



Standardized examination procedure of magnetically controlled capsule endoscopy

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Magnetically controlled capsule endoscopy (MCE), a painless noninvasive screening tool for gastric diseases, has been an emerging diagnostic modality in clinical practice.¹⁻⁷ Because the magnetic capsule in the stomach can be accurately controlled through multidimensional rotation and adaptive matching of an external C-arm robot, the diagnostic accuracy of MCE for detecting gastric focal lesions is comparable with that of conventional EGD.^{2,3}

The MCE system (Ankon Technologies Co, Ltd, Shanghai, China) consists of a guidance magnet robot, a computer workstation with ESNavi software (Ankon Technologies Co, Ltd), an endoscopic capsule, a capsule locator, and a data recorder (Fig. 1).² The capsule measures 26.8 × 11.6 mm, weighs 4.8 g, and has a permanent magnet inside its dome. Images are captured and recorded at 2 frames per second (fps) with a resolution of 480 × 480 pixels. The view angle of the capsule is 140°, and the view depth is 0 to 60 mm. The battery life of the capsule is more than 8 hours. The guidance magnet robot is a C-arm type robot, with 2 rotational and 3 translational degrees of freedom. The magnetic field generated by the magnetic robot can reach a maximum of 200 mT and is adjustable. The computer workstation with ESNavi software is designed for real-time viewing and controlling. The capsule locator is a device for activating the capsule and detecting whether it is inside the human body. The data recorder is used for receiving image data by wireless transmission from the capsule endoscope. There are 2 joysticks on the workstation desktop (Fig. 2). The left joystick controls capsule orientation in 2 rotational axes (horizontal and vertical directions), and the right joystick controls capsule location in 3 translational axes (forward/backward, up/down, left/right). The location and orientation of the capsule can be controlled not only manually by operating the external robotic arm through the joysticks but also automatically in default mode.

MCE can be performed in patients with suspected gastric diseases to investigate symptoms and for screening and surveillance. It can be particularly suitable for patients who are not willing to accept or cannot tolerate EGD. Symptoms and signs are suggestive of upper-GI disease including dyspepsia, unexplained upper-abdominal pain, weight loss, vomiting, an abnormal upper-abdominal mass, or suggestive findings on barium studies, CT, or US scanning. Screening may be appropriate in populations

with a high prevalence of gastric cancer (eg, in Asia). Surveillance could be considered for individuals who have potentially premalignant lesions, such as gastric ulcers or other focal lesions, postgastrectomy states, gastric atrophy, or intestinal metaplasia or who have undergone endoscopic resection of neoplasia. It could also be considered for the monitoring of benign lesions such as gastric varices. It also offers the opportunity to examine both the stomach and small intestine when needed.

Contraindications for MCE include the same contraindications for CE and MRI examination. Absolute contraindications include patients who (1) are unfit for, or decline, abdominal surgery in the event of capsule retention, (2) have implanted electronic devices (eg, cochlea, drug infusion pumps, nerve stimulator) or magnetic metal foreign bodies, (3) have pacemakers that are not MRI-compatible, or (4) are pregnant. Relative contraindications include patients with (1) known or suspected GI obstruction, stenosis, or fistula or (2) dysphagia.

For gastric preparation, patients are required to consume soft foods the day before the examination and to fast overnight (>8 hours). No colored drinks or medications are allowed after 8 pm the day before examination. Patients are instructed to ingest 400 mg simethicone suspension dissolved in 100 mL water 40 minutes before the examination^{8,9} and are encouraged to walk freely to maximize contact with the gastric mucosa. In addition, patients are instructed to drink 1000 mL of water 10 minutes before the examination to optimize gastric distension. Water ingestion is repeated as needed to optimize gastric distension during the examination. For patients demanding or indicated for small intestine examination, a total of 2 L polyethylene glycol is administered the night before the examination.

