Introduction

Small-bowel video capsule endoscopy (SBCE) is a prime modality for diagnosis of small-bowel [1–4] pathology such as obscure gastrointestinal bleeding (OGIB), small-bowel tumors and inflammation [5]. It plays an important role in both the diagnosis and monitoring of small-bowel Crohn’s disease (CD) [1–8]. However, one of the main limiting factors in the use of SBCE in patients with established CD is the risk of capsule retention, which has been reported to be as high as 13% in early studies [9,10], although in more recent series, the risk of retention was much lower [11–16]. In patients with established CD, assessment of small-bowel patency by cross-sectional imaging or patency capsule is recommended [7]. The patency capsule (Given Imaging, Yokneam, Israel) is a non-diagnostic capsule of the same shape and dimensions as the diagnostic capsule (Fig. 1). The cellophane-walled capsule cylinder, filled with lactose admixed with barium, is protected by hollow plugs allowing influx of intestinal fluid leading to dissolution of the lactose. In addition to barium which allows radiological detection, the patency capsule contains an inner RFID tag which enables detection by a handheld radiofrequency scanner (HHS) [3]. Successful excretion or non-detectability of the ingested patency capsule in a predefined time (40 hours for the 1st generation and 30 hours for the 2nd generation) patency capsule indicates that a diagnostic SBCE can be safely performed [1,7].

Results: In total, 20 symptomatic cases of retention out of 1615 (1.2%) patency capsule tests were identified; in one patient, the patency capsule was retained in the esophagus, in the rest, the capsule was detected in the small bowel resulting in abdominal pain or small-bowel obstruction. One patient (5%) required surgery; all other patients resolved spontaneously or after corticosteroid therapy.

Conclusions: Symptomatic patency capsule retention is a very rare complication with a favorable prognosis. It should be recognized but its use in patients with suspected small-bowel stenosis should not be discouraged.
the patency capsule in the small bowel by plain abdominal film (XR), computed tomography (CT), or HHS within or after the defined excretion time.

**Results**

A total of 1615 patency capsule examinations were registered in the clinical databases of the participating centers (between June 2005 and December 2015). In total, 20 cases of symptomatic patency capsule retention were identified (1.2%). In one patient, the patency capsule was retained in the esophagus, while in the rest, it was retained in the small bowel.

The patency capsule examination was performed in 19 patients for suspected (6/20, 30%) or established (13/20, 65%) CD, and in one patient for a suspected mesenteric ischemic event. Six patients (30%) had a previous history of abdominal surgery; 7 (35%) had previous episodes of small-bowel obstruction (SBO); 2 (10%) patients had used nonsteroidal anti-inflammatory drugs (NSAIDs) at least once within the preceding 12 months. Two (10%) of the patients had undergone previous radiotherapy. In one patient, a M2A capsule was used, and in the remainder, the Agile patency capsule was used.

All patients with a retained capsule presented with abdominal pain; in 14 of them (70%), the presentation was accompanied by overt symptoms of clinical small-bowel obstruction (vomiting, abdominal distension, failure to pass stool or gas). The median time from patency capsule ingestion to diagnosis was 9 hours (interquartile range (IQR) 8–24 hours). The patency capsule was detected by HHS in 9 (45%) of the patients; small-bowel location was confirmed by XR (Fig. 2) and CT (Fig. 3) in three patients each; in one patient with dysphagia, the patency capsule was detected by HHS and later discovered in the esophagus and advanced to the duodenum by esophagogastroduodenoscopy. In the remainder of the patients, HHS was not used and the patency capsule was detected either by XR or CT directly.

The symptoms resolved spontaneously within up to 72 hours in 13 (65%) patients. Five (20%) patients were treated with systemic corticosteroids with subsequent resolution within up to 1 week. One patient required ileocecal resection and in another, the patency capsule, which was retained in the esophagus due to a Schatzki ring, was advanced to the duodenum endoscopically. This patient underwent diagnostic SBCE (introduced endoscopically) that was normal and uneventful.

