A Systematic Review on the Passive Video Capsule Endoscopy

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Abstract

Digestive tract disorders are considered as one of the most fatal human diseases. There exist several medical treatment methods that enable timely diagnosis of these diseases, among them the video capsule endoscopy is the new invented one. In this procedure, a device similar to a vitamin pill is swallowed and takes images during its passage. The images will be sent to a computer system and can be observed. The driving agent is based on the natural movements of the digestive tract movements, called peristaltic movements. This type of video capsules is called passive video capsule. In this paper some passive video capsules, along with the clinical tests performed by them, are introduced. The aim of this review is to evaluate the performance of passive video capsule in detecting digestive tract diseases.

Keywords: Digestive tract, Passive video capsule, video capsule endoscopy, wireless capsule endoscopy

1- Introduction

Gastric Cancer is the second leading cause of deaths among all types of cancers [1]. Besides, other Gastrointestinal (GI) tract disorders have always been challenging in diagnosis and treatment, due to the difficulty in accessing the GI environment [2]. Timely and early diagnosis of the GI-tract diseases has a significant impact on the treatment process. In this regard, endoscopy systems are valuable instruments by which many serious disorders can be diagnosed [3]. Although endoscopy is a worthy method, some drawbacks exist in this procedure, such as pain and un-comfortability for the patients, as sometimes it requires aesthesia for the patients, limited access to small intestine, due to its twisted nature, and finally this job is a tedious job for the therapist. These problems led to the development a robotic endoscopy system, called video capsule endoscope or wireless capsule endoscopy, which includes a vitamin size device that will be swallowed by the patient. The capsule will take images during its passage through the GI-tract. Another equipment for this robotic endoscopy is a station, where a computer exists and a special software in installed on it. Then, a specialist can see the images, in real time, and diagnose the injuries. This method, lasts about 6 to 8 hours [4, 5].

The capsules move by the help of GI-tract movements. In other words, the natural peristaltic movements of GI-tract make the capsule to move forward. This kind of capsule are called passive video capsules [6, 7]. In this paper, some passive video capsule models are introduced, along with the clinical test performed by them, if available. The aim of this review is evaluating the performance of passive video capsule in the GI-tract diseases detection.

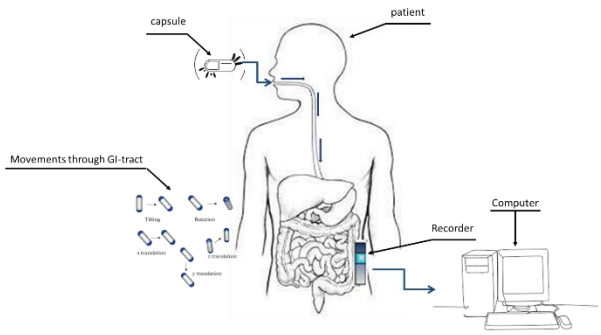

Fig. 1. The procedure of Video capsule endoscop

2- passive video capsules

In the video capsule endoscopy, which lasts between 6 to 8 hours, a capsule will be swallowed by the patient. The capsule which contains camera, takes images through its passage and sends them to a computer system, via a recorder. The specialist can observe the images of the different parts of GI-tract. This procedure is depicted in figure 1. In this part, the passive video capsules are introduced. They are highlighted based on their dimensions, imaging features and the clinical test (if available), along with the results.

2.1. M2A

The first swallowing video capsule, utilized for small intestine observations, was presented by *Given Imaging* Co. and named *M2A* [8]. In 2002, the company introduced *M2A™ Plus* and made it possible to know the location of capsule, with an accuracy of ±3 cm [9].

Imaging Specifications: Field of view 140˚, Magnification factor1:8, Resolution 0.1 mm, and Imaging rate 2 images/second [8,9].

Dimensional Specifications: 11mm×26 mm

Weight:3.7 grams [8.9].

Clinical Test: -

Results: -

2.2. PillCam SB and PillCam SB2

PillCam SB was also offered by *Given Imaging* Co. for providing images of small intestine. It differs slightly from the previous one; *PillCam SB* has a single lens, while *PillCam SB2* has three lenses. *PillCam SB* is based on standard light control, but *PillCam SB2* is based on advanced automatic light control [8, 10].

Imaging Specifications: the specifications of the PillCam SB were Imaging rate 2 images/second, Field of view 140˚, and the coverage area 500 mm^2, and for the video capsule SB2 are: Field of view 156˚, the coverage area 1100 mm2 [8,10].

