International Journal of PharmaO2
Journal Home Page: http://www.ijpo.in/
(IJPO: A Peer-reviewed Bi-monthly online journal)

Review

Technologically Advanced Wireless Capsule Endoscopy (Camera Pill): A Review.

Srushti Sakpal, Ajinkya Patil*, Prasad Kharche

Dr. Bhanuben Nanavati College of Pharmacy, Vile Parle (West), Mumbai-400056 MS, India.

ARTICLE INFO

Article history:
Received: 04/09/2020;
Accepted: 07/09/2020;
Available online: 11/09/2020.

Key Words:
Nano-technology, Camera Pill, Capsule Screening, GIT disorders.

Please cite this article as: Patil, A. *et al.*, (2020). Technologically advanced wireless capsule endoscopy (camera pill): a review. *International Journal of PharmaO2*, 2(5), 0355-0361.

ABSTRACT

It is very difficult to examine the area inside our gastrointestinal tract due to its length, location and tortuosity. However, in the advent of advance technology called as 'Capsule Endoscopy' also known as the camera pill, helps to visualize the lining of the intestinal lumen. It is now a new era to strengthen the standards in diagnostics of small bowel disorders and used to examine parts of the Gastro-intestinal tract that cannot be seen with other types of endoscopy. In the present review, we have discussed about the techniques, structure, working, safety, clinical indications, and future applications of Capsule Endoscopy. As a capsule is ingested, it transmits images at 2 frames per second over the period of 8 hrs until the battery drains. It generates a high resolution image that allows detailed inspection of the gastrointestinal mucosa. A trained gastroenterologist reviews the images. A Capsule Endoscopy plays a vital role to detect coeliac disease, small bowel tumours and other small bowel disorders in patients. A Capsule Endoscopy is used in patients with suspected bleeding or to identify evidence of active Crohn's disease if not detected by lower and upper endoscopy. Typically, Capsule endoscopy is undertaken in case the other type of endoscopy has failed to diagnosis disease. Thus, it has made revolution in the field of medicine. The tiny capsule can pass through our body, without causing any injury or harm.

*Corresponding author: Mr. Ajinkya Patil, T.Y.B Pharmacy, Dr. Bhanuben Nanavati College of pharmacy, vile Parel, Mumbai, India. Contact:+91-9359206889, e-mail: patil.ajinkya071500@gmail.com

Introduction

The camera pill also known as Capsule Endoscopy or wireless (video) camera endoscopy (WCE). It is a diagnostic tool used to visualize the lining of the gastro-intestinal (GI) tract without a need for probe or in vasive surgery. It has been available for use since 1997 and had been given FDA approval in the year 2001(Lewis BS. *et al.*, 2002). The Capsule Endoscope is a 26 by 11 mm capsule containing a battery-powered

complementary metal oxide silicon imager (CMOS), a transmitter, antenna, lens four light emitting diodes (Iddan G., *et al.*, 2000). The weight of the devices ranges from 3.4gm – 3.8gm. Once capsule is ingested; it transmits images at 2 frames per second over the period of 8 hrs until the battery drains. It generates high-resolution images that allow detailed inspection of the gastro intestinal mucosa. A trained gastro enterologist reviews the images. With current technology, the products are manufactured out of castings through milling, grinding, and chipping processes. The technology used to achieve manufacturing at molecular level is 'NANOTECHNOLOGY'. Nanotechnology is the creation of useful materials, devices and system through manipulation of such miniscule matter (nanometer). Nanotechnology deals with objects measured in nanometer can be visualized as billionth of a metero million the of the millimeter or it is 1/80000 width of human hair. The capsule when swallowed, this tiny camera helps doctors to diagnose illnesses by transmitting close-up images of the digestive tract. The device, which is about an inch long and less than half an inch across, passes naturally through the body and it is discard.

