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Original article

The effect of macrogol administration on the quality of macroscopic images and transit time in canine capsule endoscopy

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Abstract

The present experiment evaluated the quality of macroscopic images and the mean time of capsule passage through different sections of the gastrointestinal tract in dogs subjected to different preparation protocols before capsule endoscopy. In the first examination, the colonoscopy preparation protocol was applied, and in the second examination, the animals were administered macrogol. The study revealed that macrogol administration before capsule endoscopy significantly improved the quality of macroscopic images. The colonoscopy preparation protocol may not support accurate visualization of the large bowel mucosa and, in selected patients, also the small bowel mucosa. Macrogol administration had no effect on capsule transit time through the alimentary canal. Capsules used in endoscopic evaluations of the small bowel in humans may have limited applications in macroscopic examinations of large bowel mucosa in dogs.

Key words: capsule endoscopy, macrogol, dogs

Symbols:
HBC – human body communication
GTT – gastric transit time
SBTT – small bowel transit time
LBTT – large bowel transit time
TTT – total transit time

Introduction

Diseases of the small intestine are difficult to diagnose due to relatively non-specific symptoms and the low reliability of auxiliary tests. Laboratory analyses deliver low levels of sensitivity and specificity, whereas endoscopic techniques, despite recent advances in this field, are characterized by a narrow range of practical applications, in particular in examinations of the ileum, and require anesthesia (Dionisio et al 2010, Gibbs and Bloomfeld 2012, Sarria et al. 2013). Capsule endoscopy is a non-invasive method for macroscopic evaluations of the mucosa covering the small and large intestine. This technique was developed in the 1980s by dr Gavriel Iddan of Israel, and the results of the first examinations performed on healthy volunteers were published in *Nature* in 2000. In August 2001, capsule endoscopy was approved as a safe diagnostic method by the US Food and Drug Administration (Delvaux and Gay 2008, Bednarczuk et al. 2009). The FDA's approval paved the way to the rapid development of the new technique for small bowel diag-

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nosis as no alternative methods had existed at the time.

In veterinary medicine, the effectiveness of capsule endoscopy was examined in dogs and pigs. The aim of the relevant research was to evaluate the usefulness (adaptation) of capsule endoscopy in veterinary practice and its effectiveness in diagnosing selected diseases of the gastrointestinal tract, including parasitic diseases, and macroscopic evaluations of the bowel mucosa in patients administered indometacin (Tacheci et al. 2010, Lee et al. 2011). Strategies for improving the diagnostic ability of capsule endoscopy were developed based on canine models (Filip et al. 2011, Filip et al. 2013). The usefulness of capsule endoscopy in diagnosing macroscopic changes in dogs remains insufficiently investigated. Patient preparation for the procedure remains the main problem in capsule endoscopy. The preparation protocols applied in colonoscopy and panendoscopy may not produce the desired diagnostic yield because residual digesta cannot be removed from the capsule's field of view. In capsules designed for small bowel evaluations in dogs, batteries support continuous operation for 11-12 hours. During that time, the camera takes images of the stomach and the small bowel, and the large bowel can also be examined, in whole or in part, when the capsule moves fast through the GI tract. In dogs, capsule transit times may vary due to differences in the structure and motility of various sections of the alimentary canal and when different patient preparation protocols are applied. Transit time should be estimated before the procedure to speed up capsule passage in the event of a delay.

The objective of this study was to evaluate the quality of macroscopic images and mean capsule transit time through various sections of the gastrointestinal tract in dogs subjected to different preparation protocols before capsule endoscopy.

Materials and Methods

The experiment was performed with the use of 16 MiroCam Intromedic (Seoul, South Korea) endoscopic capsules measuring 24x11 mm (Fig. 1) and Miro View 2.0 image processing software. It was conducted on 8 healthy dogs, including 6 mixed-breed dogs and 2 German shepherds, represented by 4 males and 4 females, with body weight of 20-26 kg. The animals were subjected to clinical tests, blood morphology and serum biochemistry tests before the procedure. All dogs were fed identical dry feed.

