Capsule endoscopy: Improving transit time and image view

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INTRODUCTION

The capsule endoscopy (CE) is well accepted as a tool for evaluating small bowel pathology\(^1\)-\(^8\). However, this new technology has several limitations, i.e., the time required to study the video, it takes an hour to watch the video of the small bowel and the residual material, especially in the ileum adversely affects the image\(^9\)-\(^17\). Stomach emptying and small bowel motility depend upon a number of factors, such as the composition of the food and fluid in the gastrointestinal (GI) tract, diseases, etc. In addition, transit time differs according to whether the individual has eaten or is in a fasting state. The initial capsule experiences showed that the cecum could not be viewed in approximately 20% of the study population because of the short battery life, because the capsule had remained in the stomach for more than 60 min\(^18\)-\(^20\), and for a variety of other reasons. A shorter transit time would be directly beneficial in obviating the first two problems.

The CE is completely different from the standard endoscopy that allows the endoscopist to remove all the residual material to improve the image. In most CE studies, the image quality in the proximal small bowel is much superior to that in the distal ileum, due to residual material.

The reasons that some physicians refuse to adopt the CE study are the time consuming viewing procedures and the frustration of being unable to view the entire small bowel because of the residual material. So far there is still no definite answer to the question of which is the best way to prepare patients for the CE study. The Given Imaging Ltd recommendation is a 12-h fast prior to the CE study with no other preparation. Most of the published studies followed this recommendation and although other methods of preparations were mentioned, no comparative study was made.

In this study, we designed to determine the best preparation to provide the most complete visualization of the entire small bowel, as well the best preparation for rapid gastric emptying times.

MATERIALS AND METHODS

Study population

A retrospective study was performed on 97 patients who underwent the CE study (Given\(^\text{®}\) M2A video capsule system, Given Imaging Ltd, Yokneam, Israel) between August 1st,
Capsule endoscopy
After an overnight fast of 12 h, all patients ingested the CE (Given® M2A video capsule system). An array of eight sensors was attached to the abdominal wall, and a belt holding a recorder with a battery was fastened around their waists. Patients were allowed to drink 2 h after ingesting the capsule and to eat a light meal 3 h later. After ingesting the capsule with a small amount of water, patients were free to go about their own activities. Seven to eight hours after ingestion, the recorder was disconnected and the sensors removed. The recorded digital information was downloaded into the computer, and images from the stomach and all along the small bowel were analyzed using the proprietary RAPID® software.

Patients were asked to look for the capsule in the feces. All capsules were retrieved 24 h to 5 d after ingestion, except for one patient who had a non-natural excretion (the patient underwent surgery and was found to have Meckel's diverticulum). All patients signed an informed consent agreement approved by the Local and Governmental Helsinki and Ethical Committees.

Preparation of the sub-groups
They were divided into three study groups according to the preparation used. Group A (n = 26) was prepared with 3 L polyethylene glycol (PEG 400, Taro, Israel), given in two divided 2 doses, i.e., 1.5 L, 12 h before swallowing the capsule and 1.5 L, 1 h after swallowing the capsule, or with 90 mL of sodium phosphate (SP, Dexxon, Israel), given in capsule and 45 mL, 1 h after swallowing the capsule. When we analyzed each preparation separately, we realized that there was no statistical significance and so made them into one group. Group B (n = 29) was prepared by 200 mg erythromycin (Teva, Israel) in liquid from 1 h prior to the CE study and group C (n = 40) without any preparation. All patients ingested the CE after an overnight fast of 12 h. We arbitrarily divided them into three age groups: 17-40, 41-60, and above 60 years of age.

There were several reasons for colonic preparation. The subjects who needed GI evaluation (e.g., unexplained iron deficiency anemia, etc.) underwent colonoscopy on the same day. Another reason was that part of the clinical study was to compare standard colonoscopy with wireless colonoscopy (unpublished data). In our initial experience with the capsule, we found that the distal part of the ileum was not clean enough for visualization and we, therefore, decided that one group of patients had to undergo colonic preparation. Another problem is the short battery life of the capsule (approximately 7 h), which may not be sufficient to image the entire small bowel. We hypothesized that some colonic preparation or erythromycin might accelerate the movement of the capsule and also provide a better view of the entire small bowel.

