

Medical Capsule Robots: An Overview on wireless capsule endoscope.

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Abstract:

Capsule endoscopy (CE) has improved the diagnosis and treatment of the small bowel providing a non-invasive, well tolerated method of as it should be visualizing the upper and lower gastrointestinal tract. The development of Medical Capsule Robots, which has emerged from the science fiction idea of robots touring within the body to diagnose and cure issues. The first ever introduced capsule robot was a pill or capsule endoscope evolved to seize pics of the gastrointestinal tract. Today, varieties of capsule endoscopes are available and are expected to hit the market soon. They are barely large than ordinary oral dosage forms such as tablets or capsules, made of a biocompatible case and have digital circuitry and mechanisms to seize and transmit images. 15 years ago, capsule endoscopy (CE) has turn out to be the primary-line investigation system in some small bowel pathologies and scientific practices. The first marketed capsule robotic was a capsule endoscope in general evolved to seize only the pictures of the gastrointestinal tract however Later, these have been advanced to be used as a device to construct micron and sub-micron sized drug shipping structures for target shipping and treatment. Technology is swiftly progressing, assisting in the broadening and improving the benefits and applications of capsule endoscopy.

Keywords: capsule endoscopy (CE); gastrointestinal tract (GIT); medical capsule robot.

Introduction:

Upper gastrointestinal (UGI) tract pathology is commonplace international. Traditional endoscopy includes usage of a pliable endoscope that's inserted into the body cavity with the aid of a doctor for scientific imaging of a diseased component in the body. But compared to the capsule endoscopes these traditional endoscopes show certain drawbacks like risk of contamination, forming perforations and tear. In medical imaging, automatic detection and type of cancers like lesions and skin cancer, lungs cancer, brain tumor, stomach cancer and few extra are maximizing important research subjects from previous couple of decades. From these, stomach is most common most cancers name colon. The most commonplace belly infections are ulcer, bleeding, and polyps. Endoscopic capsules are non-invasive, painless and more secure to be employed for long time screening purposes.

Capsule endoscopy entered the area of scientific gastroenterology within the 12 months of 2001 with the clearance by means of the Food and Drug Administration (FDA) and obtaining CE Mark certification. A large wide variety of technical improvements had been brought in diagnostic endoscopy in the last few years, with the purpose of improving the

detection and characterization of pathological modifications in the gastrointestinal tract. High-resolution photo display in endoscopes of the newest era is supported through digital chromoendoscopy (a sort of staining of mucous membranes at the press of a button). Since 1990, the age-standardized cases of stomach most cancers have declined worldwide. Esophageal cancers being on top list for poor prognosis not only has a damaging analysis however also remains the sixth leading reason of dying global.

The detection rate of early UGI tract cancers, with traditional esophagogastroduodenoscopy still is of very low rate. The diagnostic and healing talents of UGI endoscopy strongly correlate with the technical, practical and decision-making capabilities of the operator including other variables together: (1) chance of communicable ailment transmission, i.e., viral infections which are very infectious via aerosol. (2) physician's or operators unaltered knowledge of internal curves to obtain skill ability in endoscopic techniques. (3) Patient's perspectives on conventional endoscopy of the UGI tract that in addition intervene with a success implementation. Even though at this point this approach is believed to be a safer alternative for the traditional endoscopes eliminating the probability of discomfort and disadvantages, however applying capsule

endoscopes also have certain limitations to it. Out of which one of the major limitations being capsule retention in the body. Although there is only 2% chance for capsule retention to occur but it does not eliminate the fact that it might occur and intervene with the body. Capsule retention if so, occurs gets retained inside the stomach due to gastroparesis. The subject with capsule retention is that it can lead to intestinal obstruction or perforation which are mostly asymptomatic and not easily detected. (1) (2) (3)

Capsule endoscopy:

