Endoscopic imaging of the vermiform appendix (with video)

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Background: Chronic appendicitis may be detected in as many as 10% of patients with right lower quadrant pain. Although the appendiceal orifice is easily identified during colonoscopy, its lumen has not been investigated so far.

Objectives: To determine the feasibility of endoscopic appendix imaging to identify features of chronic appendicitis in patients with recurrent right lower quadrant pain.

Design: Prospective, proof-of-concept study.

Setting: University-based tertiary referral hospital.

Patients: Colonoscopy scheduled because of right lower quadrant pain.

Interventions: First, the appendix orifice was cannulated with a guidewire and a Jagtome. Next fluoroscopic imaging was performed by injection of contrast agent into the appendix orifice, and then a SpyGlass endoscope was inserted for imaging of the appendiceal mucosa and for biopsy. Patients were monitored 3 hours after investigation, with follow-up at 4 weeks.

Main Outcome Measurements: Cannulation rate.

Results: Thirteen patients were included. Endoscopic imaging of the appendix was successful in 9 of 13 patients (69%). In 10 patients, a guidewire was placed; in 7 patients, biopsy specimens were taken, revealing histological signs of inflammation in 5. In 4 patients, visible fecoliths were removed by flushing. All patients were discharged on the same day. No adverse events occurred. Three patients reported resolution of pain at follow-up. One patient with strictures at appendicoscopy underwent surgical appendectomy. Histology confirmed the findings of chronic appendicitis with fibrosis.

Limitations: Patient number limits power for analysis.

Conclusion: Endoscopic imaging of the appendix is feasible, safe, and clinically useful in patients with suspected chronic appendicitis.
methods varies from 47% to 95%, with a specificity of 89% to 98% and could lead to unnecessary appendectomies (so-called negative appendectomies) or delay of surgical intervention.5\textsuperscript{9}

As the appendix lumen is connected to the cecum, we aimed to evaluate the feasibility of an endoscopic procedure to visualize the appendix mucosa. We envisioned performing appendicoscopy with a miniature endoscope that is introduced through the working channel of a colonoscope and inserted into the appendix lumen. Such a procedure may be complemented by fluoroscopy and targeted biopsy of appendix pathologies (eg, mucosal abnormalities and strictures). This study was performed to test the safety and feasibility of such an approach in patients with right lower quadrant pain of unknown origin.

METHODS

The study was approved by the local ethics committee and performed according to the Declaration of Helsinki. Patients between 2010 and 2013 who were scheduled for colonoscopy because of right lower abdominal pain of unknown origin were included after written informed consent was obtained after a personal interview by the investigators. Bowel cleansing was done with 4 L of a polyethylene glycol–based solution (Kleanprep; Norgine, Marburg, Germany); the dose was split to take 2 L the evening before the procedure and 2 L on the morning of the day of the investigation. Patients with a history of abdominal surgery including appendectomy, known colonic stricture, a history of cancer, and pregnant women were excluded from the study. Patients were monitored with pulse oximetry. Sedation was performed with midazolam and propofol.

Procedure

A standard colonoscope (Olympus CF 180 series; Olympus, Tokyo, Japan) was placed in the cecum, and the cecum anatomy was assessed according to 2 types: (1) oblique (Fig. 1) if the lateral cecal sacculus was larger than the medial and the appendix orifice was behind the ileocecal valve or (2) conical (Fig. 2), if both cecal sacculles were similar in size and the appendix orifice was in the middle of the cecum. The position of the cecum was classified as regular or pelvic by fluoroscopy. After placing the colonoscope in front of the appendix orifice, cannulation of the appendix with an ERCP sphincterotome (Jagtome; Boston Scientific, Natick, Mass) and its preloaded guidewire (Jagwire; Boston Scientific) was attempted. On injection of contrast media (Peritrast; Koehler Chemie Dr. Franz GmbH, Bensheim, Germany), imaging by fluoroscopy was performed. After successful cannulation, the SpyScope Access and Delivery Catheter (Boston Scientific), a single-use, single-operator controlled catheter with a 10F diameter and 230-cm length designed to provide a pathway into the biliary anatomy for diagnostic and therapeutic devices, was introduced over the guidewire. As the SpyScope system could not be placed in the appendix lumen in all patients, a Haber RAMP catheter with an 8F diameter (Cook Medical, Bloomington, Ind) with a 3-access lumen was used instead after patient 7. Next, the SpyGlass Direct Visualization System (Boston Scientific), a fiberoptic probe with 6000 pixels and a 70-degree field of view, surrounded by light fibers, was placed in the SpyScope or the Haber RAMP catheter to investigate the appendix under continuous luminal water flow. Specially designed biopsy forceps (SpyBite; Boston Scientific) was used to obtain a histological specimen. After investigation of the appendix, regular colonoscopy was continued. Patients were monitored 3 hours after the investigation with pulse oximetry. Patients were asked to report their pain status at a follow-up visit or during a telephone interview 4 weeks after the investigation.

Data analysis

In general, statistics for continuous variables include mean, median, standard deviation, minimum, and maximum. Binary variables are given as number and percentage.

RESULTS

Patient demographics (baseline data)

Thirteen patients (8 female, 5 male, mean age 31 years, range 21-58 years) were included into this pilot study: 2 in 2010, 2 in 2013, 4 in 2011, and 5 in 2012. All patients had chronic lower quadrant pain for at least 6 months. No coexisting risk factors were present. The colonoscopy preparation was judged to be adequate in 13 of 13 patients.

