Minimally-invasive imaging of the small intestine

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2014

Chapter 5

Small-bowel endoscopy – an introduction for radiologists

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Submitted for publication

Summary

The fields of small-bowel radiology and small-bowel endoscopy have changed impressively during the last decade. Nowadays, there are many diagnostic options to choose from when a small-intestinal condition is suspected, including MR and CT enterography and enteroclysis, video capsule endoscopy, and several techniques of device-assisted flexible enteroscopy. This short review provides radiologists with basic knowledge concerning the latest developments in small-bowel endoscopy. An emphasis is on the way radiology and endoscopy may interact.

Introduction

For decades, the small bowel was almost inaccessible for endoscopic examinations. Radiological studies, like small bowel-follow-through-series and single or double-contrast enteroclysis series, provided the best possible insight in suspected small-intestinal conditions.[1]

With the clinical introduction of video capsule endoscopy (VCE) and device-assisted enteroscopy, investigation of the small intestine became more readily available.[2, 3] These new diagnostic possibilities resulted in an increased appreciation of many small-intestinal conditions, especially since deep enteroscopy allowed therapeutic interventions that were previously impossible. Many considered the start of this new era in endoscopy to be the end of small-intestinal radiography, just as the introduction of colonoscopy had replaced radiological colonography as the examination of choice in suspected colonic disease. Interestingly, the opposite occurred: parallel to the introduction of novel endoscopic methods, improvements in cross-sectional techniques as computed tomography (CT) and magnetic resonance (MR) imaging were used to improve small-intestinal radiology.

So nowadays, a clinician in need to investigate the small intestine of a patient, has many diagnostic options to choose from. It is therefore mandatory that radiologists as well as endoscopists are aware of the strengths and limitations of each other's modalities, in order to make a balanced choice.

This overview aims to provide the radiologist with an insight in to the latest developments in diagnostic and therapeutic small-bowel endoscopy. Additionally, we discuss the role of radiology in the prevention, diagnosis and management of complications of VCE and flexible small-bowel endoscopy.

Video capsule endoscopy

Although video capsule technique is also being used for examination of the colon, and to a much lesser extent the oesophagus, its primary and best documented use is for the investigation of the small intestine, to which this overview is limited.

With VCE, the patients ingests a small capsule that is equipped with a light source, a lens and imaging processor and batteries.[4] Several manufacturers produce capsule endoscopes, so there is some variation in capsule size, frames per second, lens position, field-of-view and battery-life (***table 5.1***).

The capsule is propulsed by the peristalsis of the intestinal tract. Since the capsule is not equipped with rinsing facilities, as conventional endoscopes are, some kind of bowel preparation is usually given before ingestion of the capsule. Several regimens can be used, of which those containing polyethylene glycol solutions are the most frequently used.[5] Capsule endoscopes do not have the possibility to inflate the intestinal lumen, obtain tissue specimens or perform any kind of intervention.

Most small-bowel video capsules are outfitted with one camera at the distal end (***figure 5.1***). A recently introduced capsule type (Capsocam; Capsovison, Saratoga, CA, USA) has

Table 5.1: Comparison of technical specifications of the different small-intestinal capsule systems commercially available.

Capsule name	Pillcam SB3	Mirocam MC 1000W*	OMOM	EndoCapsule type 1	Capsocam SV1
Manufacturer, Country	Given Imaging, Israel	Intromedic, Korea	Chongqing Jinshan Science & Technology, China	Olympus, Japan	Capsovision, USA
Size (diameter × length, mm)	11 × 26	10.8 × 24.5	13 × 27.9	11 × 26	11 × 33
Weight (g)	3.45	3.25	6	3.80	3.80
No, type and position of image sensors	1 CMOS, end	1 CMOS, end	1 CCD, end	1 CCD end	4 CCDs, sides
Field of view (degrees)	156	170	130	145	360
Frame-rate (frames per second)	2–6	3	2, 1 and 0.5†	2	4–16 per camera‡
Battery-life (hours)#	8	12	7 ± 1	8	15
Light source	4 white light LEDs	6 white light LEDs	6 white light LEDs	6 white light LEDs	16 white light LEDs (4 per camera)
Method of wireless data-transmission	radiofrequency	Electric field propagation	radiofrequency	radiofrequency	—
Receivers	8	8	14	8	—
On-board memory	—	—	—	—	EPROM Flash Memory
Real-time viewing possibility	yes	yes	yes	yes	no

Note: CCD = charge-coupled device; LED = light emitting diode. CMOS = Complementary metal–oxide–semiconductor. EPROM = erasable programmable read-only memory. * An alternative type is MC 1000 WM, provided which can be guided through oesophagus or stomach by an external magnet in case of slow transit. Size: 10.8 × 25.5 mm; weight: 4.70 g; operation time: 8 hours. All other specifications equal to that of MC 1000W.