In this video (Video 1, available online at www.VideoGIE.org), a standardized examination procedure of MCE in a 52-year-old woman with recurrent upper-abdominal pain for 3 months is shown. After completing the gastric preparation as mentioned above, she put on the data recorder with the help of an assistant. Then, the assistant activated the capsule with the capsule locator. The patient was instructed to assume the supine or left-lateral decubitus position and to swallow the capsule with a small amount of water to effectively observe the

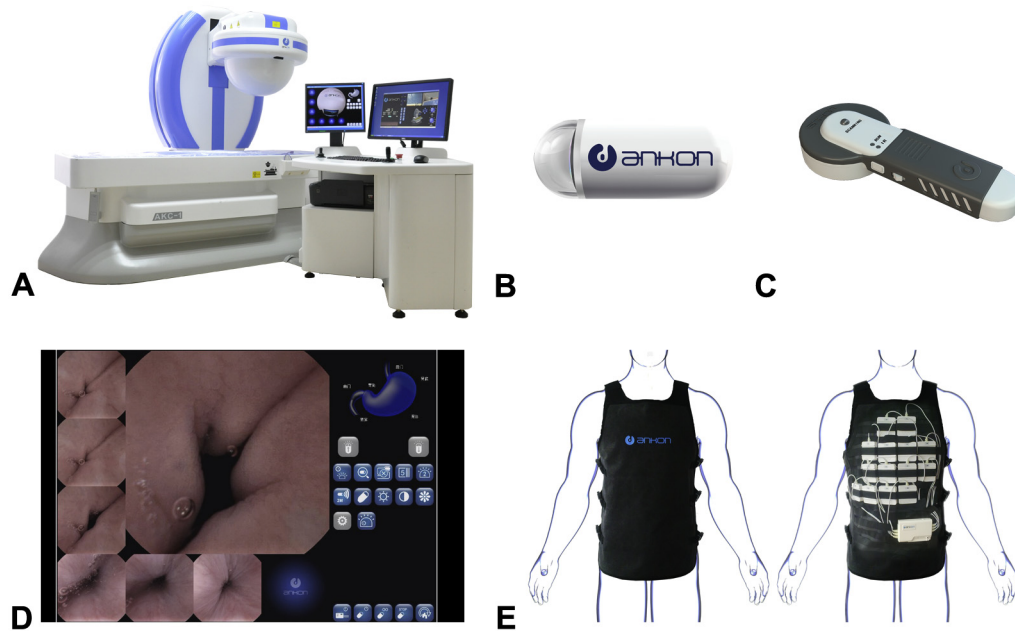


Figure 1. The NaviCam magnetic control system. It consists of **A**, a guidance magnet robot and computer work station, **B**, a magnetic capsule endoscope, **C**, a capsule locator, **D**, ESNavi software, and **E**, a data recorder.

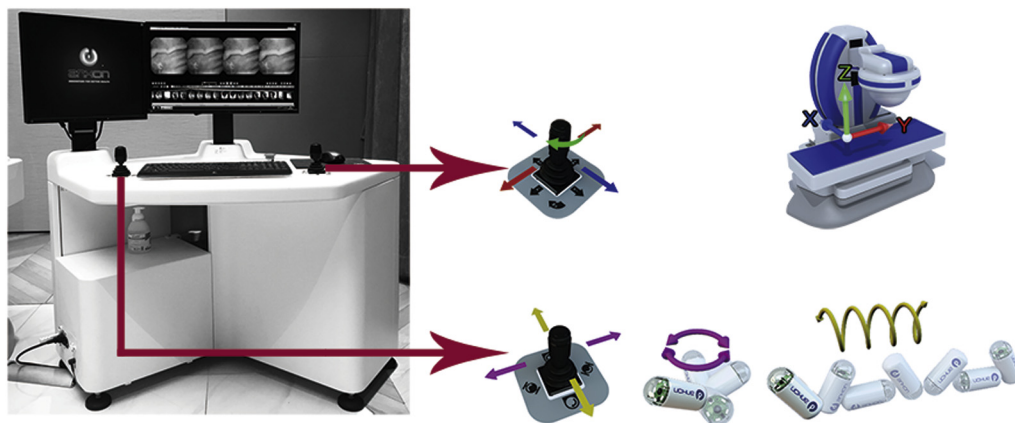


Figure 2. Two joysticks of the workstation. The left controls the capsule orientation in 2 rotational axes (horizontal and vertical directions), and the right controls the capsule location in 3 translational axes (forward/backward, up/down, left/right).