Every patient was subjected to two endoscopic examinations, conducted at an interval of one month, that differed in preparation method. In the first

Fig. 1. MicroCam endoscopic capsule measuring 24x11 mm.

experiment (I), the colonoscopy preparation protocol was applied. The dogs were fasted for 48 hours during which they were administered *per os* 0.9% NaCl solution at 30 to 40 ml/kg BW 24 and 20 hours before the procedure. A warm water enema was performed 24 and 4 hours before capsule ingestion. In the second experiment (II), saline solution was replaced with macrogol (Fortrans). One sachet of the product was dissolved in 1 liter of water, and it was administered *per os* at the dose of 25-30 ml/kg BW 18 and 12 hours before the procedure. After the second administration, the patient should excrete colorless or slightly yellow fluid.

Electrodes and a data receiver MR 1000 installed on the patient (Fig. 2). Nine electrodes were attached to shaved and degreased skin in the central region of patient's front abdomen (Fig. 3). The data receiver was attached to the patient's dorsal region with the use of a harness and elastic bandages (Fig. 4). The capsule was activated by placing it between moistened paw pads of the front limb. After capsule activation (sound and indicator signal), the patient was forced to swallow the capsule, and special attention was paid to ensure that it was not damaged in the oral cavity. The dogs were handed back to the owners after the installation of the data receiver. The images were transmitted to the data receiver by relying on the body's natural ability to conduct current (HBC technology). At the end of the experiment (memory disc was full or the capsule was excreted with feces), the data receiver was removed and connected to a computer to record images on a hard disc in the Miro View 2.0 application. The program supports macroscopic evaluations of the gastrointestinal mucosa (the camera takes 3 images per second with 320x320 image resolution), determination of capsule location and transit time. Capsules were administered to the patients between 8 and 9 a.m., and their position was monitored directly after swallowing and after 6 and 12 hours.

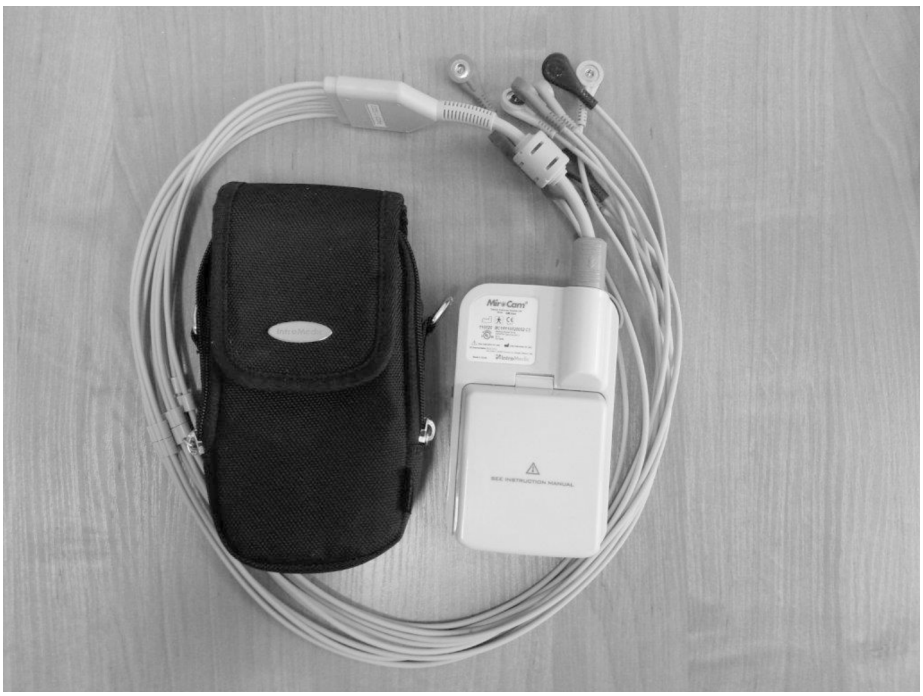

Fig. 2. Data recorder with a battery and electrodes.