† Rate can be changed by the viewer during the examination.

‡ First two hours of recording time: 16 frames per second, remaining time: 4 frames per second.

According to manufacturer's data.

four cameras at its sides (***figure 5.2***). This results in a completely different image in comparison to the other capsule brands (***figure 5.3***). A capsule system designed for capsule colonoscopy has cameras at both ends, a design that probably in the near future will be incorporated in the small-bowel version of this manufacturer. The field of view of most capsule types differs slightly. At this moment, only the novel side-viewing system provides a 360° view of the mucosa, but the clinical benefit of this modification has not been established yet.

The number of images obtained per second varies per manufacturer. One manufacturer has provided a capsule intended for video colonoscopy with a feedback mechanism, whereby the frame-rate varies with the speed of the capsule: When progress is slow, the frame-rate drops, when the capsule is moving fast, the frame-rate increases to a maximum of 35 images per second. This system, although to a limited extent, has recently become available on small-bowel video capsules, and is expected to increase the yield of VCE, especially in the duodenum, where progress is usually very quick, and motion artefacts frequently occur. The side viewing Capsocam takes 20 frames per second for the first two hours at a rate of 5 frames per second per camera and thereafter 12 frames per second at a

Figure 5.1: A selection of different brands of forward-viewing video capsule endoscopes. (a) Pillcam SB2. (b) Mirocam MC 1000W. (c) Endocapsule type 1.

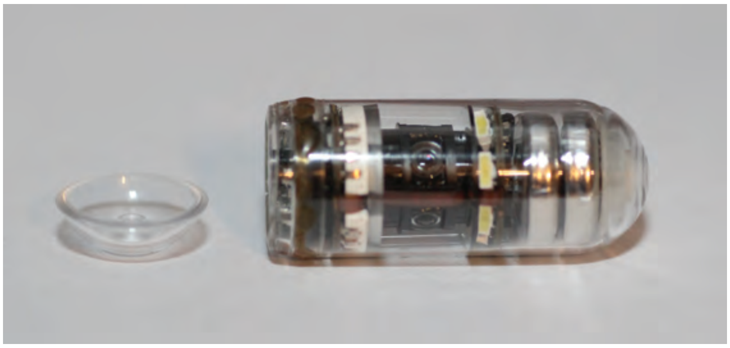

Figure 5.2: Capsocam side-viewing capsule. One of the capsule tips (left) has been cut off in order to access the recorded images from the capsule and transfers data from the capsule to the workstation. At the middle of the capsule two of the four cameras can be seen.

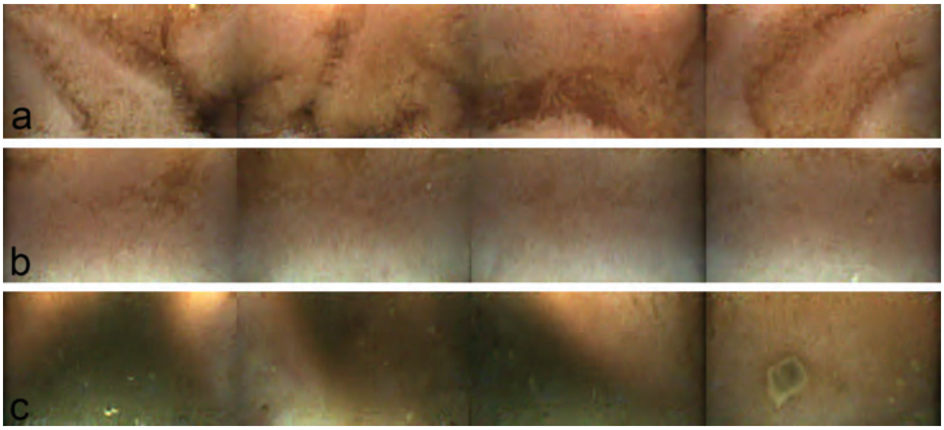

Figure 5.3: Panoramic Capsocam images. (a) Normal jejunum. (b) Normal ileum. (c) Ileum with a small ulcer (right) probably caused by non-steroidal anti-inflammatory drugs.

rate of 3 frames per second per camera, in order to have an increased yield in the proximal small bowel. Images obtained with the four cameras when the capsule is not moving are analysed, but not stored, in order to save energy.

