

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

STUDIES OF RADIOPAQUE MARKERS IN CATS AND DOGS

**A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF VETERINARY
SCIENCE AT MASSEY UNIVERSITY**

**SARA J BRUCE
2000**

Abstract

Radiopaque markers (RM) have been used to gain understanding of and assess gastrointestinal motility disorders in human medicine for some time. Development and validation of their use in veterinary medicine has commenced. The purpose of the present work was to further the knowledge and understanding of the use of RM in dogs and cats.

The physiology of gastrointestinal motility, the influence of fibre on the gastrointestinal tract and the gastric emptying of indigestible solids was reviewed to aid the reader in the interpretation of the experimental data. The disease processes affecting motility and the different methods used to diagnose dysmotilities were also summarised.

Reference values for the gastric emptying, small intestinal transit and large intestinal transit of a proprietary RM (BIPS, NZ Vet, Christchurch) fed in a high fibre diet (Hills Prescription Diet r/d) to healthy dogs were determined. The information was presented as box plots for veterinarians to use as reference curves in clinical practice.

Factors other than size and density may influence how indigestible particles empty from the stomach, such as the strength of antral contractions induced by the diet ingested. The objective of the next study was to investigate whether the size of the pieces of meat ingested along with indigestible particles (RM) affected how they emptied from the stomach.

The 50%, 75% and 90% gastric emptying times (GET) of each size of marker with each size of steak were compared by the Wilcoxon Sign Rank test. In addition, the area under the gastric emptying curves (AUC) of the RM were compared by a two-factor ANOVA. Fisher's Least Significant Difference (LSD) test was then used to compare means for the test meals.

The 50% GET of the small RM was found to be significantly faster than the large RM in the 10 mm³ steak meal. The 50% and 75% GET of the small RM were significantly faster than the large RM in the 1 mm³ and 20 mm³ steak meals.

The mean AUCs of the large RM were significantly different between the test meals ($p < 0.0068$). The large RM left the stomach significantly faster in the 10 mm³ steak compared to the 20 mm³ steak ($p = 0.0029$).

The size steak fed with the large RM can influence how they empty from the stomach. An increased lag time appeared to be responsible for the slower emptying of the RM with the 20 mm³ steak compared to the 10 mm³.

Preliminary veterinary use of RM in the assessment of gastrointestinal transit is encouraging. The objective of the last study was to assess the situations in which RM have been most often used in veterinary medicine, assess the motility abnormalities they highlight and assess how useful they have been to the diagnostic outcome. The case records of 120 dogs and 67 cats admitted to Massey University Veterinary Teaching Hospital which had undergone RM studies were utilised.

Vomiting was most common presenting sign resulting in a RM study being carried out. About half of both canine and feline studies were considered abnormal. Of the abnormal studies, delayed gastric emptying (DGE) was the most common finding. A wide range of diagnoses were associated with DGE. Other radiopaque marker patterns observed in cats and dogs were: rapid orocolic transit, adynamic ileus, delayed colonic transit (cats only) and bunching pattern.

In general, RM only rarely diagnosed primary gastrointestinal dysmotilities but regularly highlighted secondary dysmotilities. Knowledge of the gastrointestinal motility in a particular patient may allow the clinician to provide more tailored therapy to each patient. They are also useful to rule out physical obstructions in vomiting animals and have a place in the full work up of an animal with gastrointestinal disease.

Acknowledgements

I would like to thank my supervisor Grant Guilford for his guidance, patience and encouragement in helping me to achieve this goal. Grant's enthusiasm and interest in my work was a great source of motivation for me and kept me going through the tough times, especially towards the end.

Special thanks to my mother, who flew half way around the world to help out with childcare, while I was in the finishing stages of this thesis. Her support and encouragement proved vital in the completion of my thesis.

Thank you also to Frazer Allan and Elizabeth Lee for your additional help and guidance.

Special thanks also to Linda Barter, Miho McHauley, Laurinda Oliver, Sarah Taylor and Eloise Jillings who spent many long, long nights radiographing dogs.

