



Review Article

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Swallowable camera capsule: New emerging trend in diagnosis and treatment

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ABSTRACT

The Diagnosis of GI tract is a difficult task to detect a number of diseases specially in case of small intestine. Medical technology develops a major breakthrough in the area of diagnosis. The Capsule endoscopy creates a dramatic change in the diagnosis of the GI tract. Capsule endoscopy is approved by FDA Department. The capsule Used in Capsule endoscopy usually contains camera, A light bulb, battery and radio transmitter. The capsule moves in the body with the peristaltic movement. The procedure is simplest and not required special training. Capsule endoscopy becomes superior and most sensitive in diagnosing of lesions, crohn disease, Ulcerative colitis, Ulcers, Abdominal pain, Lymphoma, Carcinoid tumor etc. The swallowable camera capsule provides at least two images per second. Camera capsule are ingested orally and after 36 to 72 hours it can be excreted. After excretion the battery of the swallowable camera capsule is charged and ready for reuse. Capsule endoscopy is free from painful procedure and also provide more convenient data rather than endoscopy with more accuracy. The following article describes Recent approaches of the Swallowable camera capsule, Functioning and procedure with its application.

Key words: Radio transmitter, Light bulb, Diagnosis, GI tract etc.

INTRODUCTION

The pathology of the disease is very difficult in a number of cases. One most common conventional method is to use the endoscope which is inserted via mouth, nose and rectum of the patient. These procedures provide some information like gastroscopy provides information regarding stomach and oesophagus. while the colonoscopy investigate large intestine. These procedures are unpleasant for the patient and does not provide any information regarding small intestine. The problems can be overcome in recent advancement by using wireless swallowable camera capsule. Swallowable camera capsules becomes a gold standard for the diagnosis of the GI tract. Swallowable camera capsules inspire a number of active positioning strategies including incorporation of magnets which can apply forces in response to an external magnetic field. The swallowable camera capsule is an autonomous system which contains a sensor, electronics for signal conditioning and amplifying, and a radio transmitter, these all components are encapsulated in a biocompatible material.[1,2]

It is a recent technology in which thousand of digital photos of small bowel are provided for medical use. It is too effective that it provides two photos per second When a large size Capsule(like Vitamin) is ingested. Swallowable camera capsule naturally passes over the body within 8 to 72 hours and it provides 60,000 images for quick diagnosis. The swallowable camera capsule have some unique advantages they are given below.

- Easy to swallow
- Quick diagnosis
- Minimizing patient discomfort
- the patient can relax in comfort and walk about, without a hospital stay
- exposure to potentially harmful radiation does not occur
- Save the doctor & hospital time
- Accurate diagnosis
- Provide a large number of images so easy to diagnose from all the sides [3]



Fig 1: Swallowable Camera capsule

Recent approaches in designing of swallowable camera capsule

There are several recent approaches are in progress for developing the advancement in the technology.

• Controlling locomotion

Swallowable camera capsules are modified for controlling the locomotion. The swallowable camera capsule moves along with small intestine by emitting electric pulses that activates the motor nerves thus increases muscle contraction. The simplest locomotion device Microbot is very popular, It alters the rhythmic control of worm through the linear movement.

• Tracking location

The simplest way to track the location is by placing an antenna array around the body and measure the signal strength. Ultra sound signals are most recently used for tracking location. The capsule emits ultra sound waves for external detection. The enterion capsule uses a radioactive tracer and gamma camera for most accurate location determination.

• Tracking movement

For Tracking movement capsule contains Accelerometer, that transmits the signal to an external module for processing. By using mathematical integration the propogation velocity and the capsule displacement can be retrieved. The Eso pill monitors the transit time of the esophagus. Catheter based impedance monitoring and radiography of radio-opaque liquid are most commonly used for diagnosis of motility disorder.

• Integrating Multiple sensors

The capsule contains a number of sensors for temperature, conductivity, pH, to determine the data for real and elapsed time measurement, and to determine gastric emptying time, combined small and large intestine transit time, contraction pattern and a motility index. It samples intestinal fluid through a number of channels.