The battery-powered digital video camera has its owns to pills emitting diodes and a transmitter. It relays pictures to a data recorder, which looks like a personal streo and is worn on a belt around the waist at the rate of two frames a second for about eight hours. Doctors download information from the recorder, into a computer to get a close up of a patient's digestive tract without the need for a hospital stay. Experts say the camera will make it faster and easier to diagnose life-threatening condition such as stomach and bowel cancer as well as ailments. The M2A (mouth to anus) capsule developed by U.S biomedical was the first available pill camera and was renamed a pill camera SB (small bowel). A patency capsule can be used to confirm intestinal patency prior to the endoscopy capsule. The leap in technology is great but is not going to stop here (frank j introduction to nanotechnology 2003).

Techniques

Before performing Capule Endoscopy, patients should fast for at least 8 to 12 hours. Since the capsule usually leaves the stomach within 30 min, the patient is allowed to drink only after 2 hrs and eat after 4 hrs. Images taken by the capsule are transmitted via eight sensors, which are secured to the abdominal wall. The equipment is removed after 8 to 12 hours (the approximate battery life) by which time the capsule has reached the caecum in 85% of cases. (Swain P et al .2004) As the procedure completes, the data is downloaded into a computer workstation which allows approximately 50000 images to be viewed as a video. The average time to visualize the video images takes between 40 and 60 min. The yield of Camera pill can be affected due to two problems as given below:

1. The presence of dark intestinal contents in the distal small bowel due to which mucosa layer cannot be seen.
2. The rate of gastric emptying and small bowel transit which could lead to the exhaustion of the capsule batteries before the capsule reaches the ileo-caecal valve, due to which incomplete examination occurs in 10–25% of cases. (Pennazio M. *et al.*, 2004; Ben-Soussan E. *et al.*, 2005). There are various abstracts and small number of studies addressing the use of bowel formulation such as oral sodium phosphate or polyethylene glycol solution to improve the bowel visualization and use of prokinetics like metoclopramide/ domperidone/ erythromycin to accelerate transit times thereby improving the condition of reaching the capsule towards the colon. It has been recommended in various literatures that by taking this approach, better quality of small bowel cleanliness is achieved (Fireman Z. *et al.*, 2004).

Basic Structure

The camera pill (Capsule Endoscopy) is made up of sealed biocompatible material to withstand acid, enzymes and other antibody chemicals in the stomach.

Optical Dome: It is front part of the capsule, in bullet shape that helps to propel the capsule forward easily. The optical dome contains the Light Receiving Windows.

Lens Holder: The Lens Holder accommodates the lens tightly inside the capsule so that it does not get dislocated anytime.

Lens:
Thelensisanintegralcomponentofthecapsule.Itisar rangedbehindthelightreceivingwindows.
Illuminating LED's: Around the lens and CMOS Image Senso, four LED's are present. These plural lighting devices are arranged in donut shape.
CMOS Image Sensor: It is the most important part of capsule. It is highly sensitive and produces very high-quality images. This is the beauty of the Capsule because it detect minutes object as less than 0.2 mm and work on a precision of 140 degree.
Battery: There are two batteries used in the capsule which are in button shaped. The batteries are arranged to get her just behind the CMOS Image sensor. Silver oxide primary batteries are used with batter life of 8 to 12 hrs.
ASIC Transmitter: The ASIC Transmitter is arranged behind the batteries. Two Transmitting Electrodes are connected to the outlines of the ASIC Transmitter.
Antennae: The Antennae is arranged at the end of the capsule. It is enclosed in a dome shaped chamber (Sidhu R. *et al*., 2004).

