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SECOND-GENERATION COLON CAPSULE IN SMALL BOWEL AND COLON DISORDERS IN PEDIATRICS

Background: Aim of the study was to assess the diagnostic yield of second-generation colon capsule in pediatric gastrointestinal diseases. **Patients and methods:** Five patients with different symptoms of gastrointestinal diseases were included in the study. Among them were: suspicion on diffuse polyposis, intestinal bleeding, lymphangiectasia and inflammatory bowel disease. Image interpretation was made by experienced capsule users, previously trained on small bowel capsule and first generation colon capsule. Lesions or abnormal changes of the mucosa identified on capsule endoscopy served as indications for colonoscopy or esophagogastroduodenoscopy with biopsy or polypectomy if needed. **Results:** Standard white light endoscopy was made in all children without any adverse events. Second-generation colon capsule allows diagnosing Crohn's disease in small intestine and colon, lymphangiectasia of the ileum, single rectosigmoid polyp and diffuse polyposis of the colon. **Conclusion:** Second-generation colon capsule can be used as non-invasive screening method in children without serious complications, thus allowing differentiating indications for traditional white light endoscopy, which is usually made under general anesthesia in pediatrics.

Keywords: capsule endoscopy, pediatrics, Crohn's disease, adenomatous polyps.

Introduction

Endoscopic examination is the most informative method of diagnosing diseases of the small and the large intestine. It is especially useful for Crohn's disease, non-specific ulcerative colitis, various enteropathies and small or large intestinal polyps [1]. The latter are detected only in 1% of children due to a frequently asymptomatic course of the disease and shortage of necessary equipment at polyclinics and inpatient hospitals [1, 2].

Gastrointestinal tract is almost completely accessible for intraluminal examination with esophagogastroduodenoscopy, double-balloon deep enteroscopy and colonoscopy at specialized inpatient hospitals; this has been infeasible only recently. At the same time, each method is more or less associated with invasive intervention, considered potentially painful and linked with the risk of development of life-threatening complications; this dictates the need in prescribing sedation or general anesthesia to an overwhelming majority of patients [2, 3].

Video capsule-assisted endoscopic examination helps to examine the digestive tract along the entire length thereof non-invasively; assessment of the deep segments of the small intestine shall be considered the most significant. Unlike a small intestinal capsule, a colon capsule is activated in the deep intestinal segments and allows painlessly examining most parts of the ileum and the whole large intestine due to preserved battery charge without sedation or general anesthesia and air insufflation into the intestinal lumen, i.e., without the events, that usually accompany the traditional endoscopy in such patients. The first generation colon capsule demonstrated safety of this method of visualizing the large intestinal mucosa [4-6].

The second generation colon capsules are different from the first generation colon capsules in terms of image acquisition frequency increase (35 and 4 frames per second, respectively) and increase in the aspect angle (172° and 156°, respectively) of the two capsule's cameras; this allows examining the large intestinal mucosa at almost 360°. Also, a new recording device (DR3) features audio and video signals to monitor capsule passage in real time with a

liquid-crystal diode screen [7, 8]. Colon capsules had never been used to examine children in the Russian Federation and abroad before.

The study was aimed at assessing potential of the second generation colon video capsule for diagnosing digestive tract diseases in children.

Patients and methods

STUDY SUBJECTS

5 children (4 boys and 1 girl [average age – 12.6±4.3 years]) underwent colon video capsule examination with the second generation Pillcam COLON 2 capsules manufactured by Given Imaging (Israel). The following nosological forms of the disease were observed: 2 patients – suspected Crohn's disease, 2 children – suspected multiple diffuse large intestinal polyps, 1 child – suspected small and large intestinal lymphangiodysplasia.