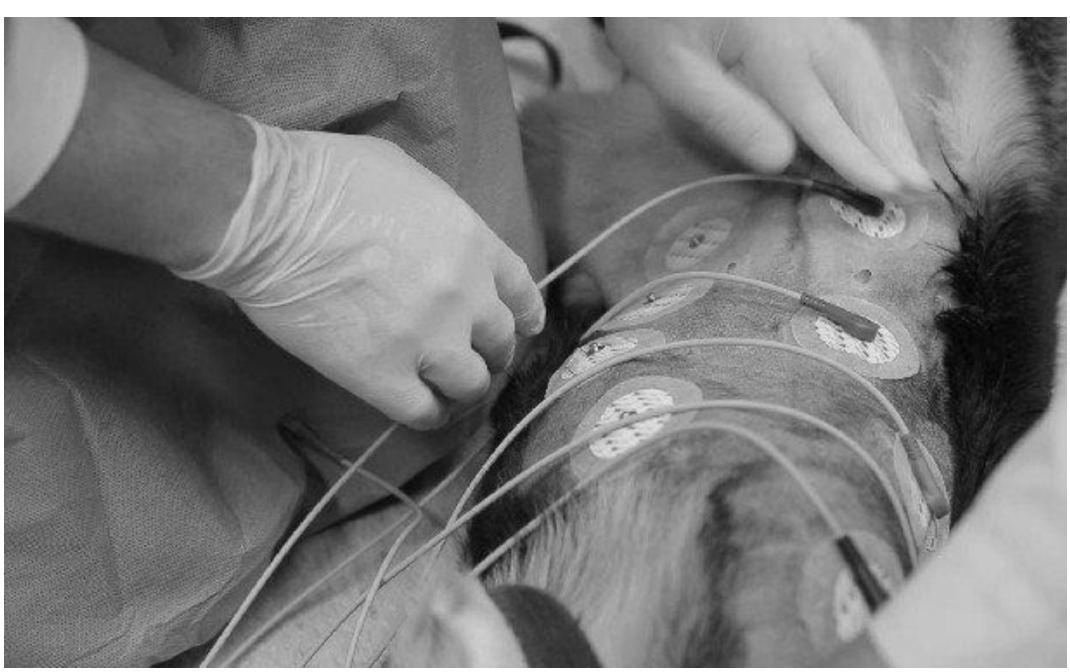

Fig. 3. Attachment of electrodes to the patient's abdomen.

During macroscopic image analysis, the presence of digesta and capsule transit time through different sections of the GI tract were determined. Image quality was classified as: good (+) – no digesta in the GI tract, with possible small, individual granules of undigested feed; satisfactory (+/–) – small amounts of liquid digesta in the GI tract that locally impair the view of the small and large bowel mucosa; and poor (-) – large amounts of digesta prevent accurate examination of the intestinal mucosa.

The significance of differences in the time of capsule transit through different sections of the GI time between experiments I and II was evaluated by Student's t-test. The results were processed at two levels of significance: significant difference ($p=0.05$) marked with the symbol "*", and highly significant difference ($p=0.01$) marked with the symbol "**". An absence of asterisks implies that the results were not statistically different.

Fig. 4. Installed electrodes and data recorder.

Results

All ingested capsules were excreted with feces. The longest capsule passage time was 3260 minutes (54 h and 20 min), and the shortest – 479 minutes (7 h and 59 min).

The quality of macroscopic gastric images was good in both experiments. Grass leaves were observed in only one patient in experiment I, but they did not impair the view of the mucosa due to gastric contractions. In all the animals, the capsule remained for the longest time in the pyloric area of the stomach.