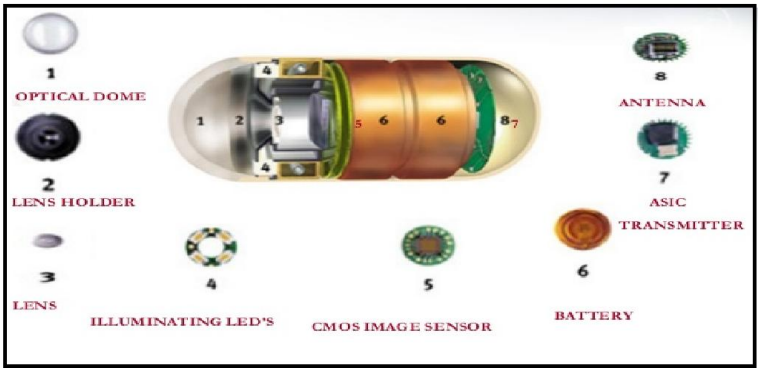

Fig 1: Inside the Capsule Camera

Fig.2: Images Captured from Camera Pill

Fig. 3: A. Sensor Array Belt; B. Pill Camera Data Recorder

Working

Intake of the camera pill

It is slightly larger than normal capsule 26 by 11 mm. The patient swallows the capsule and the natural muscular waves of the digestive tract propel it forward, over the eight hours, the pill travels passively down the oesophagus and through roughly 20 to 25 feet of intestines, where it will capture thousands of images. The patient feels nothing since it is painless.

Use of Power

The camera pill doesn't need a motor to move through the gut, but it does require milli watts to run its camera and lights. Batteries would be too bulky, so the camera draws its power through induction charging. A vest worn by the patient contains a coil that continuously transmits power.

Snapping

When it reaches the intestines, the pill cam begins capturing images (2 images per second). Fluorescent and white LEDs in the pill illuminate the tissue walls.

Spin up for Close-up

It has been revealed that in recent technology camera pill contains a permanent magnet to turn the inner capsule and the image sensor 60 degrees every two seconds. It completes a full swing every 12 seconds since the capsule takes about two minutes to travel one inch.

Data

The capsule transmits the data inside the recorder, the data is been saved to a standard SD memory card.

Deliver Video

Doctors download information from the recorder, into a computer to get a close-up of a patient's digestive tract. The software compiles thousands of overlapping images of an intestine with images of high megapixels. Doctor can easily magnify the infected area for detailed studies (Swain, C. *et al.,* 1997).

Table1: Some examples of Swallowble Camera Capsules

Model	Company Name	Physical Dimension	Image Rate& Resolution
Pilli Cam	Given Imaging	11*26 mm*mm	14imagespersecond,or2,600colourimages
Endo Capsule	Olympus Optical	11*26 mm*mm	2imagespersecond
Norika	RF System Lab	9*23 mm*mm	NA
Smart Pill	Smart pill Corp.	13*26 mm*mm	Only sensor discrete data
OMOM	Chongqing Jinshan Sci & Tech Co. Ltd.	-	VGA640*480,24bits Truecolour300,000pixels
Endoscope	Uni Kyungpook, KR	30*11 mm	-
IVP	IMD,DE	23*11 mm	-
SAYAKA	RF System Lab, JP	NA	2Mpixel
MiRo	-	-	320*320

Areas of Application

Camera pill usages in Capsule Endoscopy have found a wide range of disciplines like;

A. Crohn's Disease

Crohn's Disease is an idiopathic, chronic, transmural inflammatory process of the bowel that can affect any part of the gastrointestinal tract from the mouth to the anus. Including symptoms like diarrhoea & abdominal pain. The Camera pill is a disposable video camera that transmits high quality images of the small intestine mucosa. This enables the small intestine to be readily accessible to the physician for the presence of small bowel disorders such as Crohn's disease.

B. Ulcerative Colitis

It is a form of inflammatory bowel condition of the colon that is marked by remission and relaps, Major symptoms include rectal bleeding, passage of mucus &loss of weight.

C. Cancer Diagnosis

Cancer is a group of disease which involves uncontrollable & abnormal growth by means of potential to invade through various parts of the body**.** Nano-technology has greatly revolutionized the therapy of cancer. It minimizes the current limitations in conventional therapy.

D. Coeliac Disease

Coeliac disease called sprue or celiac, is an immune reaction to eating gluten which damages the small intestine's lining & prevents absorption of some nutrient. Including symptoms like anemia, loss of bone density, acid reflux & heartburn.

E. Examination of Esophagus

Using capsule endoscopy we can evaluate the muscular tube connecting mouth & the stomach (Esophagus) to look for abnormal, enlarged veins (varices).

F. Screen for Polyps

Capsule Endoscopy has also approved for people who have inherited syndromes causing polyps in the small intestine.

Indications

Small Bowel Capsule Endoscopy offers several advantages over traditional endoscopy procedures.

It does not require sedation, is less likely to cause discomfort and has fewer potential complications. First, it is a minimally invasive complementary option to existing colonoscopy. Its use can reduce the risk of bowel perforation.