All but one type transmit the images to receivers attached to the patient's body. Most brands of transmitting capsules use radiofrequency transmission, whereas one brand, Mirocam, uses electric field propagation, which is an energy-efficient transmission mode, not unlike the way electrocardiography records electric activity of the heart. The video signal is captured and stored on an external recorder. After a certain amount of time the battery of the capsule will run out, and no further images are recorded. The capsules are usually excreted by natural ways within 2 or 3 days.

For the transmitting-type capsules, at the end of examination, all data are downloaded to a workstation, where they can be viewed (***figure 5.4***). The excreted capsule can be disposed of. The Capsocam does not transmit the images, but stores them in an on-board memory chip. Although this reduces energy restraints, it means that in contrast to other capsule systems the capsule needs to be retrieved from the stool, in order to be read.

The viewing software allows modification of the playback speed, annotation of lesions found and also serves as reporting software. It is important to realize that in all, over 50000 images have to be reviewed, and even more in capsule types with more than one camera, or with higher frame-rates. The images are reviewed at higher frame-rates than with which they were acquired. Often, reviewing is done at a frame-rate of 15 frames/sec, and using multipanel viewing.

One capsule type, Mirocam MC 1000 WM, can be moved to some extent using an external magnet. This feature, combined with a live view, may allow a capsule that is stagnant in the oesophagus or stomach to be moved to the duodenum. To date, no studies have been published that have investigated the clinical application of this concept.

Figure 5.4: The viewing station of the Given imaging capsule system. The viewing station is configured to show two capsule images at a time. Thumbnails of selected capsule images are seen on the lower right, below the colour bar that provides the reader with an orientation of the frame position in relation to the complete examination.

The main limitations of capsule endoscopy are the passive propulsion, the lack of steering, rinsing and distension possibilities, and the lack of being able to perform interventions. All these aspects are currently vigorously investigated by the manufacturers of capsule endoscopy systems, but this has not resulted in major breakthroughs so far.

Pearls, pitfalls and complications of video capsule endoscopy

Pearls and pitfalls

VCE is a very well tolerated examination. The only parts of the investigation that can be uncomfortable are the bowel preparation prior to the examination, and the actual ingestion of the capsule. The latter provides only very minor discomfort: In general even small children are able to swallow the capsule without great difficulties. Capsule studies should not be performed in patients with (likely) small intestinal stenosis, or in patients with severe swallowing disorders or oesophageal diverticula.[6] Pacemakers and implantable cardiac defibrillators were initially considered contraindications for VCE. Most studies to date have found no evidence of interference between video capsules and implantable cardiac devices.[7-9] Many centres now consider implantable cardiac devices no longer an absolute contraindication for VCE.

The direct mucosal view provided by the capsule endoscope allows the diagnosis of minute and flat lesion, like small angioectasia, that would be invisible at radiological examinations. A drawback of VCE is that even large and relevant lesions are easily missed.[10-12] This is mainly caused by the fast transit of the capsule through the proximal intestine, which results in only a limited number of images being obtained by the capsule and because most capsule types have one lens only, resulting in lesions being missed if they are not in the same direction as the head of the capsule. Estimating the size of small-bowel lesions, such as polyps, is quite difficult with VCE. This is caused by the fact that very often only a part of a lesion is within the field-of-view of the capsule, by the lack of size reference in the small intestine and because the small bowel wall is often collapsed when the capsule passes.

Although it is not possible to know the exact position of lesions visualized with capsule endoscopy, estimations can be made based on the time a lesion is seen, in relation to the total time needed to pass the complete small bowel. The estimated location of lesions depicted aids in determining which way of insertion of a flexible enteroscope has the highest likelihood of reaching the lesion.[13]

If the small intestine, or parts of it, has not been cleaned well enough, there are no ways to correct this during the examination.[5] Therefore, if parts of the intestinal mucosa cannot be assessed due to the bowel content, examinations may have to be repeated. As in conventional endoscopy, reporting the quality of bowel preparation, for which several grading systems are available, is therefore important.[14, 15]

Another frequently encountered problem with capsule endoscopy is that the capsule battery runs out before the colon has been reached. In a study concerning Dutch patients, this occurred in up to 20% of capsule studies.[16] Since it is difficult to estimate the position of the capsule in the small intestine, it is in such cases not known how much of the intestine has not been investigated. Risk factors for incomplete depiction of the small intestine are previous small-bowel surgery, hospitalization, moderate or poor bowel cleansing, and a gastric transit time longer than 45 minutes.[16]