esophagus and dentate line. Images were captured at 2 fps. Once the capsule entered the stomach, the following steps were carried out for the complete examination of the gastric mucosa and to obtain a diagnosis (Fig. 3):

1. Gastric fundus: Gastric examination was initiated with the patient in the left-lateral decubitus position. The magnetic ball was held at the patient's right shoulder. The capsule was maintained in an obliquely upward orientation of 45° and then horizontally rotated 360° to enable observation of the gastric fundus and the junction of the gastric body and fundus (Fig. 3A).
2. Gastric cardia (distant view): The patient was placed in the left-lateral decubitus position. The capsule was

lifted with the camera oriented vertically upward to observe the cardia at a distance. We found a polyp near the cardia (Fig. 3B).

3. Gastric cardia (close view): The patient was placed in the supine position. The magnetic ball was lowered, and the camera was oriented upward to obtain a near view of the gastric cardia. The capsule was rotated 360° to enable observation of the polyp in greater detail (Fig. 3C).
4. Posterior wall of gastric body: The patient was placed in the supine position. The magnetic ball was moved to the patient's upper-left abdomen and lowered, and the camera was oriented vertically downward to observe the posterior wall of the gastric body (Fig. 3D).

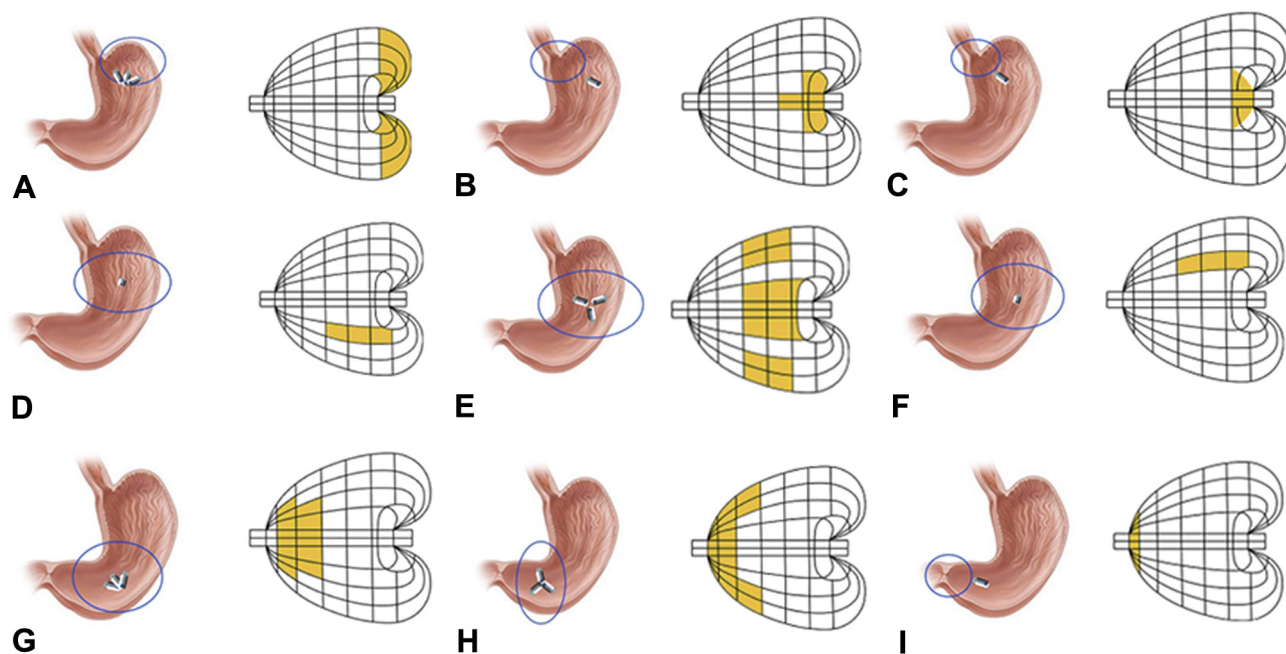


Figure 3. The standardized gastric examination procedure. When the capsule reaches the stomach, the capsule is lifted away from the posterior wall, rotated, and advanced to the fundus (**A**), long shots (**B**), and close-ups (**C**) of the cardiac regions, and then the posterior wall (**D**), the lesser and greater curvature (**E**) and anterior wall (**F**) of the gastric