Various advantages include:

- Harmless to the patient, no-scars as seamless penetration of pill into the gut.
- It can be easily swallowed.
- Easy diagnosis and faster recovery through instant treatment.
- Doctors can re-examine the images over & over again.

Contraindications

The pill will get stuck if there is any obstruction in small intestine. It is not possible to control the camera behavior. It is an all day test, although patients do not usual stay in the hospital to complete it.

- It is very expensive.
- Due to nano size the camera can capture images of only 70% of the digestive tract.
- It cannot be reused because it completes its voyage through the digestive system.

Future Developments

There has been improvement in Capsule Endoscopy technology day by day where the innovations have resulted in 18 FPS (9 FPS in each camera) video through a wide angle field of view, with the use of an advanced light adjustment control, resulting in good video quality with better z-line imaging (Swain, P. et al.2008). There are attempts at powering capsules wirelessly, increase power efficiency and data rate with wireless telemetry, quality improvement in image. The development of controlled capsules represents a good development because it would be easily handable and the gut would be easily inspected carefully by taking our time and the capsule could allow targeted biopsy with proper drug delivery system. Swain *et al*., first reported this novel technology in 2010, using a modified Pill cam Colon with one camera replaced by magnets. The magnetically manoeuvrable capsule appeared to be easily manipulated in the oesophagus and stomach using a handheld external magnet. A second study found encouraging results with > 75% of gastric mucosa visualised in 7 out of 10 patients undergoing the examination and no adverse events reported. Further studies using a magnetically steerable capsule with a magnetic guidance system similar to standard magnetic resonance imagers have been reported. In this case the capsule is manipulated using a joystick rather than a hand held paddle. Promising results were also achieved with all major areas of the stomach identified in > 85% of examinations. Comparison with conventional upper GI endoscopy was also encouraging with 58.3% of gastric lesions detected by both modalities, while 14 lesions were missed by MSCE and 31 lesions missed by OGD (that were seen on MSCE). The relative high cost of installing such a system is a major drawback to this technique. Self-locomotion strategies using paddling, legs, fish-like movement and external magnets have been tried on in vivo models of the stomach and colon with some element of success. Most utilise internal actuation mechanisms to mobilise attached legs or paddles. An externally connected cable allows a continuous power supply, steering mechanisms and retrieval of data images. (Quirini M. *et al.*, 2008; Rey JF. *et al.*, 2012).

Conclusion

Capsule endoscopy is one of the best technologies evolving the short comings of other available techniques to capture nano images of

small bowel giving the ultimate scope for the professionals to diagnose and an early treatment.