Subsequent cross-sectional imaging (CT enterography (CTE)/magnetic resonance enterography (MRE)) was performed in 12 (60%) patients; in 10/12 (83%), ileal stenosis was detected. In another two patients, cross-sectional imaging was normal. Patient details and clinical course are described in detail in Table 1.
Table 1  Characteristics and clinical course of patients presenting with symptomatic patency capsule retention.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, years</th>
<th>M/F</th>
<th>Patency capsule model</th>
<th>Indication for VCE</th>
<th>Surgical history</th>
<th>History of radiation</th>
<th>History of SB obstruction</th>
<th>Symptoms</th>
<th>Time to presentation, hours</th>
<th>Modality for patency capsule detection</th>
<th>Treatment</th>
<th>Outcome</th>
<th>Subsequent diagnostic findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49</td>
<td>F</td>
<td>M2</td>
<td>Known CD. Reassessment of disease activity</td>
<td>Ileecotomy, 4 SB resections</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, vomiting</td>
<td>50</td>
<td>HHS, XR</td>
<td>CS</td>
<td>Resolution after 2 days</td>
<td>MRE – stenosis in the terminal ileum</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>M</td>
<td>Agile</td>
<td>Suspected CD</td>
<td>None</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, nausea</td>
<td>8</td>
<td>HHS, XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>CTE – stenosis in the ileum</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>F</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>Colectomy, ileal resection</td>
<td>0</td>
<td>0</td>
<td>Abd. pain</td>
<td>6</td>
<td>HHS</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>MRE – stenosis in the terminal ileum</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>6</td>
<td>XR</td>
<td>CS</td>
<td>Resolution after 5 days</td>
<td>MRE – stenosis in the terminal ileum</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Iron deficiency anemia</td>
<td>None</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, diarrhea</td>
<td>8</td>
<td>HHS, XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>MRE – stenosis in the ileum</td>
</tr>
<tr>
<td>6</td>
<td>61</td>
<td>M</td>
<td>Agile</td>
<td>Suspected mesenterial ischemia</td>
<td>Ileal resection</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, vomiting</td>
<td>8</td>
<td>HHS, CT</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>NA</td>
</tr>
<tr>
<td>7</td>
<td>73</td>
<td>F</td>
<td>Agile</td>
<td>Suspected CD (anemia, Abd. pain)</td>
<td>Hysterectomy</td>
<td>1</td>
<td>1</td>
<td>Abd. pain, vomiting</td>
<td>24</td>
<td>HHS, CT</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>CTE – normal, VCE – ileal stenosis</td>
</tr>
<tr>
<td>8</td>
<td>47</td>
<td>F</td>
<td>Agile</td>
<td>Suspected CD (anemia, Abd. pain)</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, nausea</td>
<td>8</td>
<td>HHS, XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>CTE – normal</td>
</tr>
<tr>
<td>9</td>
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<td>F</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>8</td>
<td>CT</td>
<td>CS</td>
<td>Resolution after 7 days</td>
<td>CTE – stenosis in the terminal ileum</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>Laparoscopy</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>10</td>
<td>XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>NA</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Chest pain, dysphagia</td>
<td>0</td>
<td>XR, gastroscopy</td>
<td>Successful VCE – normal, uneventful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>68</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain</td>
<td>54</td>
<td>HHS, XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>MRE – stenosis in the ileum</td>
</tr>
<tr>
<td>13</td>
<td>36</td>
<td>F</td>
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<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Ileus</td>
<td>8</td>
<td>Abdominal CT ileecal resection</td>
<td>Resolution after surgery</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>40</td>
<td>M</td>
<td>Agile</td>
<td>Suspected CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>16</td>
<td>XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>CTE – stenosis in the terminal ileum</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>F</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, obstruction</td>
<td>12</td>
<td>XR</td>
<td>0</td>
<td>Spontaneous resolution</td>
<td>NA</td>
</tr>
<tr>
<td>16</td>
<td>49</td>
<td>F</td>
<td>Agile</td>
<td>Suspected CD</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, distension</td>
<td>24</td>
<td>XR, CT</td>
<td>Nasogastric tube, CS</td>
<td>Resolution after 3 days</td>
<td>CTE – inflammatory stenosis in the ileum</td>
</tr>
<tr>
<td>17</td>
<td>79</td>
<td>F</td>
<td>Agile</td>
<td>Suspected CD</td>
<td>Anterior resection of the rectum</td>
<td>1</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>36</td>
<td>XR</td>
<td>0</td>
<td>Spontaneous resolution – 2 days</td>
<td>Ileocolonoscopy – normal (resulted in perforation)</td>
</tr>
<tr>
<td>18</td>
<td>42</td>
<td>M</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, distension</td>
<td>12</td>
<td>XR</td>
<td>0</td>
<td>Spontaneous resolution – 2 days</td>
<td>NA</td>
</tr>
<tr>
<td>19</td>
<td>47</td>
<td>F</td>
<td>Agile</td>
<td>Suspected CD</td>
<td>None</td>
<td>0</td>
<td>1</td>
<td>Abd. pain, vomiting</td>
<td>24</td>
<td>CT</td>
<td>CS</td>
<td>Resolution in 2 days</td>
<td>CT – stenosis in the ileum</td>
</tr>
<tr>
<td>20</td>
<td>39</td>
<td>F</td>
<td>Agile</td>
<td>Known CD. Reassessment of disease activity</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>Abd. pain, vomiting</td>
<td>6</td>
<td>XR</td>
<td>CS</td>
<td>Resolution in 2 days</td>
<td>NA</td>
</tr>
</tbody>
</table>