body, followed by the angulus (**G**) and antrum (**H**) and finally the pylorus (**I**). Originally published in Zhao AJ, Qian YY, Sun H, et al. Screening for gastric cancer with magnetically controlled capsule gastroscopy in asymptomatic individuals. *Gastrointest Endosc* 2018;88:466-474.e1.

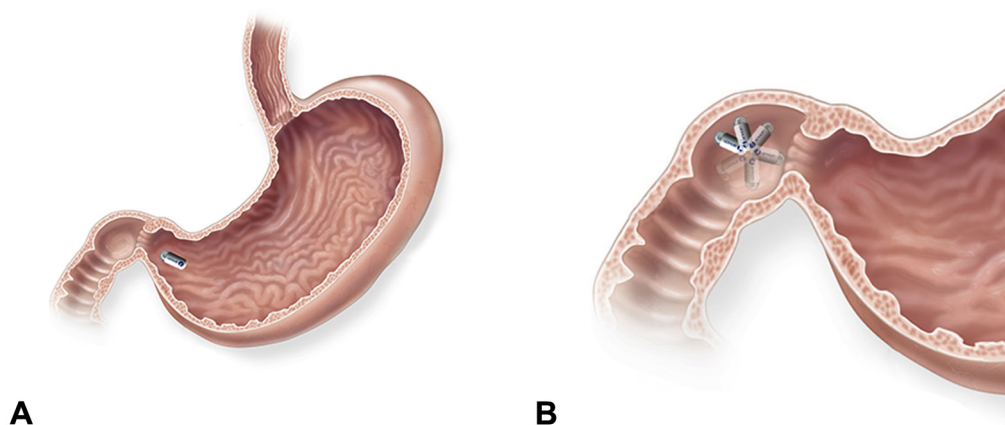


Figure 4. Schematic diagram of capsule passing through the pylorus and examination procedure of duodenum. **A**, The endoscopist rotated the capsule until the camera end faced the pylorus. **B**, In the duodenal bulb, the “360° automatic scanning” model was used during the procedure. Originally published in Jiang X, Qian YY, Liu X, et al. Impact of magnetic steering on gastric transit time of a capsule endoscopy (with video). *Gastrointest Endosc* 2018;88:746-54.

5. Curvatures of the stomach: The patient was placed in the supine position. The magnetic ball was lifted, and the camera was oriented downward at a 45° angle. Then the capsule was rotated 360° to enable observation of the gastric greater curvature and lesser curvature and also the junction of the gastric body and fundus (Fig. 3E).
6. Anterior wall of the gastric body: The patient was placed in the supine position. The magnetic ball was moved to the middle-left side of the abdomen and then lifted with the camera oriented upward, to observe the anterior wall of the gastric body (Fig. 3F).
7. Gastric angle: The patient was placed in the supine position. The magnetic ball was moved to the left hypochondrium and then lowered to enable clear observation of the gastric angle (Fig. 3G).
8. Gastric antrum: The capsule was moved into the antral region. Then the patient assumed the right-lateral decubitus position. The capsule was lifted with the camera oriented obliquely upward at 45°. The camera was then