References

1. Lewis, B.S., Swain, P. (2002). Capsule endoscopy in the evaluation of patients with suspected small intestinal bleeding: Results of a pilot study. *Gastrointest Endosc*, 56, 349–353
2. Iddan, G., Meron, G., Glukhovsky, A. 2000. Wireless capsule endoscopy. *Nature*, 405-417.
3. Davis, B.R., Harris, H., and Vitale, G.C. (2005). The evolution of endoscopy: wireless capsule cameras for the diagnosis of occult gastrointestinal bleeding and inflammatory bowel disease. *Surgical innovation*, 12(2), 129-133
4. Swain, P., Fritscher-Ravens, A. (2004). Role of video endoscopy in managing small bowel disease. *Gut*, 53, 1866–75.
5. Pennazio, M., Santucci, R., Rondonotti, E. (2004). Outcome of patients with obscure gastrointestinal bleeding after capsule endoscopy: report of 100 consecutive cases. *Gastroenterology*, 126, 643–53.
6. Rondonotti, E., Herrerias, J.M., Pennazio, M. (2005). Complications, limitations, and failures of capsule endoscopy: a review of 733 cases. *Gastrointest Endosc*, 62, 712–726.
7. Ben-Soussan E., Savoye, G., Antonietti, M. (2005). Factors that affect gastric passage of video capsule. *Gastrointest Endosc*, 62, 785–790.
8. De Franchis, R., Avgerinos, A., Barkin, J. (2005). ICCE consensus for bowel preparation and prokinetics. *Endoscopy*, 37, 1040–1050.
9. Caddy, G.R., Moran, L., Chong, A.K. (2006). The effect of erythromycin on video capsule endoscopy intestinal-transit time. *Gastrointest Endosc*, 63, 262–266.
10. Viazis, N., Sgouros, S., Papaxoinis, K., (2004). Bowel preparation increases the diagnostic yield of capsule endoscopy: a prospective, randomized, controlled study. *Gastrointest Endosc*, 60, 534–538.
11. Dai, N., Gubler, C., Hengstler, P. (2005). Improved capsule endoscopy after bowel preparation. *Gastrointest Endosc*, 61, 28–31.
12. Selby, W. (2005). Complete small-bowel transit in patients undergoing capsule endoscopy: determining factors and improvement with metoclopramide. *Gastrointest Endosc*, 61, 80–85.
13. Niv Y, Niv G. (2004). Capsule endoscopy: role of bowel preparation in successful visualization. *Scand J Gastroenterol*, 39, 1005–1009.
14. Fireman, Z., Kopelman, Y., Fish, L., (2004). Effect of oral purgatives on gastric and small bowel transit time in capsule endoscopy. *Isr Med Assoc J*, 6, 521–523.
15. Ge, Z.Z., Chen, H.Y., Gao, Y.J. (2006). The role of simeticone in small-bowel preparation for capsule endoscopy. *Endoscopy*, 38, 836–840.
16. Adler, D.G., Knipschield, M., Gostout, C. (2004). A prospective comparison of capsule endoscopy and push enteroscopy in patients with GI bleeding of obscure origin. *Gastrointest Endosc*, 59, 492–498.
17. Anonymous. (2018). https://www.slideshare.net/search/slideshow?searchfrom=header&q=Pill+Camera+Architecture+ (www.slideshare.net). Retrieved on 02/01/2018
18. Swain, C.P., Gong, F., and Mills, T.N. (1997). Wireless transmission of a color3 television moving image from the stomach using a miniature CCD camera, light source and microwave transmitter. *Gastrointestinal endoscopy*, 45(4), AB-40.
19. Swain, P., Toor, A., Volke, F., Keller, J., Gerber, J., Rabinovitz, E., Rothstein, R.I. (2010). Remote magnetic manipulation of a wireless capsule endoscope in the esophagus and stomach of humans (with videos). *Gastrointest Endosc*, 71:1290–1293.
20. Keller, J., Fibbe, C., Volke, F., Gerber, J., Mosse, A.C., Reimann-Zawadzki, M., Rabinovitz, E., Layer, P., Schmitt, D., Andresen, V. (2011). Inspection of the human stomach using remote-controlled capsule endoscopy: a feasibility study in healthy volunteers (with videos) *Gastrointest Endosc*, 73, 22–28.
21. Rey, J.F., Ogata, H., Hosoe, N., Ohtsuka, K., Ogata, N., Ikeda, K., Aihara, H., Pangtay, I., Hibi, T., Kudo, S.E. (2012). Blinded nonrandomized comparative study of gastric examination with a magnetically guided capsule endoscope and standard video-endoscope. *Gastrointest Endosc*, 75, 373–381.

22. Quirini, M., Menciassi, A., Scapellato, S., Dario, P., Rieber, F., Ho, C.N., Schostek, S., Schurr, M.O. (2008). Feasibility proof of a legged locomotion capsule for the GI tract. *Gastrointest Endosc*, 67, 1153–1158.
23. Kim, H.M., Yang, S., Kim, J., Park, S., Cho, J.H., Park, J.Y., Kim, T.S., Yoon, E.S., Song, S.Y., Bang, S. (2010). Active locomotion of a paddling-based capsule endoscope in an in vitro and in vivo experiment (with videos) *Gastrointest Endosc*, 72, 381–387.
24. Swain, P. (2008).The future of wireless capsule endoscopy. *World J Gastroenterol*, 14, 4142–4145.
25. Sidhu, R. (2006). Gastrointestinal capsule endoscopy form tertiary center to primary care. *British med J*, 4 (3), 528-331: doi 10-1136/bmj 332.7540528.