Dimensional Specifications: 11mm×26 mm [8,10].

Clinical Test: A two-year study on 122 consecutive patients in New Zealand [13].

Result: The OGIB[1] disorder was the most common reason for referral of patients. The general diagnosis procedure for relevant findings was 52% in Angio ectasia which was the most common specific finding. Also, the overt bleeding disorder was detected in inpatient subjects and 12% of subjects, mainly in male gender, had incomplete examination.

Second Clinical Test: Another experimental study was performed for the first time to describe the endoscopic aspects of small intestine diseases through PillCam SB [14]. The capsule was tested on the patients with

[1] Obscure Gastro Intestinal Bleeding

portal hypertension due to Schistosomiasis in order to evaluate the efficiency of the technology in esophageal varices diagnosis. For this purpose, nine nonrandomized patients with this problem were selected. They didn't have previous GI bleeding, according to PillCam SB's findings.

Result: The OGIB disorder was the most common reason for referral of patients. The general diagnosis procedure for relevant findings was 52% in Angio ectasia which was the most common specific finding. Also, the overt bleeding disorder was detected in inpatient subjects and 12% of subjects, mainly in male gender, had incomplete examination.

Furthermore, using the capsule, esophageal varices, Angio ectasias and Ven ectasias were found in all patients. Erosions were found in 88.9%, edam was detected in 66.7%, scarred mucosa was found in 55.6% and small bowel varices was detected in 22.2% [15].

2.3. PillCam ESO

The *PillCam ESO* was also developed by *Given Imaging* Co. to visualize the oesophagus, stomach and proximal duodenum

[8, 11]. The FDA clearance for this device was approved in November 2004. This model contained two cameras located on the two domes and made it possible to take images from its two ends.

Imaging Specifications: Imaging rate 14 frame/second, Field of view 140˚ [8,11].

Dimensional Specifications: 11mm×26mm [8,11].

Clinical Test: The first clinical trial on PillCam ESO was related to disorder diagnosis [8,11].

Result: Successful in detecting GERD [2] disorder [8,11].

2.4. Olympus Video Capsule

This video capsule, called Endocapsule, was introduced in October 2005 by *Olympus Corporation* (Tokyo-Japan), which held a CCD[3] sensor camera [8].

Imaging Specifications: Variable depth of view from zero to 20 mm, Imaging rate 2 images/second [8].

Dimensional Specifications: 11mm×26 mm [8].

Clinical Test: A comparison between the Endocapsule (Olympus America) and PillCam SB was provided by testing both of them on OGIB patients [11].

Result: Both devices (the Endocapsule and PillCam SB) were safe, subjective difference in imaging quality, providing unique data about capsule navigation in small intestine and lack of electromechanical interference between two capsules [11].

2.5. PillCam Colon Capsule (PCC)

This capsule was another product of *Given Imaging* Co. for the Colon observation [12]. The colon is anatomically different from small intestine. It is wider in diameter; therefore, the capsule would overturn during its motion, leading to taking repetitive or unnecessary images. This problem has been

[2] Gastro Esophageal Reflux Disease

[3] Charged-Coupled Device

solved by adding another camera to the other side of the capsule, creating PillCam Capsule 2 [13].

Imaging Specifications: The angle of view 154 to 172 degrees, imaging rate 4 to 35 images per second [12,13].

Dimensional Specifications: 31mm×11mm [12,13].

Clinical Test: An experimental test performed on 12 patients who had incomplete colonoscopy confirmed that the PCC is safe for colon-clinical-examinations and can detect some GI disorders [18].

Result: 6 patients suffered from obstructing tumor of the left side of the colon and in 6 cases, there were technical problems. The PCC managed to visualize the rectum in one case. In 6 of 12 cases, the capsule failed to reach the position where colonoscopy was stopped, due to tumors and technical limitations. In 1 of 3 patients which the capsule could pass via site where the colonoscopy was stopped, poor preparation caused inappropriate examination of colon. 4 patients underwent a third colon examination. The study results demonstrated that while there were no adverse events related to PCC endoscopy; it is not always capable of examining the colon [18].

2.6. OMOM Capsule Endoscope

The OMOM Capsule Endoscopy (CE), was offered by Jinshan Science and Technology Company (China) [14-16]. Its features are very similar to PillCam SB. It was approved by the State Food and Drug Administration of China in March, 2004. The OMOM CE transmitted captured images via a digital radio frequency communication channel to the receiver. So, a real-time monitoring could be available.