Complications

Complications of VCE are rare, but can be very severe. Aspiration of the capsule may occur in patients with swallowing disorders (***figure 5.5***).[17-19] The most feared complication, perforation, has been reported anecdotally and most often in patients with Crohn's disease (***figure 5.6***).[20-25] Retention of a capsule occurs much more frequently. Capsule retention can occur anywhere in the gastrointestinal tract, for instance in Zenker's diverticula or Meckel's diverticula, but retention due to stenotic lesions in the small intestine is much more frequent.[26-30] A recent meta-analysis reports the incidence of capsule retention in the small bowel to be 1.4% in the overall studied population.[31] Risk factors for retention are suspected or established Crohn's disease and neoplastic disease. Capsule retention can

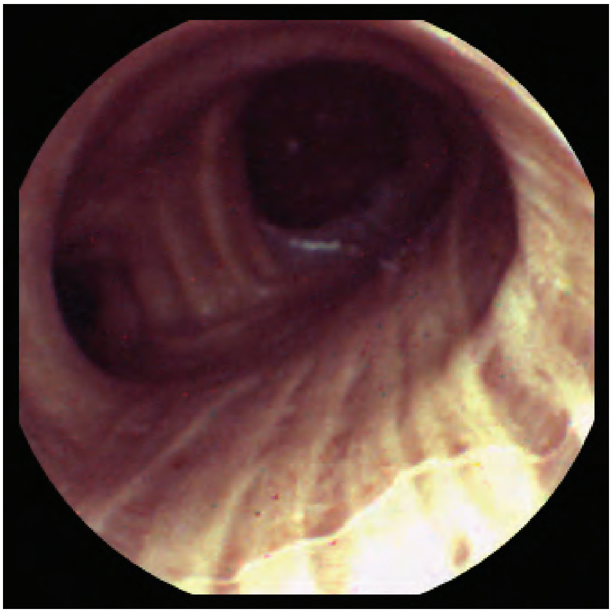

Figure 5.5: Video capsule image of the right main bronchus of a 64-year-old man. After ingestion of the capsule the patient experienced coughing, but no dyspnoea. Two hours after ingestion the capsule was dislodged after coughing.

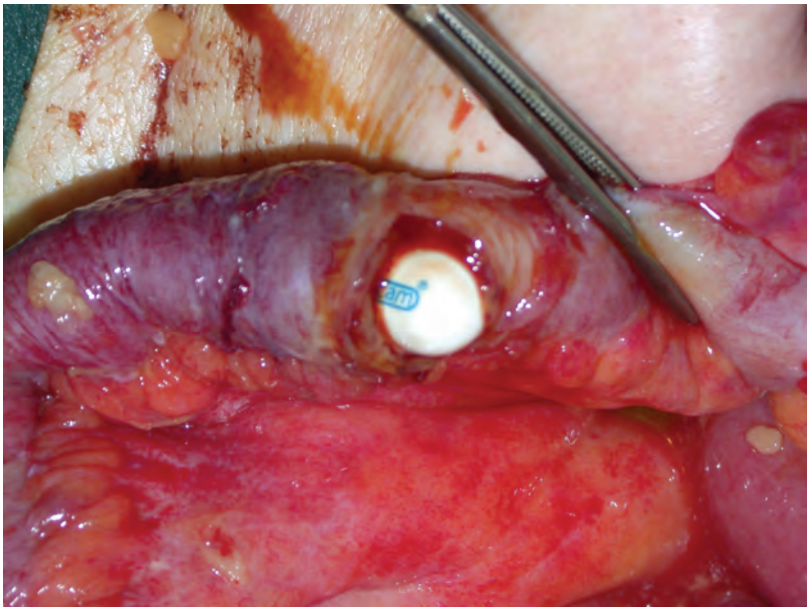

Figure 5.6: Photograph obtained during surgery shows a small-bowel perforation caused by a capsule endoscopy in an 86-year-old woman with radiation enteropathy.

be asymptomatic or symptomatic, with acute small-bowel obstruction as its most severe presentation.[32] Capsules can eventually pass spontaneously in less severe cases. However, removal of retained capsules in patients with symptomatic retention requires emergency surgery or enteroscopy.[31, 32] The latter method has the benefit of establishing a preoperative tissue diagnosis. Additionally, if the underlying cause does require surgical resection, this can be planned electively, after optimal staging and after optimization of the patient's condition.

