was entering the colon after 300 minutes.

### The Effects of Tranquilizer

The use of tranquilizer in this investigation produced rewarding results. Promazine hydrochloride<sup>1</sup> was selected for its antiemetic properties. (Promazine hydrochloride is one of the phenothiazine derivative tranquilizers.)

The advantages of having the animal in a tranquilized state were the ease of handling and no apparent effects on the pattern produced by the barium sulfate in the digestive tract.

The dosage of 1 milligram per pound of body weight placed the animal in a state of full cooperativeness. He would walk if prodded but did not care to do so on his own. Very little restraint was required to hold the animal on the table for film exposure. There was no apparent apprehension or struggle by any of the animals. The length of time the animals remained tranquilized by this dosage was sufficient to complete the entire study in each series.

The only possible disadvantage in tranquilizer usage noted in this investigation was the delay in emptying time of the stomach and the delay of the barium sulfate in reaching the colon. In

---

<sup>1</sup>"Sparine"; Wyeth Laboratories Inc., Philadelphia, Pennsylvania.

Series E the average emptying time of the stomach was 120 minutes compared to 82 minutes for Series A and 90 minutes for Series C. The average time it took the barium sulfate to reach the colon in Series A and C was 202 minutes compared to 262 minutes for Series E. The common factor in A, C, and E was that the animals were in a fasted condition. There was no significant difference between the series where the animals were fed.

The phenothiazine derivative tranquilizers possess antishock and anti-inflammatory activity and protect animals from the effects of endotoxins (Irwin, 1958). They are said to have autonomic effects which are primarily parasympathomimetic in action. They also possess varying degrees of anticholinergic activity. It is quite possible that the drugs protect in part by preventing the nervous system from over-responding to stress; however, they do not appear to block the endocrine response to stress.

The results obtained in this study indicate that the phenothiazine tranquilizers would not alter the results of a gastro-intestinal study using contrast agents.

#### SUMMARY

An investigation of the effects of food, exercise, and tranquilizers on the gastro-intestinal motility of the canine was performed utilizing barium sulfate as the contrast agent.

Eight dogs were used in the investigation. Two Beagles were aged, 2 dogs of mixed breeding were approximately one year of age,



and the remaining 4 dogs were 4 and  $\frac{1}{2}$  months old Beagle litter mates.

There were 6 individual gastro-intestinal studies conducted on each dog using barium sulfate as the contrast agent. The average number of radiographs found necessary for each study was 11 for a total of 528 to complete the investigation.

The individual studies were designated by using letters of the alphabet A through F.

- Series A. The animals were fasted 24 hours prior to administration of the barium sulfate.
- Series B. The animals were fed prior to administration of the barium sulfate.
- Series C. The animals were fasted 24 hours, then exercised for 20 minutes prior to administration of the barium sulfate.
- Series D. The same procedure was used as in Series C with the exception that the animals were fed a barium sulfate-food mixture.
- Series E. The same procedure used in Series A was used in Series E with the addition of tranquilizer administered intravenously prior to administration of the barium sulfate.
- Series F. This series was the same as Series B with the exception that tranquilizer was given intravenously prior to administration of the barium sulfate.

Radiographs were taken immediately after the contrast agent was

given and repeated again at 30 minutes, 60 minutes, 120 minutes, 240 minutes, and 300 minutes following the initial radiograph. Each series was terminated at 300 minutes or when the contrast material reached the colon.

The series (A, C, and E) with the animals fasted provided sufficient contrast so that the gastro-intestinal tract was well delineated. The average emptying time of the stomach of Series A was 82 minutes; Series C, 90 minutes; and Series E, 120 minutes.

The series (B, D, and F) with the animals fed prior to the administration did not provide sufficient contrast to outline the intestinal tract very well. The barium sulfate remained scattered throughout the digestive tract for the entire length of the series. The average emptying time of the stomach for Series B was 157 minutes; for Series D, 240 minutes; and Series F, 150 minutes. A comparison of the emptying times of the stomach in the various series adequately demonstrates that food in the digestive tract slows movement of a contrast agent thru the digestive system.

Exercise produced no significant difference in effects as compared to the non-exercised dog. It was noted however that nervousness and apprehension of handling produced more alteration of the movement and pattern of the barium sulfate than did exercise.

Tranquilization delayed the movement but did not alter the pattern and outline produced by the contrast agent. The absence of marked effects on patterns produced by the contrast agents make it feasible to recommend the use of phenothiazine derivative tranquilizers in the handling of patients requiring a gastro-intestinal

contrast study.

It was effectively demonstrated that an adequate study of the stomach and small intestine could be made within the 300 minute time interval.

## ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. J. E. Mosier for his untiring guidance and assistance in this work. Appreciation also goes to Dr. M. M. Guffy, Veterinary Radiologist at Kansas State University, for his help and advice in the use and operation of the radiographic equipment. Additional thanks goes to Dr. E. H. Coles and his associate Dr. Charles Mebus for the use of four of the experimental animals.

A final word of appreciation goes to my wife Carol Raye for her patience and assistance in the initial preparation of this manuscript.

## LITERATURE CITED

- Brody, D. A., Werle, J. M., Mehan, J., and Quigley, J. P.  
Intra-lumen pressures of the digestive tract especially the pyloric region. *Am. Jour. of Physiology.* 130:791-801. 1940.
- Carlson, W. D.  
*Veterinary Radiology*, Lea and Febiger, Philadelphia, Pennsylvania. 110-111. 1961.
- Douglas, S. W., and Williamson, H. D.  
*Principles of Veterinary Radiology.* 1st Ed., The Williams and Wilkins Company, Baltimore, Maryland. 178-185. 1963.
- Dukes, H. H.  
*The Physiology of Domestic Animals.* 7th Ed., Comstock Publishing Associates, Ithaca, New York. 414-433. 1955.
- Files, G. W.  
*Medical Radiographic Technique.* 10th Ed., Charles C. Thomas Publisher, Springfield, Illinois. 132-133. 1956.
- Golden, R.  
*Abnormalities of the Small Intestine in Nutritional Disturbances: Some Observations on their Physiologic Basis.* *Radiology.* 36:262-285. 1941.
- Holmes, G. W., Ruggles, H. E.  
*Roentgen Interpretation.* 5th Ed., Lea and Febiger, Philadelphia, Pennsylvania. 265-308. 1937.
- Irwin, S.  
*Abstracts of First Symposia on the Use of Tranquilizers in Veterinary Practice.* Department of Vet. Med., Schering Corp., Bloomfield, New Jersey. 6-7. 1958.
- Jamieson, R. A., and Kay, A. W.  
*Textbook of Surgical Physiology*, 1st Ed., E. and S. Livingston Ltd., Edinburgh and London. 395-402, 408-432. 1959.
- Jones, L. M.  
*Veterinary Pharmacology and Therapeutics.* 2nd Ed., The Iowa State University Press, Ames, Iowa. 257-268, 270-271, 186-187. 1959.
- Miller, Malcolm E.  
*Guide to the Dissection of the Dog*, 3rd Ed., Edwards Brothers, Inc., Ann Arbor, Michigan. 196-197. 1955.

- Quigley, J. P., Werle, J., Ligon, E. W. Jr., Read, M. R., Radzow, K. H., and Meschan, I.  
The influence of fats on motor activity of the Pyloric Sphincter region and on the Process of Gastric evacuation studied by balloon water manometer and by optical manometer fluroscopic techniques. Am. Jour. of Physiology. 134:132-140. 1941.
- Schnelle, Gerry B.  
Radiology in Small Animal Practice. 2nd Ed., North Am. Vet. Inc., Evanston, Illinois. 245-260. 1950.
- Seward, C. O.  
The use of barium in studying the digestive tract of the dog. Journal of the Am. Vet. Med. Assoc. CXIX:125-128. 1951.
- Werle, J. M., Brody, D. A., Ligon, E. W. Jr., Read, M. R., and Quigley, J. P.  
The mechanics of gastric evacuation. Am. Jour. of Physiology. 131:606-614. 1940.

## APPENDIX

EXPLANATION OF PLATE I

Figure 1. A reproduction of a radiograph showing a lateral exposure of the canine abdomen within which the stomach is outlined with barium sulfate.



PLATE I



EXPLANATION OF PLATE II

Figure 2. A reproduction of a radiograph from a lateral exposure of the canine abdomen within which the barium sulfate is located in the stomach and loops of the small intestine.