Reading of the capsule endoscopy
The transit time, from the first view of the gastric mucosa up to the pyloric region and the small bowel transit, was calculated from the first view of the duodenum up to the ileocecal region. The video results produced from the data recorded by each capsule were reviewed independently by one of the experts (FZ) who was unknown to the clinical data. Capsule transit times were evaluated by analysis of the videos generated during the CE passage.

The quality of the image, on a scale of 1-5, ranged from good (1) with more than 10% of the view with residual material, to poor (5) with more than 90% with residual material.

Statistical analysis
The gastric emptying time and the small bowel transit time was analyzed by computerized software SPSS. The differences in transit time and sub-groups preparation (correlated to age, gender, and normal or abnormal findings) were analyzed by ANOVA multi-changes test. The differences in transit time and preparation were analyzed separately, by ANOVA test, in each of the three sub-groups.

RESULTS
Ninety-five patients (55 men and 40 women, aged 18-91 years, mean age 50.1±17.5 years) were enrolled in the study (Table 1). The reasons for the CE studies: iron deficiency anemia (49 patients); abdominal pain/irritable bowel syndrome (27 patients); suspected Crohn’s disease (9 patients); and miscellaneous disease (10 patients) (celiac disease, familial adenomatous polyposis, intestinal lymphoma, ulcerative colitis, Table 1).

There were pathological findings in 54 (56.8%) patients, such as angiodysplasia, ulcer, suspected Crohn’s disease, erosions, polyps, edematous mucosa, etc. In 17 cases (17.9%), the capsule failed to reach the cecum before the end of the -420 min recording time.

| No. of patients                  | 95 |
|---------------------------------|----|
| Gender male/female              | 55/40 |
| Mean age (yr)                   | 50.1 |
| Indications of the CE study     |     |
| Iron deficiency anemia          | 49 |
| Abdominal pain/irritable bowel syndrome | 27 |
| Suspected Crohn’s disease        | 9  |
| Miscellaneous disease           | 10 |

Miscellaneous disease includes celiac disease, familial adenomatous polyposis, intestinal lymphoma, and ulcerative colitis.
The mean gastric emptying time was 41.7±51.5 min and the transit time of the small bowel was 225±80.6 min of the entire study group. The gastric emptying time in the group prepared with erythromycin was shorter but not statistically significant (Table 2). In elderly subjects prepared by PEG or SP, the gastric emptying time was significantly longer (163.7 min) compared to the other preparations (P = 0.05, Table 3). The small bowel transit times were similar in the three age sub-groups; however, a non-significant shorter transit time was seen in the mid-age group (41-60 years) prepared with PEG or SP (Table 3). The gender and pathology neither affected the transit time of the whole study group nor that of the three age sub-groups.

The grade of the cleaning of the entire study group was 3.27±1.1, on a scale of 1 (best image) to 5 (worst, Table 4). In comparison with the other sub-groups, the erythromycin group significantly presented the worst quality of image (P = 0.05). Age, gender, and pathology had neither effect on the quality of the cleaning of the entire small bowel study group nor on the arbitrarily selected three age sub-groups (Table 4).

The capsule passed through without difficulty in all cases except for one (1.05%) patient who had no natural excretion, and was found to have Meckel’s diverticulum (the Meckel scan that was done prior to the CE study was interpreted as normal).

The average amount of time needed for an expert to review one video was about 50 min.

| Groups   | Emptying gastric time (min) | Small bowel transit time (min) | P       |
|---------|-----------------------------|--------------------------------|---------|
| Group A (n = 26) | 53.1                        | 216                            | NS      |
| Group B (n = 29) | 26.4                        | 240                            | NS      |
| Group C (n = 40) | 45.5                        | 218                            | NS      |

Group A: prepared by PEG or with SP; group B: prepared by erythromycin; group C: without any preparation; NS: non-significant.

| Groups   | Grade of cleaning |
|---------|-------------------|
| Group A (n = 26) | 3.1±1.18         |
| Group B (n = 29) | 3.7±1.09         |
| Group C (n = 40) | 3.0±1.06         |

