

# Capsule Endoscopy

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### Summary

Capsule endoscopy is non-invasive, safe, and patient friendly, technologically advanced diagnostic method. This is the only method of examination which does not require general anesthesia and allows macroscopic evaluation of the entire gastrointestinal tract. Thanks to its numerous advantages capsule endoscopy contributed to the development of gastroenterological diagnostics in humans and is beginning to also be applied in animals, especially in dogs. The article presents available capsule endoscopy systems, the construction of the camera pill (endoscopy capsule), indications and contraindications for application. Furthermore, the advantages and disadvantages of this diagnostic method in dogs and future developments of capsule endoscopy systems are discussed.

**Keywords:** capsule endoscopy, dog, small intestine, colon

Diseases of the small intestine are difficult to diagnose due to relatively non-specific symptoms and the low reliability of auxiliary tests. Laboratory analyses deliver low levels of sensitivity and specificity, whereas endoscopic techniques, despite recent advances in that field, are characterized by a narrow range of practical applications, in particular in ileum examinations, and require anesthesia (19). Capsule endoscopy is a non-invasive method for macroscopic evaluations of small intestine mucosa. This technique was developed in the 1980s by Gavriel Iddan of Israel, and the results of the first examinations performed on healthy volunteers were published in *Nature* in 2000. In August 2001, capsule endoscopy was approved as a safe diagnostic method by

the US Food and Drug Administration (1). The FDA's approval paved the way to the rapid development of the new technique for small bowel diagnosis, as no alternative methods had existed at the time.

Several capsule endoscopy systems for small intestine examinations are available today. The first system to be approved by the FDA was Given Imaging – Rapid with the Pillcam SB capsule and, subsequently, the Pillcam SB 2 capsule. Olympus EndoCapsule (Olympus, Tokyo, Japan) is a nearly identical solution that has also been approved by the FDA as an equally effective diagnostic system. Other popular systems include OMOM (Jinshan Science&Technology, Chongqing, China) and MicroCam (Intromedic, Seoul, South Korea).

All capsule endoscopy systems comprise the following elements:

- disposable endoscopic capsule;
- sensor array (electrodes);
- data recorder;
- imaging workstation (computer with software) for evaluating and processing endoscopic images.

The first capsules measuring  $26 \times 11$  mm and weighing 3.4 g were somewhat larger than the contemporary devices. New-generation capsules are  $24 \times 11$  mm in size, and their field of view has been expanded from  $156^\circ$  to  $170^\circ$  in MiroCam devices (Fig. 1). The capsule comprises an optical module with a lens, several (mostly 6) LEDs, a digital camera developed in the CMOS (Complementary Metal Oxide Semiconductor) technology which converts images into series of electrical pulses, two batteries and a radio transmitter

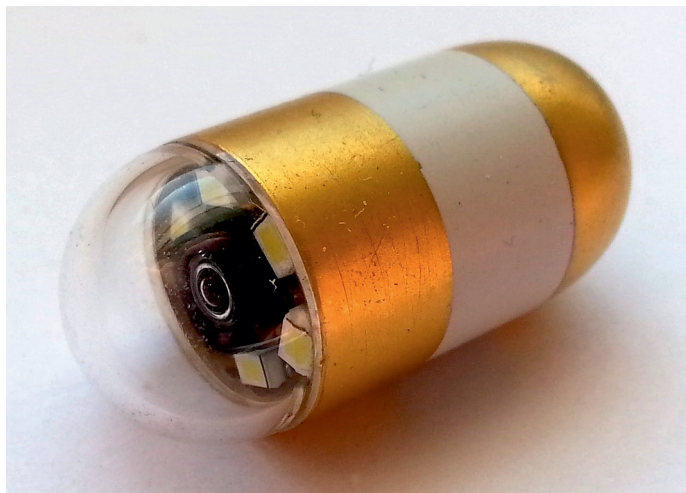


Fig. 1. MicroCam endoscopic capsule measuring  $24 \times 11$  mm



**Fig. 2. Data recorder with a battery and electrodes**

which transmits the image to the sensor array (Fig. 2). Capsule endoscopy systems allow real time viewing of the gastrointestinal tract by USB or wireless connection (Fig. 3). The capsule has a special coat which aids passage through the intestine and protects optical components against contamination with intestinal



**Fig. 3. USB real time viewing of gastrointestinal tract via notebook**

digesta. Batteries support continuous operation for 11 to 12 hours, during which the camera takes 3-4 images per second (subject to manufacturer) to produce a total of 120,000 or more images that form a video recording. The capsule is equipped with an advanced system for automatic light intensity control. The structure of the capsule ensures that its proximal section (containing the camera and diodes) is always oriented in the direction of peristaltic movements. Special capsules for examining the large intestine and the esophagus are also available (3).