Various clinical manifestations of the gastroenterological disease, suspected multiple polyps in the small and the large intestine, digestive tract hemorrhage, lymphangiodysplasias etc. served as indications for video capsule examination. Moreover, we also performed video capsule endoscopy in order to diagnose the spread of the several pathological mucosal alterations detected in the course of the traditional endoscopic examination or the lack thereof in the setting of clinical manifestations of the disease. Dysphagia and any other difficulties swallowing, allergic reactions to the drugs used to prepare the intestine for examination, high risk of ileus and use of non-steroidal anti-inflammatory drugs served as contraindications against the examination.

All the patients were prescribed residue-free diet 3 days before the video capsule examination; they had also been taking prokinetics 15 minutes before meals for 3 days; they were also prescribed 30-50 ml of antifoaming agents at 15.00 the day before the examination and 30 minutes before the preparation for the examination. Large intestines of all the children were prepared for the examination with indoor-temperature cleansing enemas until only plain water would be yielded the day before and on the date of the examination. Colon capsule endoscopy was considered completed when the capsule had been evacuated from the patient's digestive tract.

STUDY METHODS

The second generation capsule is 11.6x31.5 mm; it is larger than the first generation capsule; however, it is fitted with two cameras with a considerably larger aspect angle (up to 172° for each camera), so it is possible to examine the intestinal surface at 360°. Moreover, the capsule features an adaptive image acquisition system, which allows watching the obtained images with the speed of 35 frames per second in motion and 4 frames per second during the idle time, in order to improve visualization of the large intestine and preserve battery charge. The capsule's adaptive image acquisition frequency control system results from a new interaction between the capsule and a new recording device Data Recorder 3, which allows for at least 10 hours of battery life. Program RAPID was used to determine the size of polyps when viewing the capsule's video image (Given Imaging Ltd, Israel).

The obtained results were interpreted by the personnel commanding the technique of colon capsule endoscopy and having previous experience of application of capsule endoscopy for visualization of the small intestine. The revealed pathological alterations of the upper or lower digestive tract accessible for the traditional intraluminal examination served as indications for esophagogastroduodenoscopy and colonoscopy with mucosal biopsy sampling and endoscopic polyp electroscission and further histological verification thereof.

Results

All the 5 colon capsule examinations were successful; we did not observe any reasons, such as, e.g., inability to swallow the capsule or technical failure of the visual diagnosis system Given Imaging, to cancel them.

Venous vascular pattern augmentation in the lower third of the esophagus were registered in one child, even though the capsule passed through the esophagus rather fast (pic. 1). Pathological alterations of the stomach mucosa were more diverse; they were characterized by honeycombed mucosal edema (pic. 2), intense macrofocal and diffuse hyperemia of the antrum and the fundus, visualization of flat hemorrhagic erosions of the antrum and abundant opaque content with admixture of green bile (pic. 3).



Pic. 1. *The endoscopic picture of increase of venous vascular pattern of the lower third of the esophagus*



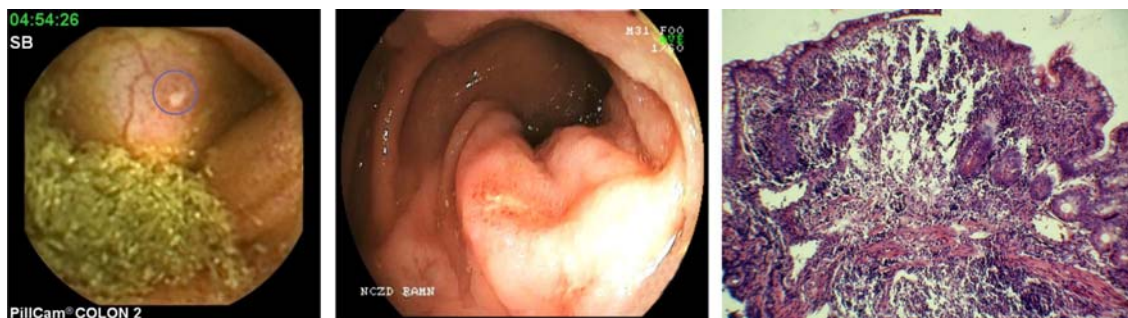
Pic. 2. *Endoscopic picture of inflammatory changes in the gastric mucosa*