Appendicoscopy

In all patients, the colonoscope was introduced into the cecum, and a stable view of the appendix orifice was achieved (Video 1, available online at www.giejournal.org). The cecum was considered oblique in 12 and conical in 1 case. The location of the cecum was regular in 10 and pelvic in 3 patients. Investigation of the appendix was successful in 9 of 13 patients (69%).

In 10 patients, a guidewire and catheter could be placed 1 to 7 cm into the appendix lumen (Fig. 3). In these patients, visualization with a contrast agent was possible. No perforations were diagnosed, a fecolith was suspected on fluoroscopy in 4 (Fig. 4), and postinflammatory appendiceal strictures in 1 patient (Fig. 5). In 3 patients, the guidewire could not be placed in the appendix lumen.

Take-home Message

- Endoscopic imaging of the vermiform appendix with SpyGlass system via a colonoscopic approach is feasible and safe and may be useful in patients with right lower quadrant pain of unknown origin.
even with the support of the bent sphincterotome. There was no relationship between such failure and cecum anatomy or cecum location.

In 9 of the 13 patients (69%), who are 9 of the 10 patients in whom the guidewire could be inserted, the SpyGlass was introduced, and visualization of the appendix lumen was achieved (Figs. 6 and 7). In the first 7 patients, the SpyScope system was used and was successful in 4 of 7 patients, whereas starting with patient 8 the Haber RAMP catheter was used for delivery of the SpyGlass to get access in 5 of 6 patients. The total investigation time decreased from a median of 75 minutes (range 50-120 min) in the first 7 patients to 40 minutes (range 20-75 min) in patients 8 to 13.
In 7 patients, usable specimens with the SpyBite biopsy forceps could be taken. Histology revealed signs of inflammation in 5 and regular histology in 2 specimens. In 3 of 4 patients, appendiceal fecoliths were removed by flushing the appendix with saline solution (Video 1). No patient reported additional pain during and 3 hours after the procedure, and no pre-, peri-, or postprocedural adverse events occurred.

In 3 patients, relief of right lower quadrant pain was achieved. In 1 of these patients, a fecolith had been removed during the appendicoscopy. In this patient, the pain resolved the day after the investigation. One patient in whom appendiceal strictures were found (Fig. 5) underwent laparoscopic appendectomy within 6 weeks postintervention with resolution of pain. Pathological assessment of the specimen confirmed the finding of post-inflammatory appendiceal strictures with histological signs of chronic appendicitis and fibrosis. In the third patient, the pain resolved spontaneously and did not recur during the 4-week follow-up.

**DISCUSSION**

To the best of our knowledge this is the first serial attempt to investigate the lumen of the appendix by means of endoscopy. This proof-of-concept study revealed that the appendix lumen can be cannulated in the majority of patients without adverse events. Pathological findings were found in 8 patients (5 patients had histological signs of inflammation, 2 of whom also had fecoliths; 2 other patients had fecoliths; and 1 had appendiceal strictures). In 3 patients, we failed to insert a guidewire into the appendix, making endoluminal investigations difficult.

In as many as 50% of patients, chronic appendicitis is the origin of right lower quadrant pain.\(^1,2\) SpyGlass appendicoscopy may be introduced as a diagnostic measure in selected cases. Particularly during initial appendicoscopies, investigation time was longer compared with regular colonoscopy because cannulation of the appendix orifice was sometimes difficult compared with cannulation of the papilla vateri during ERCP. However, after an initial learning curve and adapting the cannulation equipment, it was markedly reduced. Appendicoscopy provides the opportunity to retrieve histological specimens or removal of fecoliths, which may be the actual cause of discomfort. Using the Haber RAMP catheter instead of the SpyScope device reduced the procedural cost and enhanced its success rate. Furthermore, the SpyScope has a larger diameter and, although steerable, has less flexibility, which also kept us from trying to cannulate the appendix directly with ultrathin transnasal endoscopes. Histological specimens were taken with the SpyBite; however, when getting direct access, a regular biopsy forceps could even collect larger specimens because we could only collect usable specimens in 7 patients. Appendicoscopy can be considered “therapeutic” in certain patients in whom fecoliths are removed and the pain is relieved. At its current stage, a proper cost-efficiency analysis is too early to perform.

Because initial procedures were time-consuming, sometimes with multiple cannulation attempts, chronic inflammation could not be differentiated from acute inflammation caused by the procedure itself generally. Another limitation is the fact that this early study did not include a control group to investigate the rate of possible spontaneous pain resolution or clinical improvement in patients undergoing colonoscopy without appendicoscopy. This fact and the small number of patients can therefore not provide sufficient data on the effect of interventions or other causes such as colonoscopy preparation, placebo effect, or natural evolution of symptoms over time. Patients were asked to participate in a personal interview by the investigators and not a consecutive cohort of patients with right lower quadrant pain. Furthermore, we did not include asymptomatic patients and therefore cannot provide the incidence of appendiceal inflammation or appendicoliths in these patients.
The main interest of our group is the clinical development of colonoscopic appendectomy. As the appendiceal lumen connects to the cecum, appendectomy through a colonoscopic approach seems to be a reasonable endoluminal procedure that does not require access to the peritoneal cavity. As previously shown in a cadaver model, the inversion of the vermiform appendix into the cecum and its removal are feasible by means of colonoscopy. To further advance the approach into the clinical setting, the construction of a colonic access device to deliver additional equipment in front of the appendix orifice was mandatory and successfully evaluated. With a 69% cannulation rate of the appendix lumen, colonoscopic appendectomy might be a possible alternative to laparoscopic removal. Similar to cannulation of the papilla, we believe that further training leads to a success rate of more than 90%.

To conclude, endoscopic imaging of the vermiform appendix is feasible and safe and may be useful in patients with right lower quadrant pain of unknown origin.

REFERENCES