• Providing therapy

By using the nanotechnology and Microelectronics it makes a significant advancement in Diagnosis and treatment of digestive cancer. A entirely new developed capsule known as “robotic beetle” contains ultrasound transducers and bioanalytical and mechanical sensors. Robotic arms present on this type of capsule contains tissue sample and provide treatment such as targeted drug releasing and thermal tissue destruction.

Data provided by swallowable camera capsule

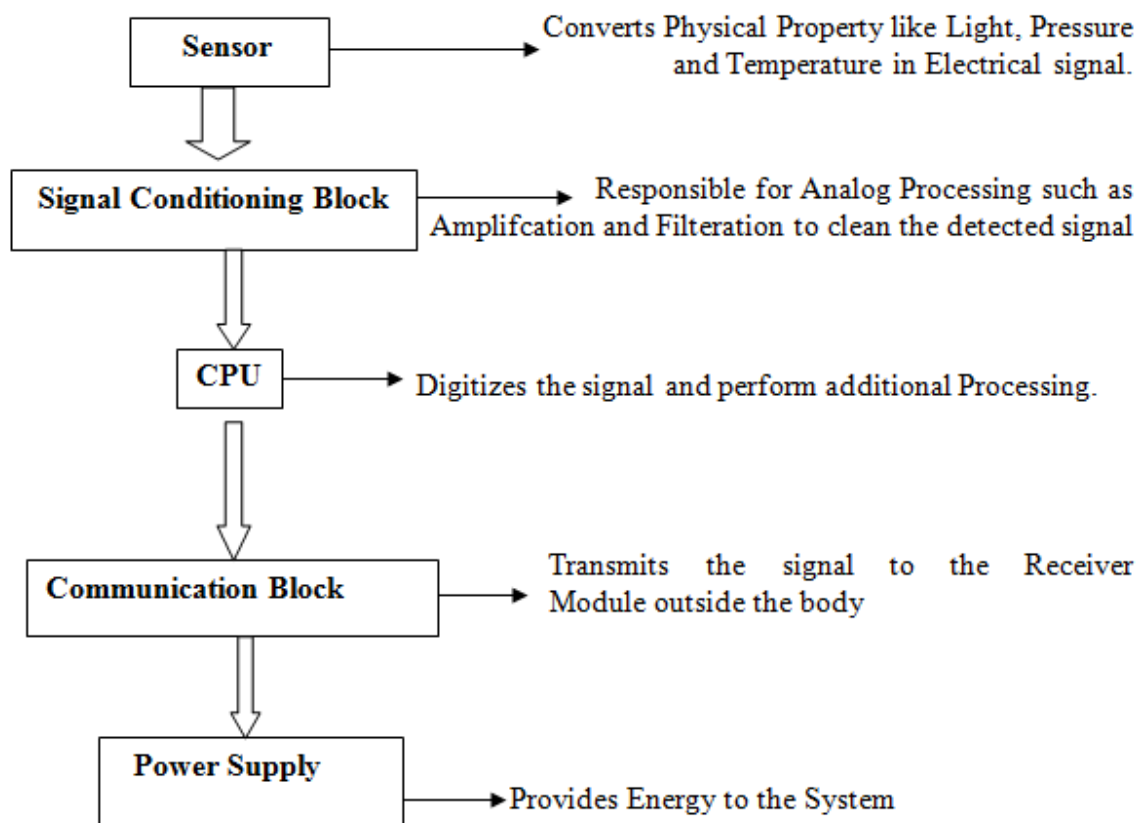
Most commonly swallowable camera capsule provides following data for diagnosis of various disorder.

- Temperature
- Pressure
- Imaging
- pH

- Conductivity [4]

Functioning of swallowable camera capsule

Swallowable camera capsule is basically a self contained microsystem that performs actuating function in the body. The system consists of core components encapsulated in a biocompatible material. The functioning of Swallowable camera capsule can be understood by following scheme.