F, female; M, male; CD, Crohn’s disease; Abd., abdominal; HHS, hand-held scanner; XR, plain abdominal film; CT, computed tomography; CS, corticosteroids; VCE, video capsule endoscopy; SB, small bowel; CTE, CT enterography; MRE, magnetic resonance enterography.
The patency capsule is an important tool for assessment of small-bowel patency in patients who are at high risk of capsule retention. Utilization of a patency capsule may significantly reduce the risk of SBCE retention [22]. The latest patency capsule model (Agile) was designed to minimize the occurrence of abdominal pain secondary to non-extraction of the patency capsule; the dissolution time of the Agile patency capsule is shorter (30 vs 40 hours) due to the presence of two timer plugs instead of one as designed for the first generation patency capsule, allowing an enhanced contact with intestinal secretions as well as shrinkage of both sides minimizing the chance of obstruction. Complications with a patency capsule are rare and usually manifest as abdominal pain with rare cases of overt bowel obstruction [17–20]. We collected the results of the available prospective studies and case series pertaining to the use of a patency capsule (Table 2). The pooled rate of patency capsule-related complications was 40/629 (6.3%). The retention resolved spontaneously in 35/40 patients (87.5%); five patients (12.5%) required surgery. In addition to abdominal pain and small-bowel obstruction, a single case of intestinal ischemia [23] after patency capsule ingestion was described.

The most probable explanation for patency capsule complications is lodgment of the capsule in a strictured segment of the small bowel, resulting in pain and partial obstruction. In most cases, the capsule dissolves upon contact with intestinal fluids and passes by itself; however, in some cases, such contact may be limited leading to slower dissolution, or even failure to completely dissolve.

The current study is the largest real life case series describing symptomatic patency capsule retention. Almost all of our cases were patients with suspected or established CD. The prevalence of this adverse event was very low. Significant ileal stenosis was demonstrated on cross-sectional imaging in most of the patients. In all but one patient, symptoms resolved without the need for surgery or endoscopy, most probably after patency capsule dissolution. Interestingly, two patients did not have any evidence of small-bowel stenosis on cross-sectional imaging. As these patients were symptomatic and presented with a suspected bowel obstruction, this most probably reflects the limitation of cross-sectional imaging for prediction of capsule retention [24, 25]. The rate of symptomatic patency capsule retention in our series is the lowest reported even when compared to earlier prospective series, most probably due to the retrospective nature of our...
series that focused on serious adverse events requiring hospitalization. Importantly, even in these severe cases, surgery was required in only one single patient (0.6% of all evaluated patients), obstruction usually resolving spontaneously or with corticosteroid treatment in the majority of cases. One may argue that cross-sectional imaging is safer in comparison to a patency capsule to evaluate small-bowel patency, but it is significantly less accurate in the evaluation of functional small-bowel patency, frequently overestimating the risk of obstruction. In a recent study evaluating the accuracy of MRE for prediction of patency capsule retention in patients with established small-bowel CD, the sensitivity and specificity of MRE were 92.3% and 59%, respectively [24]. Thus, if the decision to administer SBCE was based on imaging and not patency capsule results, at least 40% of the patients would have been denied the procedure.

Our study has several limitations. First, this was a retrospective multicenter study. The description of the clinical presentation is limited to the description as presented in the clinical charts at the time. Furthermore, we did not use a quantitative pain evaluation scale. Also, we did not document the shape of the patency capsule on expulsion. Moreover, cross-sectional imaging following patency capsule retention was not routinely available in all patients.

In conclusion, symptomatic patency capsule retention is a very rare adverse event that resolves without surgical or endoscopic intervention in the vast majority of cases. This rare complication should be recognized and acknowledged, but should not discourage physicians from utilization of the patency capsule in patients with suspected small-bowel stenosis before administering SBCE.

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