To minimize the chance of small-intestinal capsule retention, it is in general advised not to perform capsule endoscopy in patients with signs or symptoms that might indicate the presence of small-intestinal stenosis. Additionally, care should be observed when performing capsule endoscopy in patients with known Crohn's disease or other conditions that harbour the risk of intestinal stenosis.[8, 17]

A patency capsule has been developed to test the patency of the intestinal tract, before capsule endoscopy is performed.[33] The dissolvable patency capsule is composed of a lactose body with 5% barium, surrounding a small radiofrequency identification tag. At each end of the capsule there are so-called timer plugs that will dissolve after the capsule has been in the intestine for approximately 30 hours, resulting in disintegration of the capsule, after which the remaining fragments will pass (***figure 5.7***).[34] So, if a patency capsule is excreted in its original form, it is unlikely that a relevant stenosis will impair progress of a capsule endoscope. On the other hand, patency cannot be established when the capsule is (partially) disintegrated when it is excreted, or if a specially designed portable scanner detects the presence of the small radiofrequency identification tag 32 to 38 hours after ingestion.[34] Despite these measures, capsule retention can occur even after successful passage of a patency capsule.[32, 35] Therefore, careful history taking and physical examination before capsule endoscopy is ordered, remains mandatory. Additionally, radiological small-bowel studies can offer insight in patency, which will be discussed later.

Technique of device assisted enteroscopy

Before the era of device-assisted enteroscopy, the first proximal 50 centimetres of the small intestine could be examined using push enteroscopy.[36] Further evaluation required the passage of a sonde enteroscope, which was very time consuming and did not allow interventions, or intraoperative enteroscopy.[37] During intraoperative endoscopy the surgeon manually slides the small bowel over a paediatric colonoscope or push enteroscope which has been introduced through the mouth or through an enterotomy.[38-40] Although this technique has long been considered the gold standard in enteroscopy, the rate of complications and mortality has been very high.[40]

All methods of deep enteroscopy rely on methods to secure the visualized part of the small intestine on an overtube and all require deep or conscious sedation of the patient. Additionally, the bowel needs to be prepared using laxatives. All endoscope types have channels to inflate air or carbon dioxide in order to achieve bowel distension and to rinse the lens, a suction channel for air and fluids, and a working channel that can be used to introduce all kind of accessories

Figure 5.7: Photographic sequence of the consecutive stages of a dissolving patency capsule. The timer plugs can be seen at both ends of the capsule. When these dissolve, the capsule disintegrates. The small radiofrequency identification tag that is originally located in the middle of the capsule can be seen at the lower images. The flexible plastic sleeve can pass even tight strictures.

for obtaining tissue samples or to perform interventions. Additionally, this channel can be used for instillation of water to remove residual bowel contents

The clinical introduction of the first method of device assisted enteroscopy, double-balloon endoscopy (DBE), coincided with the introduction of VCE. With DBE a 2 meter long flexible endoscope equipped with an inflatable balloon at its tip, is passed through an overtube that also has an inflatable balloon at its distal end.[3] With the use of a balloon pump controller, the balloons can be inflated and deflated. The balloon pressure is closely monitored by the system, and never exceeds 8.2 kPa. The main principle of DBE is that by anchoring the balloon of the endoscope to the intestinal wall, the overtube can be advanced over the endoscope without the endoscope slipping from its position. This reduces loop formation. By inflating the balloon of the overtube and stretching the overtube-endoscope combination, the inserted intestinal tract is pleated over the overtube and shortened. The balloon of the endoscope is than deflated and the endoscope is inserted as deep as possible, after which the cycle can be repeated.

The principle of single-balloon endoscopy (SBE) is quite similar to that of DBE.[41] In SBE, only the overtube has an inflatable balloon at its distal end. Therefore, keeping the endoscope anchored to the intestinal wall requires sharp angulation and fixation of the endoscope tip during straightening manoeuvres.

Spiral endoscopy uses a somewhat different approach: A long flexible endoscope is passed through an overtube that is equipped with a raised hollow spiral of approximately 0.5 cm high.[42, 43] The overtube and endoscope are then advanced to the distal duodenum with gentle push and rotation of the overtube. The overtube is than unlocked from the endoscope, which can be advanced in to the jejunum. The overtube is then advanced by clockwise rotation until its tip is near the tip of the endoscopy and locked. By rotating the overtube advancement can be continued. In general, this examination is carried out while the patient is under deep sedation or general anaesthesia.