Imaging Specifications: 140° field of view, resolution of 0.1 mm, and rate of two images per second [14,15,16].

Dimensional Specifications: 13 mm × 27.9 mm, weighs less than 6 grams [14,15,16].

Clinical Test: 89 patients suspected of intestinal diseases were recruited and performed the capsule endoscopy by OMOM CE on them [15].

Result: While the capsule failed in one patient, small bowel was completely observed. The rate of abnormality detection was 70.5% for small bowel diseases. OGIB diagnosis was higher than abdominal pain or diarrhea and the most common small bowel disorder was Angiodysplasia. The sites with bleeding in small bowel were detected in 11 cases. At the end of study, it can be concluded that OMOM CE is a useful tool to detect small bowel disorders.

Second Clinical Test: In another test study via OMOM CE, a database including 2400 Chinese patients who received OMOM CE in 27 endoscopy canters in China was prepared [15].

Result: The patients were suffered from OGIB, abdominal pain and chronic diarrhea. The overall diagnostic disorder was 47.7%, which was the highest in OGIB. There was no significant difference between men's and women's diagnosis [15].

2.7. MiroCam Capsule Endoscope

This wireless video capsule was introduced by IntroMedic, Korea and got Conformité Européenne mark in 2007 [17].

Imaging Specifications: resolution of 320 × 320, rate of three images per second, auto

lightning control, field of view of 170°, battery duration of 12 hours and size of 10.8 × 24.5 mm2 [19].

Dimensional Specifications: 24.5mm×10.8 mm [18].

Clinical Test: A study was done with the aim of comparing MiroCam CE with PillCam CE and targeted detection of source of OGIB [20].

Result: Both capsules could detect abnormalities in 48% of patients. Both video capsules were successful in the abnormality's detection in 58% of cases. In 2 cases, MiroCam could identify the source of OGIB which were not detected by PillCam. In 7 cases, PillCam was capable of identifying the OGIB sources which were not seen by MiroCam [20].

Second Clinical Test: In another study, the clinical impact and randomized performance of MiroCam was evaluated in comparison with the Endocapsule device. The primary goal of this study was to determine the rate of complete small bowel examination in 50 people. The secondary goal referred to diagnose disorders and the rate of re-bleeding in patients with overt or occult obscure GI tract [17, 21].

Result: The small intestine was examined completely in 48 cases by MiroCam and in 45 cases by Endocapsule. The correct diagnosis was obtained in 25 cases by MiroCam and in 24 of 25 cases by Endocapsule. Both capsules showed no significant statistical differences. Full examination of the entire small bowel was performed in 96% of cases.

Conclusion

Gastrointestinal disorders have become one of the major causes of deaths nowadays. However, early detection of these disorders plays an important role in the improvements and health recovery. In this regard, video capsule endoscopy is a new method, by which screening the GI-tract is easily accomplished. In this review paper, some video capsules are introduced, which are moved forward by the help of peristaltic motions of digestive organs, called passive video capsules. The search strategy includes the papers and case studies published from 2005 to 2013, as no newer study was found. Besides, the clinical tests, performed by these devices are also of interest.

As the results showed, the most referral disease, such as GERD and OGIB could be detected by capsule endoscopy method. On the other hand, injuries in different segments of GI-tract were detectable, such as esophagus, small intestine and colon. Some studies compared two different models with each other, [11] and [20], which indicated that this method was completely safe. The differences were in the images' specifications, where no significant statistical differences observed. Despite these successes in the diagnosis of the disease, the colon tumor could not be diagnosed, both by colonoscopy and capsule endoscopy, due to technical problems and the presence of the tumor in that area. It seems that utilizing capsule endoscopy requires special preparation before doing the procedure.

As mentioned before, this type of video capsules is driven forward by the help of peristaltic movements of GI-tract. Despite

usefulness of this type, these capsules have some limitations as follows:

• Duplicate images are taken due to slow motion of peristaltic movements, so the battery power will be wasted.

• The peristaltic movements of the GI-tract are uncontrollable, so the field of view in imaging would be limited and significant lesions maybe not seen.

• Since there is no control over the stopping and speed of inactive capsule, this mode is not appropriate for doing medical interventions such as biopsy, drug delivery and surgery.

• The passive capsules cannot move reversely; therefore, the specialist doctor cannot precisely evaluate the suspicious area and check them again.

These problems led to the development of active video capsules which are not included in this review.

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