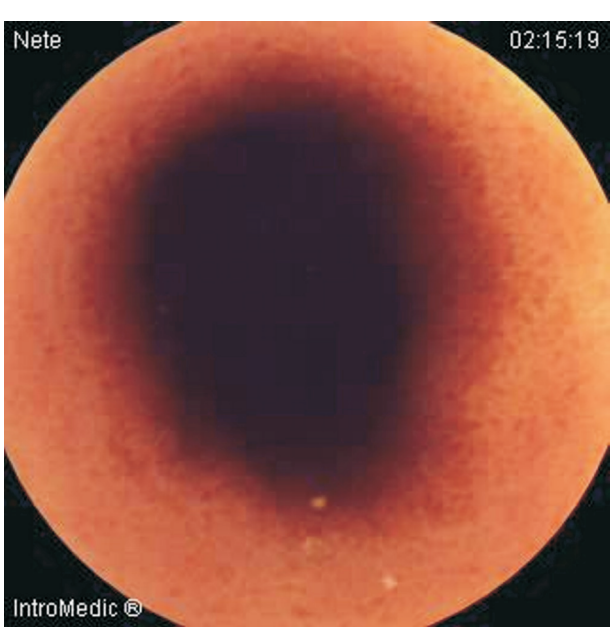

Fig. 5. Good quality image – no digesta in the GI tract.

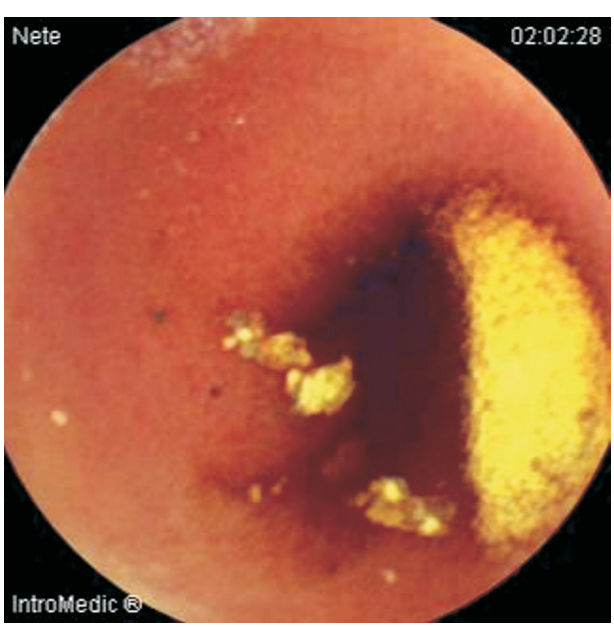

Fig. 6. Satisfactory quality image – small amounts of liquid digesta in the GI tract.

In experiment I, the quality of macroscopic images of the small bowel mucosa was evaluated as good in only 50% of patients (Fig. 5) and as satisfactory in the remaining 50% – 4 dogs (Fig. 6). In experiment II, where dogs had been administered macrogol, the image quality was good in all 8 patients. Small feed

Table 1. Quality of macroscopic images obtained in dogs in experiments I and II.

Dog	Experiment I			Experiment II		
	stomach	small bowel	large bowel	stomach	small bowel	large bowel
1	+	+	–	+	+	+
2	+	+/–	–	+	+	+/–
3	+	+/–	+/–	+	+	+
4	+	+/–	+	+	+	+
5	+	+	+/–	+	+	+/–
6	+	+	+/–	+	+	+/–
7	+	+/–	–	+	+	+/–
8	+	+	–	+	+	+

Image quality: good – (+), satisfactory – (+/–), poor – (–)

Table 2. Time of capsule transit (in minutes) through the canine gastrointestinal tract in experiments I and II.