Pearls, pitfalls and complications of device assisted enteroscopy

Pearls and pitfalls

In contrast to VCE, with device assisted enteroscopy it is possible to obtain an optimal view and closely examine a lesion once detected. Additionally, with device assisted enteroscopy, all kind of therapeutic interventions are possible. The working channel allows passage of biopsy forceps to obtain biopsy specimens, snares to perform polypectomy, balloons to perform dilations and haemostatic devices, such as argon plasma coagulation (APC) probes.

With balloon-assisted enteroscopy it is possible to traverse the complete small intestine in one session. However, even in expert centres this can only be accomplished in a minority of all examined patients.[44] Therefore complete enteroscopy usually requires two sessions: one antegrade through the mouth, and one retrograde, through the anus, during which first the complete colon needs to be passed. At the deepest point of insertion a tattoo can be placed, so when this tattoo is encountered during the second session, one is sure the complete small intestine has been visualized.

The depth-of-insertion is in general higher with DBE than with SBE or spiral enteroscopy, which in several studies was reflected in an increased yield of DBE.[45-47] The rate of complete enteroscopy in two sessions is much higher with DBE than with SBE.[48] To date, there are no data on complete enteroscopy with spiral enteroscopy. This suggests that DBE is the gold standard in small-intestinal endoscopy.

Complications

The need for deep or conscious sedation throughout the complete procedure increases the risk of sedation-related complications like hypoventilation, aspiration and depression of cardiac function. Procedure-related complications include perforation, ileus and pancreatitis. Perforation can occur in the setting of small-bowel stenosis and in patients with surgical altered anatomy, but is very rare in diagnostic procedures.[49, 50] Perforation after endoscopic interventions, including polypectomy and balloon dilation of stenosis, is more frequently observed.[49, 50] A less easy to comprehend complication, which seems only to occur with antegrade flexible enteroscopy, is post-procedural pancreatitis, occurring in approximately 0.3–3% of all patients.[51-54] Possible mechanisms include increased intraluminal pressure and shear-stress to the pancreas.[53] Since there is much less experience with spiral enteroscopy compared to balloon assisted enteroscopy, less is known on the complications of this technique.[55, 56]

Because the invasiveness, long duration and limited availability of flexible enteroscopy, it is preceded in many centres by VCE and/or radiological small bowel imaging.[12, 57-59] With such a strategy invasive enteroscopy is reserved for patients requiring endoscopic therapy. Additionally, such a strategy facilitates the choice of the insertion route with the highest chance of reaching a known lesion.

Radiology in the prevention, diagnosis and management of complications of VCE and enteroscopy

Radiology and VCE

Small-bowel radiology may play an important role in the prevention of capsule retention, which can be caused by stenotic lesions in the small bowel. In general, pre-VCE imaging is not routinely indicated in the absence of signs suggestive of small-bowel obstruction. However, caution is advised in patients with conditions known to be associated with stenosis, such as for instance, Crohn's disease or radiation enteropathy.

In patients with an increased risk of having a small-bowel stenosis, the results of radiological imaging may make performing VCE redundant, because a diagnosis is already established. For example, if in a patient with Crohn's disease and abdominal pain and vomiting MR enterography depicts a small-intestinal stenosis, VCE is not only contraindicated, but also unnecessary. In a study of 75 patients in whom a patency capsule indicated a possible small-bowel stenosis, results of subsequent MR or CT enteroclysis made caregivers decide not to proceed with VCE in 50 patients.[60] These decisions were mostly based on normal radiological examinations and on findings consistent with Crohn's disease.

If VCE is considered to be mandatory in a patient with either signs or symptoms of small-intestinal stenosis, or with an increased risk of stenosis, small-bowel patency can be investigated with the previously discussed patency capsule, or by means of radiology. There is limited data regarding the comparison between both methods. One recent study reports on 42 patients with suspected small-bowel stenosis in whom VCE was planned.[61] All patients underwent both a patency-capsule test and non-enteroclysis small-bowel studies, such as CT and CT enterography. Sensitivity of the patency capsule and radiology to detect small-bowel stenosis was similar (57% *vs* 71%; $p > 0.99$), as was specificity (86% *vs* 97%; $p = 0.22$). False-positive results occurred in five patency-capsule examinations and in one radiological examination, whereas patency-capsule examination had three false-negative results (9%), compared to two (6%) of the radiological examinations.

There is even less data on the use of cross-sectional small-bowel imaging as a tool to prevent capsule retention. A study on 38 patients with Crohn's disease showed the detection of high-grade small bowel stenosis by MR enteroclysis had a sensitivity of 91% and a specificity of 99%.[62] MR enteroclysis was false negative in one patient, leading to capsule retention caused by a high-grade stenosis in the distal jejunum.