Group A: prepared by PEG or with SP; group B: prepared by erythromycin; group C: without any preparation.

| Groups   | Emptying gastric time (min) | Small bowel transit time (min) |
|---------|-----------------------------|--------------------------------|
| Age (yr) | Age (yr)                     |                               |
| 17-40   | >60                          | 17-40                          | >60 |
| Group A (n = 26) | 16.8                        | 46.5                           | 163.7 |
| Group B (n = 29) | 31.6                        | 27.7                           | 22.5  |
| Group C (n = 40) | 54.2                        | 46.9                           | 34.5  |

Group A: prepared by PEG or with SP; group B: prepared by erythromycin; group C: without any preparation. P = 0.05.

DISCUSSION

The Given Diagnostic Imaging System M2A Capsule is a new system designed to aid the gastroenterologist in diagnosing small bowel diseases[5,7-9].

The ingestible capsule records video images during natural propulsion through the digestive system. Averages of 50 000 images are obtained during the 8-h passage of the capsule. The CE is propelled by peristalsis through the intestinal tract and permits direct viewing of the entire small intestine[5-9]. From the initial capsule experience, we learned that in approximately 20% of the study population, the capsule did not reach the cecum (the view not the capsule) for several reasons: short battery life (7 ± 1 h); the capsule remaining in the stomach for more than 60 min; and as well the quality of the image, especially in the distal part of the ileum. Practical experience has shown that visualization of the entire small bowel mucosa may sometimes be hindered by the presence of residual material. For these reasons, in some of the CE studies, it was impossible to visualize the entire small bowel[5-7].

More than 180 000 patients worldwide have swallowed the CE. It is estimated that 19 million people in the USA alone may suffer from diseases related to the small intestine, including obscure bleeding, irritable bowel syndrome, Crohn’s disease, chronic diarrhea, and cancer. Hence, these will expand the need for CE, and endoscopy services are under increasing strain and to read one CE study takes approximately 1 h of the very expensive time of an expert endoscopist. This could well be the reason that some physicians refuse to adopt the CE study[5-9]. CE is a diagnostic tool with enormous potential and our expectations are that it will yield answers that other procedures are not capable of providing, and with time demand for CE, studies will grow.

There is a lack of data of the effect of colonic preparation on the stomach and the small bowel. Recently, Basit et al[10], have demonstrated that PEG 400 has a marked accelerating effect on small intestinal liquid transit, which, in turn, has implications with PEG 400. In addition, SP effectively shortens small bowel transit time[11]. On the other hand, Sood et al[13], found no significant difference in the mean transit time in the stomach, duodenum, and small bowel between PEG 400 and plain water. The macrolide antibiotic erythromycin has been known to be associated with increased GI motility because of its introduction more than 35 years ago and evidence for its therapeutic efficacy in gastroparesis[13,14]. However, regarding the effect of erythromycin on the transit time of small bowel and its cleaning effect, we have no data. At present, the two major requisites are image quality improvement and reduction of...
the time spent in viewing the CE videos.

As shown by our study, the gender and the presence of pathology lesions had no impact on the cleaning and transit time. Preparation with erythromycin reduced the transit time in the stomach (especially in 40-60-year-old age group), but had a negative effect on the quality of the image in the small bowel. In elderly patients, small bowel transit time and gastric emptying time were significantly longer in those prepared with PEG or SP when compared to the other preparations (P = 0.05), but with no effect on the quality of the image.

To the best of our knowledge, this is the first time a study tried to deal with the problems of image quality improvement and reduction of CE viewing time through evaluation of various preparation techniques. After testing the various preparations, we had to concede that they neither offered any improvement in the time needed to read the study nor in image quality over the 12-h fasting period as recommended by the Given Company. Even though erythromycin has the best effect on gastric emptying time, the quality of the view in the small bowel is the worst, for which we have no explanation and preparation with PEG or SP has a negative effect on the transit time of the small bowel. We need other pharmaceutical tools and/or technical aid to improve the time and the quality of the CE study.

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