Dog	Experiment I				Experiment II			
	stomach	small bowel	Large bowel	total transit time	stomach	small bowel	Large bowel	total transit time
1	160	113	720>	720>	154	103	410	667
2	410	138	720>	720>	252	99	720>	720>
3	40	91	348	479	79	126	324	529
4	100	118	369	587	91	113	720>	720>
5	109	159	720>	720>	55	147	353	555
6	235	107	720>	720>	174	102	720>	720>
7	67	118	720>	720>	186	116	346	648
8	197	206	720>	720>	122	122	720>	720>
x	164.5	131.2	–	–	139.1	116	–	–

Significance of differences.
* at p=0.05 – significant differences; ** at p=0.01 – highly significant differences

granules that did not impair the view of the mucosa were noted for short periods of time in only two dogs. In examinations that produced images of satisfactory quality, digesta did not adhere to the capsule lens during passage through the small bowel. The results of the evaluation of the small intestinal mucosa in experiment I are presented in Table 1.

In experiment I (without macrogol), the quality of macroscopic images of the large bowel mucosa was evaluated as poor in 50% of the patients (4 dogs). The large intestine was filled with large amounts of liquid digesta that impaired the view of the mucosa. In 3 dogs, the image quality was evaluated as satisfactory due to the local presence of large amounts of digesta that prevented a comprehensive examination of the colon. In experiment I, macroscopic images of the good quality were reported in only 1 patient. In experiment II, where dogs had been administered macrogol, none of the acquired images were evaluated as poor. The image quality was regarded as satisfactory in 4 dogs and as good in the remaining 4 animals. The results of the evaluation of the small bowel mucosa in experiment II are presented in Table 1.

In experiment I, gastric transit time (GTT) varied significantly between 40 and 410 minutes. The average GTT was 164.5 minutes. In experiment II, where dogs had been administered macrogol before the procedure, the shortest GTT was 55 minutes and the longest – 252 minutes. The average GTT was similar in both experiments at 164.5 minutes in experiment I and 139.1 minutes in experiment II. GTT values in both experiments are shown in Table 2.

Small bowel transit time (SBTT) was similar in both experiments. In experiment I, the shortest SBTT was 91 minutes and the longest – 206 minutes. In experiment II, the shortest SBTT was 99 minutes and the longest – 147 minutes. SBTT values in both experiments are presented in Table 2.

In experiment I, in 6 dogs (75%), the capsule remained in the large bowel until the battery ran out. It was evacuated from the large intestine before battery depletion in only 2 patients. In experiment II, in 4 dogs (50%), the capsule had been excreted with feces before the battery was depleted and data transfer was interrupted. In the remaining 4 patients, the capsule had not left the gastrointestinal tract before battery depletion. Large bowel transit times (LBTT) in both experiments are shown in Table 2. In experiment I, total transit time (TTT) was longer than 720 minutes in 6 dogs (75%), and lower TTT values were observed in only two dogs at 479 and 587 minutes, respectively. In experiment II, TTT values exceeded 720 minutes in 50% of patients, and the shortest TTT was 529 minutes. TTT values in both experiments are presented in Table 2.

Discussion

Elastic bandage was used in the experiment to stabilize and protect the electrodes. In all 16 endoscopic examinations, none of the electrodes became detached, and they remained correctly positioned until the end of the exam. Elizabethan collars had to be used in some dogs to prevent equipment damage. Standard cotton bandage was not effective in keeping the electrodes and the data register in place. Cotton bandages were frequently displaced, causing the electrodes to come off and the data register to slide down to the animal's flanks. There is another way of fixing the data reciever using data belts with special pocket. In this experiment, Sorimex EK-s-56P liquid gel ECG electrodes were used because the original electrodes supplied with the endoscopic capsules weakly adhered to the patient's skin, even after it had been thoroughly shaved and degreased. The animals were kept active during image recording to ensure effective capsule passage.