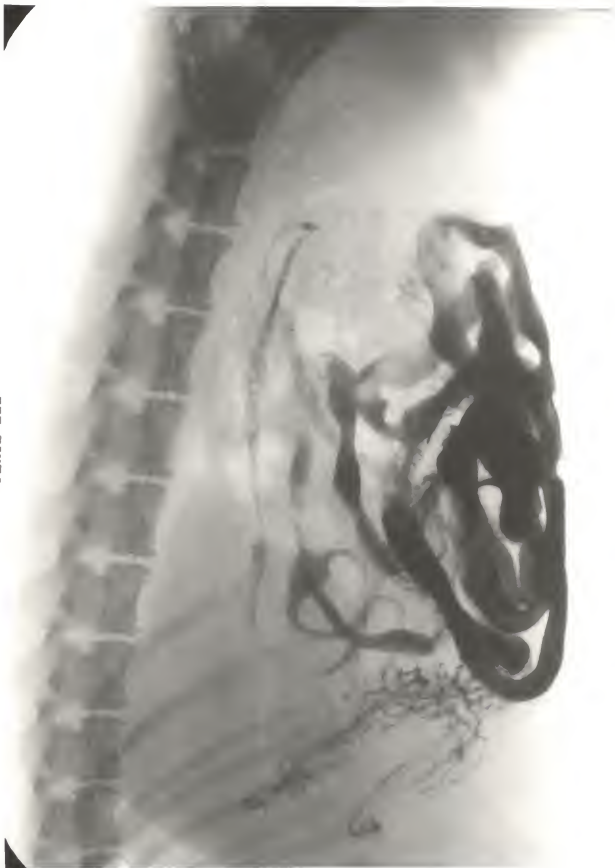
PLATE II



EXPLANATION OF PLATE III

Figure 3. A reproduction of a radiograph from a lateral exposure of the canine abdominal cavity showing the barium sulfate within the posterior loops of the small intestine.

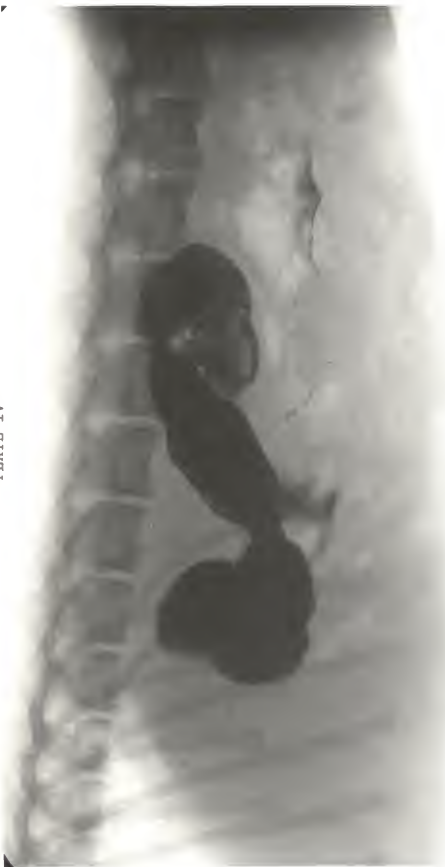
PLATE III



EXPLANATION OF PLATE IV

Figure 4. A reproduction of a radiograph from a lateral exposure of the canine abdominal cavity showing barium sulfate within the colon.

PLATE IV



R  
KANSAS STATE UNIVERSITY 7  
HOSPITAL 240M

EXPLANATION OF PLATE V

Figure 5. A reproduction of a radiograph from a lateral exposure of the canine abdominal cavity with barium sulfate shown in the stomach and throughout the small intestine. The stomach is also full of food.



PLATE V

R  
KANSAS STATE UNIVERSITY  
VETERINARY HOSPITAL  
6 0 1 1

EXPLANATION OF PLATE VI

Figure 6. A reproduction of a radiograph from a lateral exposure of the canine abdominal cavity showing the barium sulfate concentrated in the posterior small intestine and well within the colon. The stomach is also filled with food.