Table of Contents

Chapter One

Introduction

Chapter Two

The Physiology of Gastrointestinal Motility

2.1	Introduction.....	1
2.2	The Function and Motility of the Stomach.....	5
	<i>Proximal Stomach</i>	6
	<i>Distal Stomach</i>	7
	<i>Neural and Hormonal Input</i>	8
	<i>Summary</i>	10
2.3	Small Intestinal Function and Motility.....	11
	<i>Individual Phasic Contractions</i>	12
	<i>Organised Groups of Contractions</i>	14
	<i>Special Propulsive Contractions</i>	15
	<i>Specific Intestinal Reflexes</i>	15
	<i>Hormonal and Neural Input</i>	16
	<i>Summary</i>	17
2.4	Colonic Function and Motility.....	17
	<i>Electrical Activity of Muscle Layers</i>	18
	<i>Types of Contractions</i>	19
	<i>Proximal Colon</i>	20
	<i>Middle Colon</i>	21
	<i>Distal Colon</i>	21
	<i>Neural and Hormonal Input</i>	22
	<i>Other Factors Influencing Colonic Transit</i>	22
	<i>Summary</i>	24

Chapter Three Effects of Fibre on the Gastrointestinal tract

3.1	Introduction.....	25
3.2	Classification of Fibres.....	25
3.3	Effects of Fibre on Gastric Emptying.....	27
3.4	Effects of Fibre on Small Intestinal Function.....	28
	<i>Summary</i>	30
3.5	Effects of Fibre on the Colon and Faeces Production.....	31
	<i>Summary</i>	33

Chapter Four The Gastric Emptying of Solids

Digestible Solids

4.1	Introduction.....	34
4.2	The lag phase.....	35
4.3	The emptying phase.....	36
	<i>Trituration</i>	37
	<i>Control of Gastric Emptying</i>	39
	<i>The Role of the Pylorus in Gastric Emptying</i>	40
4.4	Summary.....	41

Indigestible Solids

4.5	Introduction.....	42
4.6	Emptying of Indigestible Particles From an Empty Stomach.....	43
4.7	Influence of Particle Size on the Gastric Emptying of Indigestible Solid Particles.....	43
4.8	Influence of Particle Density on the Gastric Emptying of Indigestible Solid Particles...	45
4.9	Influence of Gastric Chyme on the Gastric Emptying of Indigestible Solid Particles....	46
4.10	The Hydrodynamic Theory of Gastric Emptying.....	48
4.11	Other possible factors influencing indigestible particle emptying.....	52

Chapter Five

Gastrointestinal Motility Diseases and their Diagnosis

Diseases Affecting Intestinal Motility

5.1	Introduction.....	53
5.2	Gastric Motility Disorders.....	55
	<i>Gastric Motility Disorders Resulting in Accelerated Emptying</i>	58
	<i>Gastric Motility Disorders Resulting in Retrograde Transit</i>	59
5.3	Intestinal Motility Disorders.....	59
	<i>Adynamic Ileus</i>	60
	<i>Irritable Bowel Syndrome</i>	61
	<i>Intestinal Pseudo-Obstruction</i>	62
	<i>Dysautonomia</i>	64
	<i>Megacolon</i>	65

Diagnosis of Motility Disease

5.4	Introduction.....	67
5.5	Plain and Contrast Radiography.....	67
5.6	Radiopaque Markers.....	68
	<i>RM Use in Humans</i>	68
	<i>RM use in Animals - Barium Impregnated Polyethylene Spheres</i>	73
5.7	Scintigraphy.....	79
5.8	Magnetic Resonance Imaging.....	81
5.9	Ultrasonography.....	83
5.10	Manometry.....	84
5.11	Less Common Methods of Assessing Gastrointestinal Motility.....	85
5.12	Summary.....	87

**Chapter Six Development Of Reference Intervals For The Gastric Emptying,
Small Intestinal Transit And Colonic Transit Of Radiopaque Markers
Fed With A High Fibre Diet To Dogs**

6.1	Introduction.....	88
6.2	Materials and Methods.....	90
	<i>Dogs</i>	90
	<i>Diet</i>	91
	<i>Radiopaque Markers</i>	91
	<i>Administration of the Radiopaque Markers</i>	92
	<i>Radiography</i>	92
	<i>Radiographic Interpretation</i>	93
	<i>Statistical Analysis</i>	93
6.3	Results.....	96
	<i>Experimental Protocol</i>	96
	<i>Gastric Emptying</i>	96
	<i>Small Intestinal Transit Time</i>	96
	<i>Colonic Filling Times</i>	97
	<i>Colonic Transit Times</i>	97
6.4	Discussion.....	98