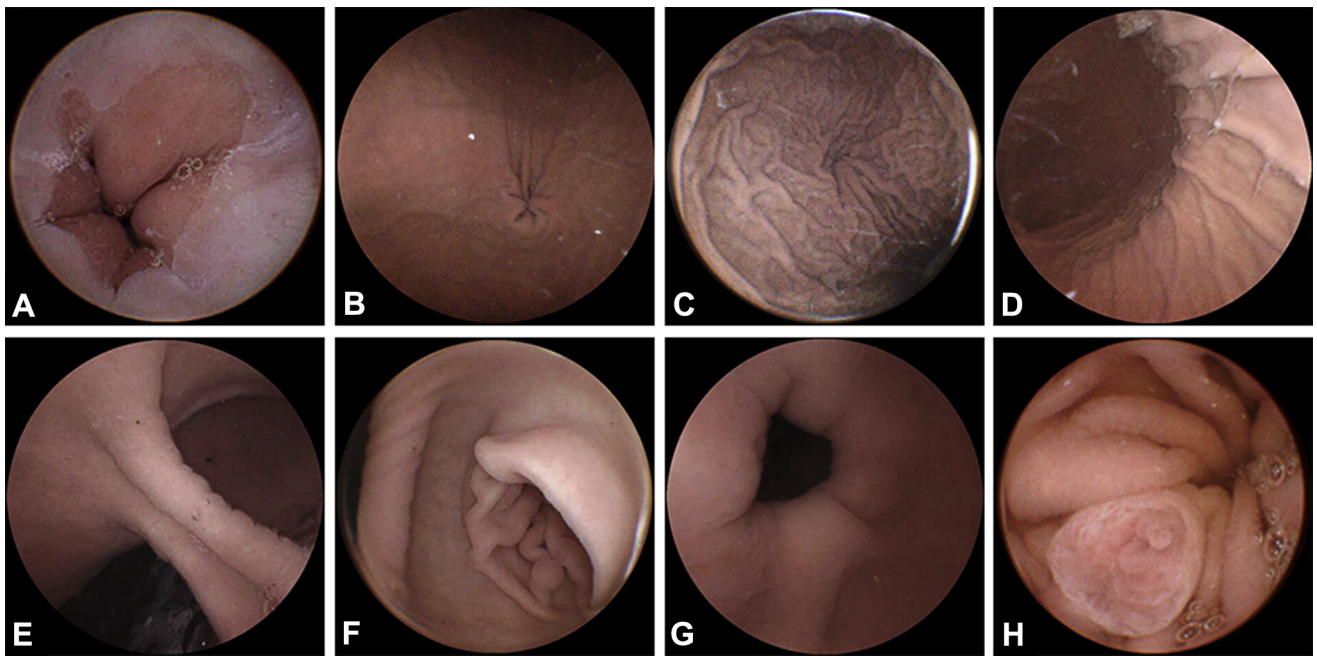


Figure 5. Standard landmarks of upper-GI tract: **A**, Z-line; **B**, gastric cardia; **C**, fundus; **D**, body; **E**, angulus; **F**, antrum; **G**, pylorus; **H**, duodenal papilla.