Capsule endoscopy, additionally referred to as WCE (wireless capsule endoscopy) or VPE (video pill endoscopy), is a gastrointestinal study that makes use of a pill digicam to take photos of the intestinal lumen. The M2A tablet (mouth to anus) was primary available pill digicam and changed in the end renamed as Pill Cam SB (small bowel). The capsule is ingested which transmits snap shots at 2 to six frames in keeping with second over the time of eight to twelve hours till the battery expires. It generates 512 by means of 512-pixel, excessive-resolution pictures that allows designated inspection of the gastrointestinal mucosa. Capsule endoscopy is a diagnostic method and has no therapeutic benefits. It can be most effective in case of localized lesions inside the esophagus, belly, small bowel, and colon but cannot be used for biopsy or remedy. It is used in case of gastrointestinal bleeding but failed to identify its source of bleeding. The diagnostic yield of capsule endoscopy has been determined to be higher than small bowel research, CT, angiography. (5) (6)

WCE is the medical imaging technique to look at the gastrointestinal (GI) tract. This method is extensively utilized in hospitals for the detection of gastric abnormalities including ulcer, bleeding. A recent record indicates that the remedy of approximately one million sufferers has been successfully done with WCE [15]. A small digital camera is used to capture the snap shots of human gastrointestinal tract. Wireless capsule endoscopes with advanced functionalities along with biopsy or drug delivery are distinctly quite helpful. For the release of medicine at different sections of GIT in controlled way, Drug Delivery System (DDS) tablet endoscopy was also designed. (7) (8)

Wi-fi capsule endoscopy or video tablet endoscopy. Capsule endoscopy uses a tiny wireless camera to capture photos of your GI tract. The digicam that's used for the system is placed in a small capsule that's fashioned like a tablet. When you swallow the capsule, the digicam inner of it starts off evolved a journey through your GI tract. During this time, the digicam takes heaps of photos. These pix are transmitted to a recording device which you put on around your waist. Although it can be used to visualize many elements of the GI tract, capsule endoscopy is especially beneficial for looking on the small intestine. This is due to the fact the small intestine is difficult to get right of entry to the usage of extra conventional endoscopy strategies. (8) (9)

Need for this procedure:

A doctor might recommend this to a patient for following reasons:

1. Find the cause of gastrointestinal bleeding: The maximum commonplace reason for doing capsule endoscopy is to explore unexplained bleeding in the small intestine.
2. Diagnose most cancers: Capsule endoscopy can display tumors within the small intestine or other parts of the digestive tract.
3. Diagnose inflammatory bowel diseases (such as Crohn's disorder): Capsule endoscopy can display regions of infection inside the small gut.
4. Examine the esophagus: Capsule endoscopy has additionally been authorized to evaluate the muscular tube that connects your mouth and your belly (esophagus) to look for peculiar, enlarged veins (varices).

5. Screen for polyps: People who have inherited syndromes that can be the reason behind polyps within the small gut may go through tablet endoscopy.
6. Diagnose celiac disease: Capsule endoscopy is once in a while used in diagnosing and tracking this immune response to eating gluten.
7. Do follow-up checking after X-rays or different imaging assessments: If the outcomes of an imaging check are uncertain or inconclusive, your health practitioner might suggest a tablet endoscopy to get extra statistics. (10)

Types of medical capsule robots (capsule endoscopes):

1. Capsule robots for endoscopy
 2. Capsule endoscope for esophagus
 3. Capsule endoscope for stomach
 4. Capsule endoscope for small intestine
 5. Capsule endoscope for large intestine
1. Capsule robots for endoscopy: WCE is used to diagnose problems of diverse elements of the GI tract.
 2. Capsule endoscope for oesophagus: The ingested substance has very speedy transit time i.e., 10s so a twin pill Cam or digicam system and faster photograph capture pace is required. The marketed capsule exam is Pill Cam ESO and has a frame price of 14 frames/s [3,4].
 3. Capsule endoscope for stomach: There is a requirement of floating capsule fulfilling the purpose to provide 3-d steerable locomotion assets a propeller is used. The marketed pill example is Pill Cam ESO 2 and has a body rate of 18frames/s.
 4. Capsule endoscope for small intestine: Capsule travels thru the small gut with the aid of peristaltic motion. There can be energetic locomotion. If the pill is meant to hit upon signs and symptoms inside the small intestine for a long-term interval, a powerful battery backup is needed. The marketed product example is Pill Cam SB2 with body price of 2frames/s. Other advertised capsule endoscope examples are Pill Cam SB, OMOM, Endo capsule and Micro Cam Capsule
 5. Capsule endoscope for big intestine:As the diameter of the big gut is quite huge, energetic locomotion is wanted to view the complete floor region of inner intestinal wall. Capsules can be longer in length in comparison to different pill endoscopes. The advertised capsule is Pill Cam colon with the frame price four-35 frames/s.