**Chapter Seven Influence of the Size of Pieces of Food in a Meal on the Gastric Emptying of
Indigestible Solid Particles**

7.1	Introduction.....	109
7.2	Materials and Methods.....	111
	<i>Test Meals</i>	111
	<i>Indigestible solid particles</i>	111
	<i>Dogs</i>	113
	<i>Experimental design</i>	113
	<i>Radiography and radiographical interpretation</i>	114
	<i>Statistical analysis</i>	115
7.3	Results.....	116
7.4	Discussion.....	118

**Chapter Eight A Retrospective Study of the Use of Radiopaque Markers in Dogs and
Cats With Gastrointestinal Problems 1993 – 1998**

8.1	Introduction.....	124
8.2	Objectives.....	125
8.3	Materials and Methods.....	125
	<i>Case records</i>	125
	<i>Radiopaque markers</i>	125
	<i>Information collected from the case records</i>	126
	<i>RM study assessment</i>	126
8.4	Results.....	128
	<i>Signalment</i>	128
	<i>Clinical signs manifested by animals undergoing RM studies</i>	128
	<i>Indications for RM studies</i>	129
	<i>Administration techniques</i>	129
	<i>Radiographic findings of RM studies</i>	131
	<i>Survey radiographs</i>	132
	<i>Final diagnoses - Delayed gastric emptying pattern</i>	132
	<i>Final Diagnoses- Adynamic ileus pattern</i>	133
	<i>Final Diagnoses- Bunching pattern</i>	134
	<i>Final Diagnoses- Rapid orocolic transit pattern</i>	134
	<i>Final Diagnoses - Delayed colonic transit pattern (cats only)</i>	134
	<i>Diagnostic procedures used with RM</i>	134
8.5	Discussion.....	136

Chapter Nine	Summary and Conclusions.....	147
---------------------	-------------------------------------	------------

List of Tables

Table 6.1	Average nutritional analyses of the diet.....	102
Table 6.2	Gastric emptying times.....	102
Table 6.3	Small intestinal transit.....	102
Table 6.4	Colonic filling times.....	103
Table 6.5	Mean residence times.....	103
Table 7.1	Gastric emptying times for all studies.....	121
Table 7.2	Area under the curve data.....	121
Table 8.1	Sex of the dogs.....	142
Table 8.2	Sex of the cats.....	142
Table 8.3	Clinical signs manifested by animals undergoing a RM study.....	143
Table 8.4	Final diagnoses associated with studies showing the delayed gastric emptying pattern	144
Table 8.5	Final diagnoses associated with studies showing adynamic ileus.....	145
Table 8.6	Additional radiographic abnormalities found on RM radiographs.....	146

List of Figures

Figure 6.1	Box Plot Depicting the Gastric Emptying of the Small RM at different times after administration.....	104
Figure 6.2	Box Plot Depicting the Gastric Emptying of the Large RM at different times after administration.....	104
Figure 6.3	Box Plot Depicting the Colonic Filling of the Small RM at different times after administration.....	105
Figure 6.4	Box Plot Depicting the Colonic Filling of the Large RM at different times after administration.....	105
Figure 6.5	Box Plot Depicting the Percentage of Small RM in the Proximal Colon at Different Times after Administration.....	106
Figure 6.6	Box Plot Depicting the Percentage of Large RM in the Proximal Colon at Different Times after Administration.....	106
Figure 6.7	Box plot Depicting the Percentage of Small RM in the Distal Colon at Different Times after Administration.....	107
Figure 6.8	Box Plot Depicting the Percentage of Large RM in the Distal Colon at Different Times after Administration.....	107
Figure 6.9	Box Plot Depicting the Percentage of Small RM in the Total Colon at Different Times after Administration.....	108
Figure 6.10	Box Plot Depicting the Percentage of Large RM in the Total Colon at Different Times after Administration.....	108
Figure 7.1	The percent gastric emptying of the small RM for each test meal as a function of time with standard deviation bars.....	122
Figure 7.2	The percent gastric emptying of the large RM for each test meal size as a function of time with standard deviation bars.....	123