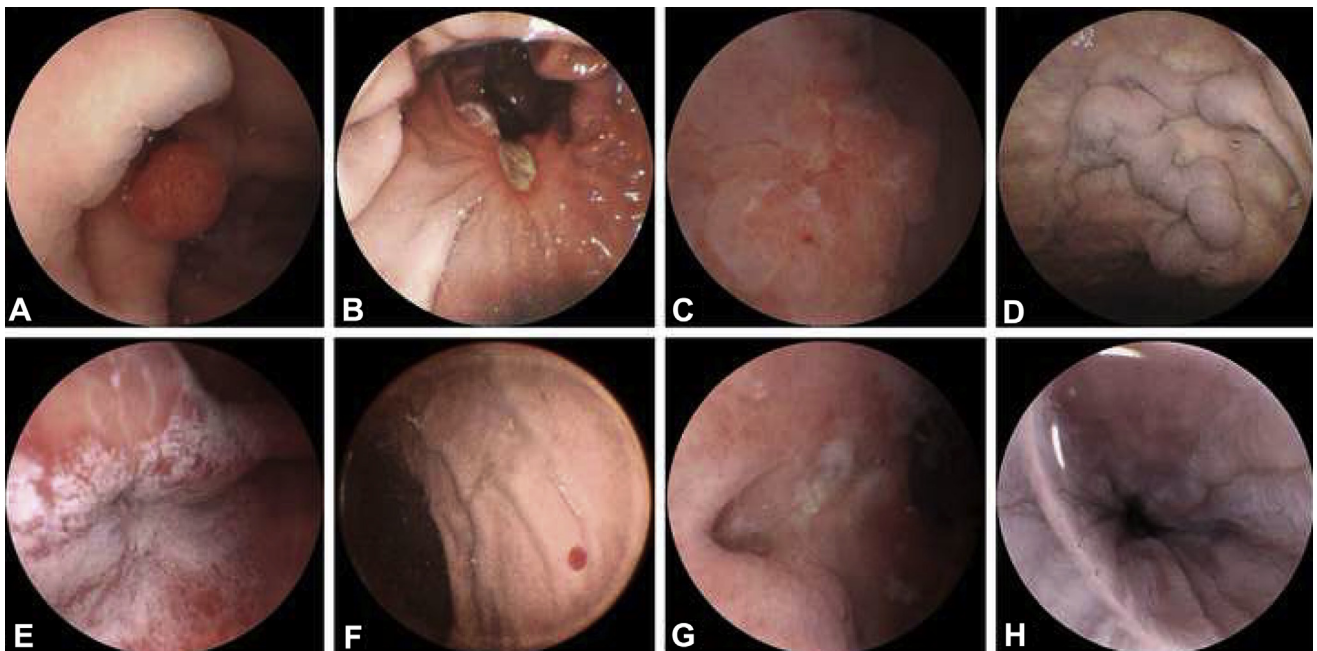


Figure 6. Typical GI lesions of upper-GI tract observed on magnetically controlled capsule endoscopy in different examinees: **A**, polyp; **B**, ulcer; **C**, gastric tumor; **D**, varices of gastric fundus; **E**, erosive gastritis; **F**, vasodilatation; **G**, diverticulum; **H**, reflux esophagitis.

horizontally rotated 360° to observe the antrum and the junction of gastric antrum and gastric body (Fig. 3H).

9. Pylorus: The patient was placed in the right-lateral decubitus position. The camera was oriented horizontally toward the pylorus for observation (Fig. 3I).
10. Transpyloric passage: The magnetic ball was moved toward the abdomen over the gastric antrum. The capsule was then rotated until the camera end faced

the pylorus. The capsule was dragged close to the pylorus with the guidance magnet robot. Once the pylorus opened, peristalsis propelled the capsule into the duodenum (Fig. 4A).¹⁰

11. Duodenum: The magnetic ball was held vertically at the highest point, and the "360° automatic scanning" button was pressed to scan the duodenum automatically (Fig. 4B).

12. Small bowel: If the patient needed a further examination of the small bowel, after the capsule passed through the duodenum, the “small intestine mode” button under the “real-time view” interface was pressed. The patient was allowed to leave the hospital with the data recorder for further collection of images of the small intestine.

The patient returned the data recorder the next day after the capsule battery expired, and all images were downloaded to the computer workstation and were reviewed by the reading physician. The reading physician generated an MCE report after carefully reviewing all the captured images. For a better understanding of the procedure, we present the standard landmarks of the upper-GI tract (Fig. 5) and typical GI lesions detected by MCE (Fig. 6).

If the patient has not observed capsule excretion within 2 weeks (ie, the capsule in the feces), she should return to the hospital to confirm capsule retention/excretion using a hand-held capsule locator. Detection of the capsule is indicated by the red signal light of the capsule locator; otherwise, the signal light remains green.

MCE has been used clinically as an important screening and examination tool for GI diseases.^{3,5-7,11,12} This novel MCE is a comfortable, highly acceptable alternative to EGD for patients refusing, or unfit for, conventional endoscopy, and it has the advantages of not requiring anesthesia, no risk of cross infection, and excellent patient acceptance.

DISCLOSURE

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Abbreviations: fps, frames per second; MCE, magnetically controlled capsule endoscopy.

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