Components of a typical capsule endoscope are:

External biocompatible shell of a big antibiotic tablet length With 11mm in diameter and 26mm in length

- Camera
- Control and communication unit
- Energy source
- Capsule case
- Optical dome
- Light emitting diode
- Optical head
- Complementary metal oxide semiconductor (CMOS) or charge coupled device (CCD) image sensor

- Microelectromechanical System (MEMS) magnetic switch
- Printed circuit
- Battery
- Receiver-transmitter

System architecture of a robotic capsule: emerging solutions enabled by micro robotic technologies.

A robot capsule platform consists of at least six primary modules:

- locomotion,
- localization,
- imaginative and prescient,
- telemetry
- Powering, and vi) Diagnosis and treatment gear. However, most robot endoscopic capsules, developed till date, include best a subset of the aforementioned modules due to size constraints.

Wireless capsule endoscope:

The WCE system consists of 3 components:

- a capsule endoscope
- a sensing machine with sensing pads or a sensing belt to attach to the patient, a facts recorder, and a battery percent
- a private computer pc with proprietary software program (RAPID v 6. Five, Given Imaging; WS-1 Endo Capsule, Olympus America; MiroView, IntroMedic) for photograph review and interpretation.

All capsule endoscopes have similar components:

- a disposable plastic pill,
- a complementary steel oxide semiconductor or
- excessive-decision rate-coupled tool
- picture capture device
- a compact lens
- white-mild emitting diode illumination sources
- an internal battery source.

The device turned into capable of navigating with all instructions in a water-crammed region, achieving reliable locomotion and guidance inside the stomach. The capsule can assure diagnostic pace between zero

to 5–7 cm/s and is able to be actively managed for greater than 30 min at a specific diagnostic speed (i.e., 1.5 cm/s) with a mean cutting-edge consumption below 40 mA. This gadget offered the capacity for clinicians to inspect the gastric cavity in actual-time. Through the human system interface, clinicians will be capable of manipulate the capsule closer to areas of interest the usage of a triaxial joystick. A superior model of this capsule, with an embedded digicam module, became developed with the aid of De Falco et al., as part of the equal group, in 2014. The capsule gastroscope is 32 mm in period and 22 mm in diameter (nevertheless no longer suitable for being ingested), and it's been equipped with a miniaturized wireless imaginative and prescient machine that acquires pics with a body fee as much as 30 FPS.

WCE allows inspection of the complete GI tract without discomfort or the need for sedation, consequently avoiding many of the potential dangers of conventional endoscopy. Therefore, it could inspire patients to simply accept GI tract examinations without issues of ache or invasiveness. However, modern-day WCE models are passive devices and their movement is predicated on natural bowel peristalsis, which implicates the risk of failing to capture photos of huge regions, since the practitioner cannot manipulate pill/digital camera orientation and movement. For this reason, they are commonly used for inspecting the small bowel (even if small bowel cancer is much less frequent than CRC, but not approached with standard endoscopes), seeking for sources of occult bleeding. (11) (10)

Clinical applications:

Following are the indications of CE most common one's are underlined.

- Esophagus
 - Gastroesophageal reflux disease
 - Barrett
 - Esophageal varices
- Small bowel
 - Obscure gastrointestinal bleeding
 - Intestinal tumors
 - Crohn's disease
 - Celiac disease
- Colon
 - Polyps
 - Cancer
- General
 - Diarrhea
 - Abdominal pain

WCE COMPANY	WEIGHT (gm)	FIELD OF VIEW	IMAGES/ SEC	BATTERY LIFE	RESOLUTION(Pixels)
Pillcam SB2 (given imaging LTD, yoqneam, Israel.	2.8	156 °	2	8 hours	512 x 512
Pillcam SB2EX (given imaging).	2.8	156 °	2	12 hours	256 x 256
Microcam (IntroMedic co LTD, Seoul, south korea).	3.3	170°	3	11 hours	256 x 256
Pillcam ESO2 (given imaging).	<4	169 °	18	8 hours	320 x 320
Endoscapsule (Olympus America, Inc, Center valley, Pennsylvania.	3.5	145 °	2	8 hours	256 x 256

FDA (food and drug administration), WCE (wireless capsule endoscopy).