It is very important to remove any residual digesta prior to the capsule endoscopy examination. In this study, macroscopic images obtained from dogs that had been prepared in line with the colonoscopy protocol and dogs that had been administered macrogol (experiment II) were compared. The quality of mucosal images was significantly higher in experiment II, in particular in distal segments of the GI tract. The quality of gastric images was similar and evaluated as good in both experiments. Differences in the quality of macroscopic images between the two groups of dogs subjected to different preparation protocols were observed during examinations of the small bowel mucosa. The administration of macrogol improved the quality of images of the small bowel mucosa, which was evaluated as good in all dogs. In experiment I, good image quality was determined in only 4 dogs, and images of satisfactory quality were reported in the remaining 4 animals. Large amounts of digesta present in distal sections of the jejunum and in the ileum impaired the view of the mucosa. An improvement in the image quality was noted after several peristaltic movements, but it was followed by repeated deterioration. In capsule endoscopy, air cannot be insufflated into the intestinal lumen, and even small amounts of residual digesta can affect diagnostic yield. The results of this study indicate that the colonoscopy preparation protocol applied in experiment I is not fully satisfactory and can lower the quality of macroscopic images of the gastrointestinal mucosa.

Capsule transit time is an important consideration in capsule endoscopy due to limited battery life. In the capsules used in this experiment, batteries supported continuous operation for approximately 720 minutes (12 hours). In experiment II, the patients had been administered macrogol before the procedure. Macrogol is a laxative that promotes intestinal peristalsis. The administered substance contributes to the quality of macroscopic images, and it can also speed up capsule passage through the gastrointestinal tract. Capsule transit times have been evaluated by very few studies, and the existing research reveals significant variations in this parameter. In a study by Boillat et al. (2010a) who evaluated the effect of body weight on transit times of endoscopic capsules, GTT values were determined in the range of 405 to 897 minutes, and they exceeded the battery life of 720 minutes. In our experiment, GTT values were smaller, reaching 164.5 minutes in experiment I and 139.1 minutes in experiment II on average, with the longest GTT of 410 minutes. SBTT values reported in this experiment were similar to those noted by Boillat et al. (2010a). In our study, the average SBTT values were similar in both groups at 131.2 minutes in experiment I and 116 minutes in experiment II. Somewhat lower SBTT values in the range of 96 to 224 minutes were reported by Boillat et al. (2010a). In the two compared studies, capsules remained for the longest time in the large bowel. The longest LBTT was 2573 minutes (42 hours) in the work of Boillat et al. (2010a) and 3060 minutes (51 hours) in our experiment. In our study, no significant differences in GTT and SBTT values were observed between the animals subjected to different preparation protocols. A statistical analysis of LBTT values in both experiments could not be performed because in most dogs, the capsule had remained in the large bowel until battery depletion. Capsule transit times can be influenced by the animal's size and the length of the alimentary tract, but no correlations were observed between body weight

and capsule transit time (Boillat et al. 2010a). No variations in gastrointestinal tract motility were observed in measurements performed with the use of endoscopic capsules and scintigraphy (Boillat et al. 2010b).

The results of the present study indicate that macrogol administration before capsule endoscopy can improve the quality of macroscopic images. The colonoscopy preparation protocol does not always support accurate visualization of the large intestinal mucosa and, in selected patients, also the small intestinal mucosa. Macrogol administration had no effect on the time of capsule passage through the gastrointestinal tract, and no significant differences in transit times were noted between the two experiments. The average times of capsule passage through the stomach and the small intestine were shorter in the macrogol group, but further studies with larger sample size are required to validate the above observations. The capsules used in endoscopic evaluations of the small bowel in humans may have limited applications in macroscopic examinations of the large bowel mucosa in dogs due to long times of passage through this section of the GT tract. The administration of prokinetic drugs to speed up capsule passage through the alimentary canal is not always effective. In a study by Hwa-Seok et al. (2008), metoclopramide did not shorten total transit times, and lower TTT values were obtained when water was used. In our experiment, the entire GT tract had been successfully visualized before battery depletion in only 50% dogs in experiment II and in 25% of dogs in experiment I. The battery capacity of the capsules applied in this experiment was insufficient to comprehensively visualize the gastric, small and large bowel mucosa in most patients.

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