In short, both the patency capsule as radiological studies can be used to investigate the presence of small-bowel stenosis prior to VCE, but radiological methods have the additional benefit of providing additional diagnostic information. However, even with advanced small-bowel radiology prior to VCE, capsule retention still may occur.

Radiology plays an important role in the detection of capsule retention.[32] Capsule retention can occur with or without small bowel obstruction. Asymptomatic retention is usually defined according to the consensus statement of the International Conference on Capsule Endoscopy as having a capsule endoscope remain in the digestive tract for a minimum of 2 weeks or as the capsule remaining in the bowel lumen unless directed medical, endoscopic, or surgical intervention was instituted.[63]

The capsules are usually easily identified on plain abdominal X-ray studies, but sometimes capsule orientation makes discrimination from other foreign bodies more difficult (***figure 5.8)*** In case of complete bowel obstruction by the capsule, dilated small-intestinal loops and/or fluid levels can be observed (***figure 5.9***). Such findings warrant urgent capsule retrieval, which can be done by means of DBE or surgery.[32, 64]

Retained capsules have been reported to be found in asymptomatic patients years after VCE examinations.[65] In patients who report they have not witnessed the capsule leaving the bowel, the presence of a retained capsule should be excluded after two weeks,

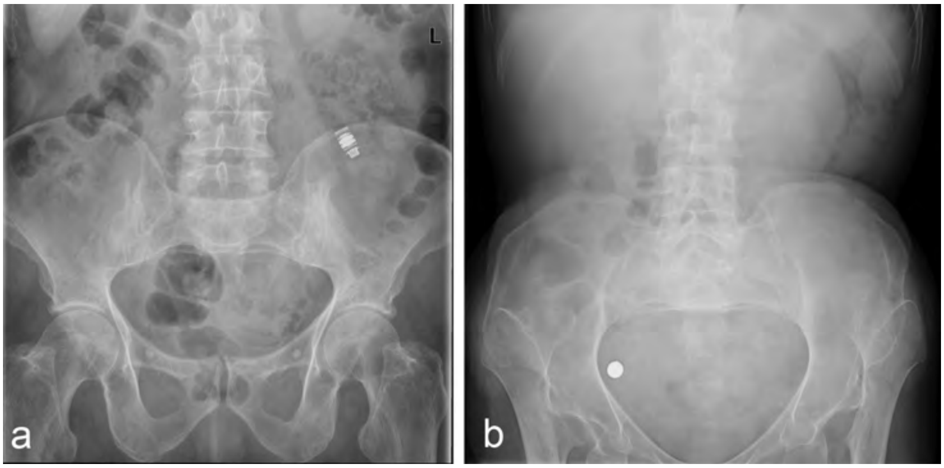

Figure 5.8: Plain abdominal X-rays performed in patients with asymptomatic capsule retention. (a) The foreign body in this patient can easily be identified as a video capsule. (b) In this patient, the orientation of the capsule does not allow direct recognition of the foreign body.

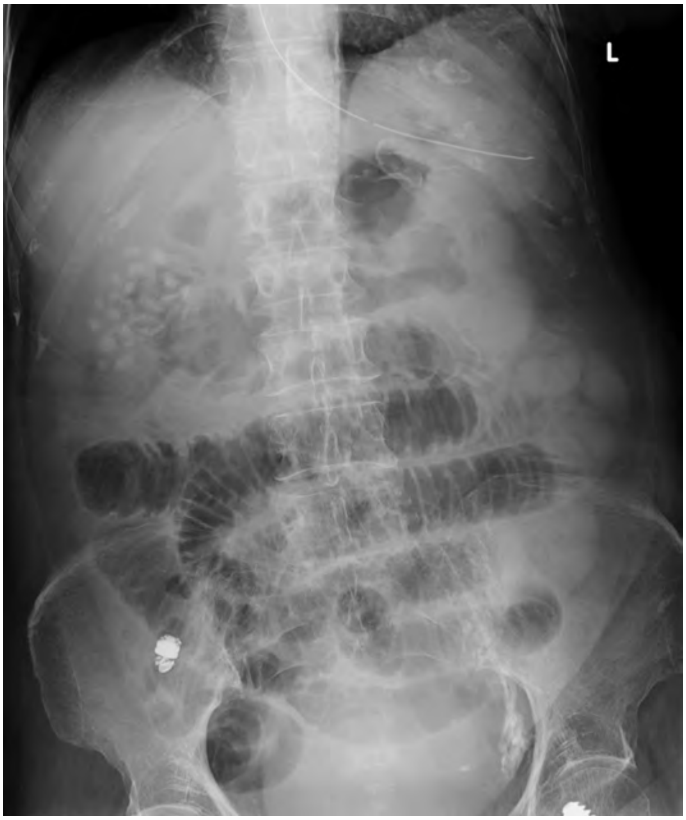

Figure 5.9: Plain abdominal X-ray in an 86-year-old woman with symptomatic capsule retention caused by radiation enteropathy shows dilation of the small intestine and the retained capsule. During emergency surgery performed for progressive abdominal symptoms, the capsule was found to have perforated the small-bowel wall (see figure 5.6).