Pic. 3. *Endoscopic picture of duodenal reflux*



Pic. 4. *Endoscopic picture of a polyp of the jejunum*



Pic 5. *From left to right: capsule, endoscopic and histological (drugs provided by PhD, prof. S.G. Khomeriki) images presenting aphthous lesions of the mucous membrane of the ileum - Crohn's disease*

Endoscopic semiotics indicating inflammatory alterations of the duodenal mucosa was observed in two children. Video recording of the colon capsule passage demonstrated a pronounced mucosal edema with fragmented vascular pattern, microfocal hyperemic elements with multiple whitish semolina-like lymphangiectasias along the top of folds.

Intraluminal condition of the small intestinal mucosa was characterized by soft pink coloring with well-defined vascular pattern and pronounced villous “velvety” layer on the surface thereof in all the children. We detected a 2x3 mm semispherical polypiform formation on a broad foundation, which did not differ from the adjacent mucosa and required further follow-up, in one child in that setting (pic. 4). Ileum was characterized by multiple circular folds with well-defined villous layer and vascular pattern and singular areas of lymphofollicular hyperplasia along the entire length. Mucosal lymphofollicular hyperplasia conglomerates were visualized in the terminal ileum in two children in that setting; one examination also revealed multiple mucosal defects with hyperemic areola – aphthae (pic. 5).

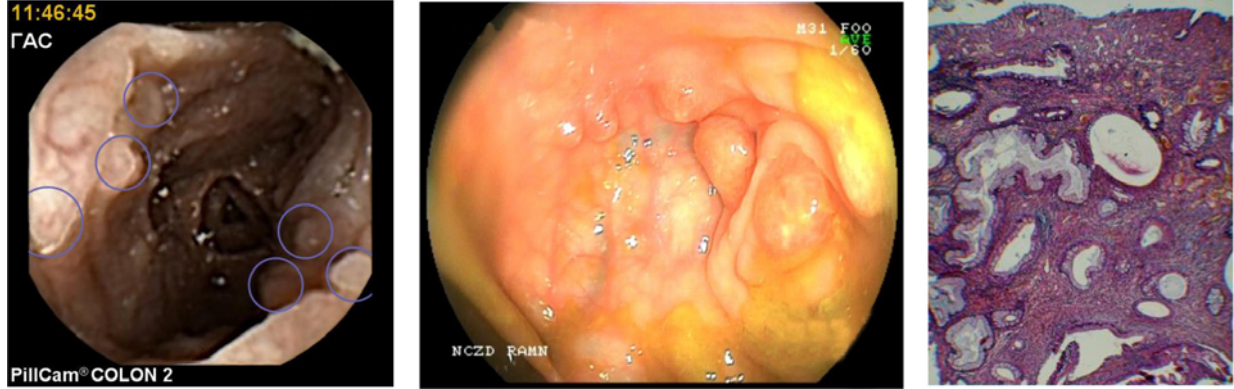
We assessed intraluminal condition of the large intestinal mucosa in all the children. Alterations of the ileocecal valvular mucosa similar to the ones at Crohn’s disease at the infiltration stage were characterized by flattened folds as a result of an edema with no vascular pattern, overlay of bile and fibrin and singular erosive irregular round formations (in one child). Further video capsule passage through the large intestine revealed skip lesions of right segments of the large intestine similar to the aforementioned one. A 4x2 cm polyp with torose hyperemic surface overcovering 50% of the intestinal lumen was observed in rectosigmoid angle of one other patient (pic. 6).

At the next stage (after the video capsule examination), the child underwent the traditional proctosigmoidoscopy with polyp electroscission under general anesthesia. Histological examination revealed a tubular adenoma. Diffuse polyposis with multiple 2-7 mm (in diameter) polyps was diagnosed in one child; it was confirmed by the traditional intraluminal study methods and histologically (pic. 7); the child later underwent operative treatment – total colectomy.