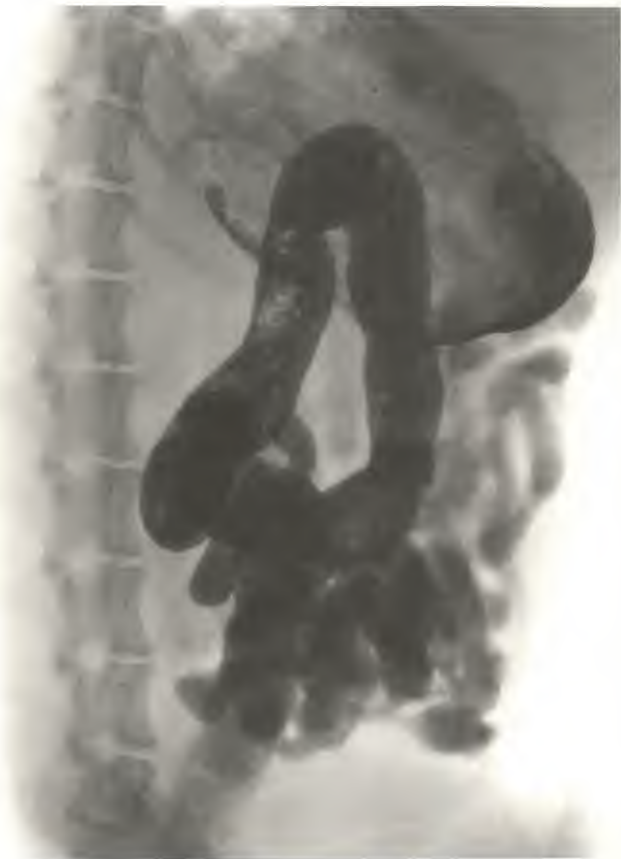
PLATE VI



EXPLANATION OF PLATE VII

Figure 7. A reproduction of a radiograph from a lateral exposure of the canine abdominal cavity showing a significant amount of barium sulfate in the stomach, small intestine, and colon. The stomach is also filled with food.

PLATE VII



A RADIOGRAPHIC STUDY OF THE EFFECT OF  
FOOD, EXERCISE, AND TRANQUILIZER ON  
GASTROINTESTINAL MOTILITY OF THE CANINE

by

JOHN DAVID RHOADES

---

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the  
requirements for the degree

MASTER OF SCIENCE

Department of Surgery and Medicine

KANSAS STATE UNIVERSITY  
Manhattan, Kansas

1964

The lack of contrast in the radiography of the alimentary tract and its surrounding tissues in the human and animals has led to the use of contrast materials. The contrast materials utilized are those designed to be relatively opaque to x-rays.

The passage of the contrast agent through the alimentary tract is a dynamic process. Observations of this process as it is taking place can be accomplished by the use of fluroscopic equipment. This can be carried out in human hospitals where they are properly equipped for safe operation. Since most veterinary hospitals are not properly equipped for safety to the operator, fluroscopy is not widely used in veterinary medicine. The usual procedure in veterinary medicine is the use of x-ray producing equipment with the exposure and development of film.

The effects of food, exercise, and a tranquilizer of phenothiazine origin on the movement of the contrast agent thru the digestive tract were studied.

Exposures were made immediately after administration of the contrast material and at 30 minutes, 60 minutes, 120 minutes, 180 minutes, 240 minutes, and 300 minutes post administration. The study was terminated at the 300 minute time interval or at the time the contrast agent reached the colon.

Eight dogs were used in the investigation. Six different studies were conducted on each dog. The first study was conducted with the animal fasted for 24 hours prior to the administration of the contrast agent. The second study was conducted with the animal fed prior to the administration of the contrast material. The third

study was conducted with the animals fasted for 24 hours, then exercised for 20 minutes prior to administration of the contrast agent. The fourth study was conducted with the animals exercised for 20 minutes and fed a contrast material food mixture. The fifth study was conducted with the animals fasted for 24 hours and tranquilized prior to the administration of the contrast agent. The sixth study was conducted with the animals fed and tranquilized before the administration of the contrast agent.

The contrast agent used in the investigation was barium sulfate. The use of barium sulfate provided contrast of the alimentary tract and defined the structure very well from surrounding tissues.

There was no statistical significant difference found in the movement and pattern of the barium sulfate in the studies conducted with the animals in a fasted condition. This was also true in the comparison of the studies conducted where the animals had been fed.

There was a statistical difference between the fasted series and the series where the animals had been fed. In the series where the animals were given food the barium sulfate remained in the stomach for longer periods of time and mixed with the stomach contents. The food barium sulfate mixture moved throughout the digestive tract never concentrating well enough in any area to provide good contrast with surrounding tissues. The barium sulfate provided good contrast and delineation of the digestive tract in the fasted animals.

Each series was concluded after 300 minutes had passed or the



barium sulfate had reached the colon. The investigation demonstrated that the stomach and small intestine can be adequately studied within the 300 minute time period. In 35 out of 48 studies the barium sulfate had reached the colon before 300 minutes. In 11 of the remaining 13 studies the barium sulfate had entered the colon by 300 minutes.

There was no significant difference in the pattern produced or the movement of the barium sulfate in the series where a tranquilizer was given and the series without tranquilization.

The dosage of one milligram per pound of body weight of a phenothiazine derivative tranquilizer administered intravenously placed the animal in a state of cooperativeness. Very little restraint was required to hold the animal on the table for film exposure.

The length of time the animals remained tranquilized by this dosage was sufficient to complete the entire study in each series.

This investigation demonstrated that phenothiazine derivative tranquilizers can be very useful in conducting barium studies of the digestive tract of the canine. The investigation also demonstrated that it is necessary to have the animal in a fasted condition to provide good definition of the digestive tract with a contrast agent. It was also demonstrated that an adequate study of the canine stomach and small intestines can be made within the 300 minute time period.