Table 1: FDA approved wireless capsule devices and specifications (12)

WCE for small intestine imaging:

WCE typically is accomplished in an ambulatory outpatient setting. Fasting is standard practice but consumption of clear liquids only for 10 to 12 hours is considered. Numerous research suggests that use of a complete or partial bowel coaching the night time earlier than the observe yields stepped forward visualization of the small gut. At the time of the technique, the sensing machine (e.g., pads or a belt) is carried out to the stomach wall and connected to the information recorder this is worn by the patient. The pill is activated by elimination from a magnetic holder. The data recorder is subsequently connected to a workstation for transfer of the acquired images.(13) (14)

WCE for esophagus imaging:

The Pillcam ESO2 capsule is the only WCE system currently available for esophageal applications. At the time of the examination, the patient should be fasting for 2 hours. The patient is geared up with 3 thoracic sensors, in a designated sample, which might be connected to the statistics recorder. According to standard protocol, the affected person liquids 100 mL of water while status after which ingests the activated tablet in the supine function with a 10-mL sip of water that may be administered with the help of a syringe or straw. ingestion protocol is recommended for 5 mins. Protocol is recommended, comprising a 2-minute recording with the patient supine, then 2 minutes raised to 30, after which a further minute at 60, followed by using an upright role for 15 mins.(12)(13) (14)

WCE for colon imaging:

The function of the colon capsule endoscope has no longer but been hooked up in the United States and it is not commercially available here, although it has been approved to be used in Europe. Briefly, the primary generation colon pill (Pillcam Colon, Given Imaging) discovered a in keeping with affected person sensitivity for polyps of any size and “sizable findings” of 71% and 68%, respectively, as compared with conventional colonoscopy. randomized trials of the second one-era colon tablet have proven per-patient sensitivity for polyps R 6 mm and R 10 mm of 84% to 88% and 88% to 89%, respectively, as compared with conventional colonoscopy. (12)(13) (14)

Limitations of Current Capsule Endoscopy:

The most obvious disadvantage is the operator’s incapacity to control its locomotion through GI tract. Incomplete small-bowel examination. Uncontrolled air insufflation. No therapeutic value produced. (12)

Conclusion:

Capsule endoscopy is now an invaluable tool for investigating the small bowel because it outperforms other research modalities while ultimate appropriate to sufferers. Esophageal, colon and doubtlessly gastric capsule exam have a few manners to head in an effort to challenge their conventional investigational opposite numbers. Ultimately underlying these problems, the truth stays that endoscopy is uncomfortable for sufferers and incurs chance. Despite having correct patient tolerability and protection profiles tablet examination out of doors of the small bowel will need to fit these traditional exams in each diagnostic yields and price-effectiveness so that it will compete. Technology is rapidly advancing and consequently if these requirements may be met CE would have a clear advantage over traditional endoscopy in particular within the context of screening. CE has proven its efficacy in multiple trials in view that its advent nearly 12 years in the past. The primary indicators for CE

interventions are nevertheless difficult to understand GI bleeding, observed by using scientific signs only and suspected Crohn’s sickness. Multiple studies have shown that CE for those interventions is superior to radiologic interventions and push enteroscopy. In case of tremendous CE findings balloon-assisted endoscopy (i.e. Unmarried- and double-balloon enteroscopy) offers the capability to apply targeted biopsies or remedy. In the beyond, CE became best a diagnostic test and tablet movement was passive in step with the intestine motion. In the future, new pill gadgets might also offer a fantastic capability for minimally invasive analysis and targeted therapy. Moreover, capsule movement will be actively controllable thereby commencing new avenues for superior precise prognosis and centered remedy.

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