even if there are no symptoms. In our experience, in most patients, the capsule did leave the body, but patients were not aware of this. In a minority, a capsule is retained in the intestine. In general we prefer to remove the capsule endoscopically, since there is a small chance of capsule disintegration, or the capsule causing obstruction at a later moment.[66] Additionally, if in a later stage MR imaging is performed, a retained capsule results in artefacts, and possibly injury (***figure 5.10***).[67]

Perforation is rare, but should be suspected when peritoneal signs or free abdominal air occur during VCE. Imaging strategies in these rare circumstances should not be different from those followed in other cases with suspected perforation of the gastrointestinal tract, and may include plain abdominal X-rays and abdominal CT.

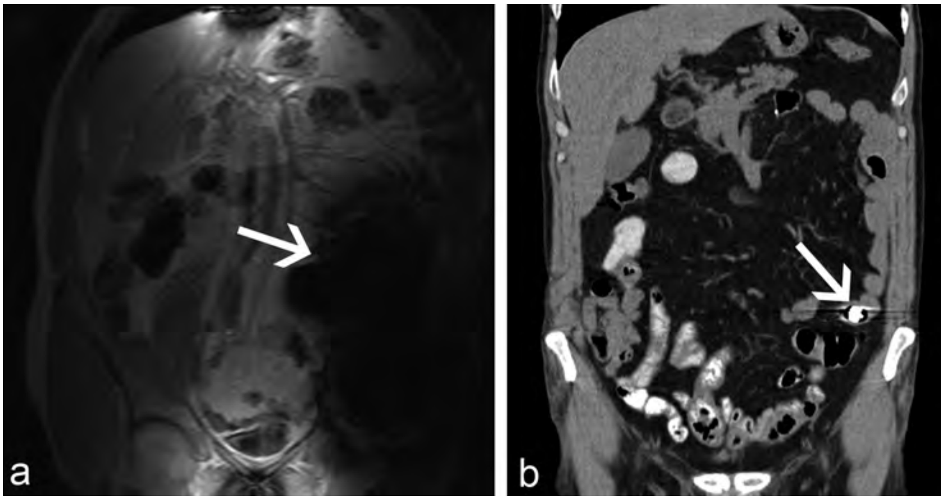

Figure 5.10: Images obtained in a patient with unknown asymptomatic capsule retention. (a) MR image shows artefacts caused by the metallic capsule parts (arrow). (b) CT image shows the capsule is retained in the small bowel (arrow).

Radiology and enteroscopy

One retrospective study studied the effect of pre-DBE radiological small-bowel imaging on the diagnostic yield of DBE.[68] The diagnostic yield of DBE was highest in the group with abnormal findings on small-bowel radiography (71%), followed by the group with no small-bowel radiographs (46%) and the group with normal findings on small-bowel radiography (36%). Except for selecting patients, radiology also may be useful to select the route of insertion for flexible deep enteroscopy. If abnormalities are depicted in the jejunum or proximal ileum, the enteroscope can be inserted through the mouth. When lesions are depicted in the distal ileum, the per-anal route can be followed. Interestingly, as far as we are aware, this strategy has not been formally studied. Although perprocedural fluoroscopy informs the endoscopist on the shape of the enteroscope, there is in general no need for routine fluoroscopy during DBE.[69] In case of stenotic lesions that can not be passed with the endoscope, fluorosocpy can be of use in performing endoscopic enteroclysis to depict the more distal small bowel.

Flexible enteroscopy is a safe procedure, but as mentioned, complications can occur, especially after interventions have been carried out. In patients with post-procedural abdominal pain, the presence of small-bowel perforation needs to be investigated. This can be done with plain abdominal X-rays. In case of suspected post-procedural pancreatitis, serum amylase or lipase should be measured. CT of the pancreas is not needed when symptoms are mild and resolve quickly. However, in case of persisting or suspected severe pancreatitis, imaging may be required, similar to the follow-up of pancreatitis with other causes.[54]

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