Scheme 1: Functioning of the Swallowable camera capsule

Recent advancement in swallowable camera capsule

• Spider pill

The main disadvantage of swallowable camera capsule is that its movement can not be controlled by the physician this can be overcome by spider pill. The spider pill when swallowed its tiny legs are activated by wireless radio. There are 4 to 5 spider legs present in the spider pill on both front and back side. A radio frequency receiver is present in the spider pill that receives the wave signal and open the legs either from front or back side as per command given by the physician and crawls like a spider.

• Magnet controlled pill

It provides the control over the movement of the pill in the body. It allows the precise examination of the junction between esophagus and stomach. In this a magnetic device is used, the size of the magnetic device is like a bar of chocolate. The physician can hold the magnetic device in the hand and move the pill up and down in the patient body [5]

• CMOS optical sensors incorporation in swallowable camera capsule for cancer cell detection

Complementary metal oxide semi conductor optical sensors are incorporated in swallowable camera capsule for the detection of cancer cell. This technique is entirely based on autofluorescence emission spectra. These optical sensors

are incorporated for diagnosis of GI diseases. Cells and tissue shows autofluorescence when excited by U.V or Visible light. The emission spectra of normal and cancerous cell are measured by using CMOS photodetector. The emission spectrum of the healthy and cancerous tissue are different in intensity. This technique eliminates the requirement of the video camera to detect the different areas of the GI tract [6]

- **Olympus new release capsule**

It provides magnetic propulsion. The main aim of the designing this type of capsule is to administer drug directly to the affected area. In Olympus new release capsule a body fluid sampling system is present that takes sample of the body fluid for diagnosis and analysis.



Fig :2 Endo Capsule of olympus

- **Sayaka capsule**

Sayaka capsule contains a lens on the lateral side instead of the front as present in other swallowable camera capsule. The capsule spins in the GI tract at an angle of 7.5° and it provides 30 images per second. It provides clear cut images of the GI wall. All the images obtained by the sayaka capsule are combined by the process called 'mosaicing'. The process mosaicing provide complete description of the GI tract [7]

- **Wideband technology**

A high capacity radio system is used in electronic pill technology to visualize the digestive tract with better and detailed images. In wideband technology a prototype system include UWB transmitter and antenna are used to investigate the feasibility with high data rate transmission. Due to high data rate transmission capacity electronic pill can transmits raw video data, without any compression, increased picture resolution, less delay in real time and low power requirement [8]

Capsule Endoscopy procedure

The patient is kept on fasting after the midnight before the day of examination. Simethicone is administered as a surfactant to increase the viewing ability. A number of medical examination are carried out to the patient and after that antenna array and image recorder are fitted to the patient. The capsule is checked out before swallowing that either it is fully charged or not and have able to transmit the data to the receiver etc. The capsule is usually swallowed with small amount of water. The capsule moves or passes in the body with the peristaltic movement. The patient is free for moving after swallowing but the patient is advised to avoids all the foods other than clear liquid during 2 hours of the ingestion.

Seven to eight hours after the ingestion the examination is completed. The recording device is removed from the patient & capsule is collected after the excretion. The gastro intestinal motility is varies according to the individual and it affects the floating of the capsule. Data are collected and interpreted and save for the future [9]

Contraindication of capsule endoscopy

Swallowable camera capsule are contraindicated in some of the disease they are given below.

- Pregnancy
- Patient that have swallowable disorder
- Patient that have cardiac pace maker and other implanted battery device
- Patient that are suffering from GI obstruction, and fistulas
- Different motility disorder
- * Zenker Diverticulum [10]

Adverse effects

Usually the swallowable camera capsule not have any adverse effect but the problem may arises when the capsule may stuck and unable to move in the GI tract. The patient should be aware of the following things before ingestion of swallowable camera capsule.