Olympus and Siemens are currently conducting clinical research into a new endoscopic capsule navigated by an external magnetic field and new image processing systems. During the examination, the patient's stomach is filled with water, and the capsule is controlled by the physician with the use of an external magnetic field. The capsule produces real-time images which are transmitted to the monitor by the electrodes. The physician uses two manipulators to control the capsule's position in all planes. The main advantage of the new system is a precisely targeted diagnostic tool that can be applied in selected locations (11). Conventional capsules are set into motion by bowel peristalsis. In recent years self-stabilizing capsules have been developed, which provide a more accurate macroscopic evaluation of obtained images (6).

#### **Indications and contraindications for capsule endoscopy**

Capsule endoscopy is a useful device for diagnosing patients with suspicion of small bowel disease manifested by symptoms such as chronic diarrhea, weight loss, iron deficiency anemia and latent gastrointestinal bleeding (3, 7, 16, 20). The sensitivity of capsule enteroscopy ranges between 89 and 92% in bleeding diagnostics, and its specificity has been estimated at 95% (17). Capsule endoscopy is equally or more effective in diagnosing bleeding than conventional endoscopic methods, and it should be the preferred diagnostic method before treatment (15). Capsule endoscopy has also been found to be a highly sensitive and specific method in diagnosing inflammatory bowel disease in humans (2, 4). The discussed technique has not yet been applied in dogs, but it should be equally effective in canine patients, in particular in distal jejunum and ileum lesion diagnostics. Those sections of the intestinal tract are difficult to access during conventional endoscopy (panendoscopy and colonoscopy) and require specialist equipment such as enteroscopes. Other indications for capsule endoscopy include small and large intestinal polyps and tumors. In human patients with small intestinal tumors, capsule endoscopy improved the diagnostic yield from 3% to more than 6% (3, 18).

Capsule endoscopy is also used to evaluate small intestinal changes resulting from pharmacological treatment. In patients administered non-steroidal anti-inflammatory drugs, the discussed technique revealed intestinal tissue reddening, erosion, small and shallow ulcers (1, 3).

Contraindications for capsule endoscopy include suspicions of gastrointestinal stenosis, fistulas (based on the clinical picture and the results of previous tests) and confirmed cases of dysphagia (8).

Capsule endoscopy can also lead to complications, mostly delayed capsule passage which is reported in 25% of patients. Complications are manifested in three clinical forms: capsule retention, incomplete passage and capsule blockage in a constricted area of the intestinal tract, which is the most common problem. The capsule had to be surgically removed in 4% of patients (18). According to some authors, direct surgical removal of the capsule is not required. Gerber reported a case where the capsule was retained due to constricted intestinal lumen and swelling of the intestinal mucosa in a patient diagnosed with Crohn's disease (8). The patient received pharmacological treatment, and the capsule was evacuated from the gastrointestinal tract two years later. Capsule endoscopy is also used to localize bowel obstructions which are then surgically managed (10, 12).

In veterinary medicine, the effectiveness of capsule endoscopy was examined in dogs and pigs. The aim of the relevant research was to evaluate the usefulness (adaptation) of capsule endoscopy in veterinary practice and its effectiveness in diagnosing selected diseases of the gastrointestinal tract, including parasitic diseases, and macroscopic evaluations of the intestinal mucosa in patients administered indometacin at 400 mg/day (14, 21). Strategies for improving the diagnostic ability of capsule endoscopy were developed based on canine models (5, 6). In human and veterinary medicine, endoscopic capsules are most often used in examinations of the small bowel, but they can also be applied for macroscopic evaluations of the large intestine in suitably prepared patients.

### Strengths and weaknesses of capsule endoscopy

Capsule endoscopy has a number of limitations. It cannot be used for collecting histological tissue samples (prototypes capable of sampling small sections of mucosal tissue have been developed), sections of the capsule's passage may be obscured (behind mucosal folds, in areas filled with undigested food and intestinal digesta), some changes are not precisely visualized and may be difficult to interpret, and certain sections of the intestinal tract may be omitted due to rapid capsule passage (9, 13). The strengths and weaknesses of capsule endoscopy are presented in Table 1.

Tab. 1. Strengths and weaknesses of capsule endoscopy

Strengths	Weaknesses
Supports macroscopic evaluations of the entire gastrointestinal tract	Tissue samples cannot be collected
No need for general anesthesia	Capsule movement cannot be controlled
Non-invasive diagnostic method – no stimulation of the vagus nerve	Problems with patient preparation (no insufflation)
Outside clinic exam	High price
	Limited availability in veterinary medicine

Despite its limitations, capsule endoscopy effectively complements conventional imaging techniques. Rapid advancements are made in capsule-related research. In addition to the vision module, future capsules will contain sensors for measuring pH, peristaltic movement and detecting cancer markers, and they will be equipped with endoscopic ultrasound probes. Despite numerous technological and financial limitations in veterinary medicine, the development of capsule endoscopy will significantly improve the diagnosis of gastrointestinal diseases.

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