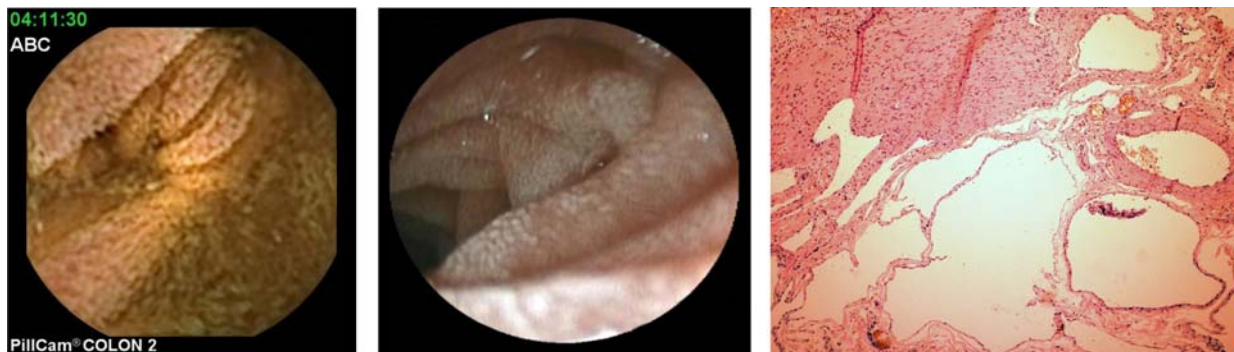
The child operated for lymphangiectasia of the small and the large intestine was prescribed colon capsule examination in order to rule out lymphoproliferative processes of deep segments of the small intestine. Video capsule examination in a limited timespan demonstrated reduction in the height of villous layer of the ileac mucosa and multiple hoarfrost-like lymphangiectasias along the top of folds (pic. 8).



Pic. 6. From left to right: capsule, endoscopic and histological (drugs provided by PhD, prof. S.G. Khomeriki) tubular adenomas images of rectosigmoid department



Pic. 7. From left to right: capsule, endoscopic and histological (drugs provided by PhD, prof. S.G. Khomeriki) tubular adenomas images – diffuse polyposis of the colon



Pic. 8. From left to right: capsule, endoscopic and histological (drugs provided by PhD, prof. A.G. Talalaeva) images of ileum lymphangiectasia

Discussion

Despite a small number of subjects, the results of the study may be considered satisfactory and corresponding to results of the most previously performed diagnostic manipulations with a video capsule employed in order to examine the small intestine in children [9]. This type of intraluminal study was successful in all the children; no side effects were observed. It ought to be mentioned that diagnosis of the pathological alterations established using the second generation colon video capsule was in all the cases confirmed by the traditional method of intraluminal digestive tract examination with histological verification of the disease. All of these facts may indicate high sensitivity of this method for diagnosing clinically significant pathological alterations, whereas safety and the possibility to perform colon video capsule examination may be considered an adequate instrument of non-invasive visualization of the small and large intestinal mucosa; this allows for differentiated approach to determination of the indications for the traditional diagnostic colonoscopy, which in most cases in pediatrics is performed under general anesthesia.

Conclusion

Colon capsule endoscopy in the event of no severe complications is a non-invasive method, which allows for examination of the small and large intestinal mucosa without the necessary sedation or general anesthesia and air insufflation into the intestinal lumen; this fact is of very high significance for intraluminal examination of these organs in children.

The second generation colon capsules with high image acquisition frequency and broad aspect angle of both cameras allows obtaining considerably better defined images and contributes to high sensitivity to various pathological alterations on the small and large intestinal mucosa, thus improving efficacy of endoscopic diagnosis in children.

Colon capsule endoscopy may be considered a screening method of non-invasive visualization of the small and large intestinal mucosa; it promotes differential approach to determination of the indications for the traditional diagnostic colonoscopy performed under general anesthesia in the overwhelming majority of pediatric cases.

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