- Trouble swallowing
- Increasing abdominal and chest pain
- Unusual difficulty in opening bowels [11]

Efficacy of the Swallowable camera capsule

It is showed by the investigators that capsule are better than endoscopy and enteroscopy at locating small beads. Capsule is more effective than small bowel X-ray in finding the cause of bleeding. The capsule endoscope is the first line test for the evaluation of small bowel GI bleeding. [12]

Table :1 Swallowable camera capsule with their company name, Physical Dimension and Image rate & Resolution

Model	Company Name	Physical Dimension	Image Rate & Resolution
Pilli Cam	Given Imaging	11X26 mmxmm	14 images per second, or 2,600 color images
EndoCapsule	Olympus Optical	11X26 mmxmm	2 images per second
Norika	RF System Lab	9X 23 mmxmm	NA
SmartPill	Smartpill Corp.	13X26 mmxmm	Only sensor discrete data
OMOM Capsule	Chongqing Jinshan Science & Technology Co. Ltd.	Pill Size	VGA 640×480,24 bits True color 300,000 pixels
Endoscope	Uni Kyungpook, KR	30x11mm	-
IVP	IMS, DE	23x11mm	-
SAYAKA	RF System Lab, JP	NA	2Mpixel
MiRo	-	-	320×320

Application of swallowable camera capsule**• Crohn's Disease**

It is a type of inflammatory bowel disease which mainly affects small intestine and colon. Various analysis shows that wireless capsule endoscopy is less costly than current diagnostic perspectives. wireless capsule endoscopy is the first line test for diagnosing Crohn's Disease. Wireless capsule endoscopy is the test that offers saving by reducing the number of tests required for diagnosing of Crohn's Disease [13]

• Obscure GI Bleeding

It is the bleeding from the GI tract that persists or reoccurs without an obvious etiology after imaging with upper and lower endoscopy. Capsule endoscopy have higher sensitivity of locating bleeding lesion in compared to other diagnostic techniques. According to different analysis it is showed that capsule endoscopy is 95% sensitive to detect Obscure GI bleeding.

• Acute upper GI bleeding

Capsule Endoscopy provides useful information In identifying gross bleeding, Inflammatory lesion, The yield of capsule endoscopy in localizing the bleeding source is lower then esophagogastroduodenoscopy, which is the standard initial evaluation for acute upper GI bleeding due to this reason the capsule endoscopy can take place of upper endoscopy.

• Ulcerative colitis

Ulcerative colitis is the inflammatory disease of the large intestine. Colonoscopy and biopsy is used for the diagnosis of Ulcerative colitis. Capsule endoscopy is utilized for assessing the extent and severity of the disease in ulcerative colitis.

• Celiac disease

It is an immunological disease of the small intestine. Capsule endoscopy is more effective in celiac disease with patchy distribution. Capsule endoscopy is able to detect the celiac disease in 87% patients.

• Esophageal condition

Capsule endoscopy visualizes several types of esophageal disease. Capsule endoscopy provides more comfort and convenience. It is more advantageous over upper endoscopy. The sensitivity of the capsule endoscopy is not too good to replace the endoscopy.

• Colorectal cancer

Capsule endoscopy is utilized in colorectal cancer. Capsule endoscopy for compassionate use instead of colonoscopy after stenting. Capsule endoscopy Imaging enables to diagnose the synchronous cancer and polyps thus according to this the surgical treatment can be modified and endoscopic polypectomy is utilized before and after surgery depending on the size of the polyps.

• Portal hypertensive enteropathy

Patient that are suffering from liver cirrhosis and portal hypertension can develop portal hypertensive enteropathy which may lead in GI Bleeding. Capsule endoscopy is also a diagnostic tool for Portal hypertensive enteropathy. [14,15,16,17]

CONCLUSION

Swallowable camera capsule is widely used in advanced countries due to lack of advantages over endoscopy. It is too effective and provides a large number of collective form of data within a minutes. It is concluded from various research that it is more advanced technique and most suitable for diagnosis of the small intestine, Colon and Jejunum. The role of the swallowable camera capsule can be understood by detecting its action against cancer cell. The recent advanced form of swallowable camera capsule are more effective in detecting cancerous cell from a number of normal cells and also effective in targeted drug delivery to destroy the cancerous cell.

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