The small bowel video capsule: a new device for new levels of performance

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« *Exploration of the small intestine with an endoscopic video capsule is one of the latest technological revolutions in gastrointestinal endoscopy. The main indications are an investigation for occult bleeding after a normal result from a standard endoscopic assessment, and suspected damage to the small intestine in the context of Crohn's disease. The continuous technological development of the capsule has generated a new device (PillCam SB 3 ® system) capable of producing a film with better image resolution and an even greater coverage of the intestinal mucosal surface, with the development of an image capture adapted to the speed of progression of the capsule in the intestine. Finally, the new RAPID 8 ® software associated with this SB 3 ® capsule is even more performant (speed of image interpretation, numerous modes for optimized playback) and represents a valuable aid for the reader.*"

Having for a long time been frustrated at not being able to explore the small intestine optimally, endoscopists have welcomed the small intestinal video capsule as a technological revolution. While this examination is currently in routine use for well-defined indications, the capsule has also been the focus of continuing technological development. New devices are currently being proposed that aim to improve the video image quality, and thus to improve the diagnostic yield of intestinal endoscopic investigations. Another objective is to facilitate the interpretation of video recordings with innovative software. It is with these considerations in mind that the new PillCam SB 3 ® system has been developed. The package comprises: the PillCam SB 3 ® capsule, the PillCam ® Recorder DR3, the PillCam ® Sensor Belt SB3, and the RAPID ® for Pillcam Software v8.0 (*figure 1*).

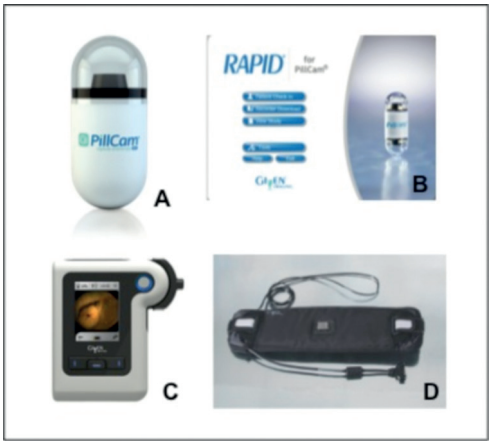

Figure 1. The PillCam SB3 ® system, composed of the following elements: the PillCam SB 3 ® capsule (A), the RAPID ® for Pillcam Software v8.0 (B), the PillCam ® Recorder DR3 (C), and the PillCam ® Sensor Belt SB3(D).

PillCam SB3 system hardware

The PillCam SB3 capsule

The PillCam SB 3 ® capsule proposed by Covidien (GI Solutions) Given Imaging is a new-generation capsule derived from a technological improvement allowing the acquisition of a better image quality and the exploration of the small intestinal surface with an even

greater coverage. The optics and sensor have been modified. This "ecological" capsule does not contain mercury. Its functioning time is approximately 11 hours, which limits the number of incomplete examinations resulting from battery failure during recording.
The improvements in image resolution result in a sharper and brighter image, which allows the details of the intestinal mucosa to be seen more clearly (*figure 2*).
Small intestinal lesions, such as angiodysplasias that are red or ulcers with a whitish, fibrinous background, are thus easier to identify.

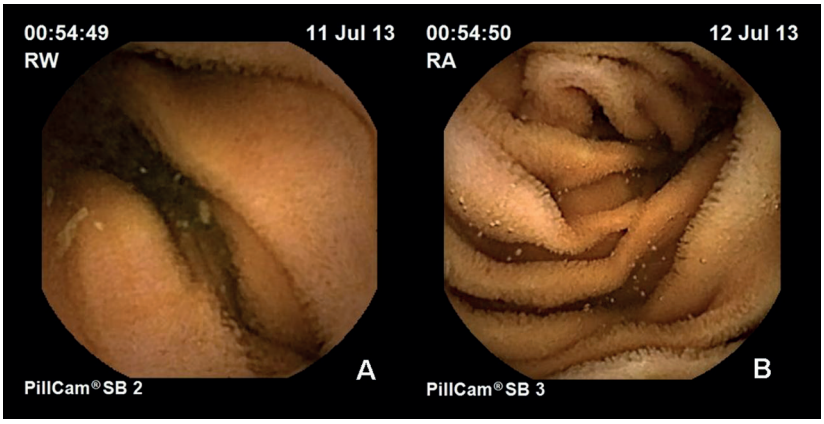

Figure 2. The PillCam SB 3 ® capsule (A): better definition than the PillCam SB 2 ® capsule (B). Images of the small intestine with normal villi, in the same patient and in the same intestinal portion.

This increase in resolution is estimated to be 30% as compared with the previous device, the PillCam SB 2 ® capsule. The smallest object that can be detected with PillCam SB 3 ® is 0.07 mm, *versus* 0.1 mm with PillCam SB 2 ®. This improvement in the image is useful in the detection of submucosal tumors, where the eye is often drawn to a simple deformation of a mucosal fold, and for which diagnosis is often difficult. Furthermore, the contrast is increased, which facilitates analysis of the mucosal surface and the better detection of small bowel polyps, such as in patients with polyposes such as Peutz-Jeghers disease.
Adaptation of the image capture to the capsule speed is one of the most important innovations of the SB 3 ® capsule. Thus, when the capsule is moving fast, as for example in the distal duodenum, proxi-

mal jejunum, or during passage through a descending intestinal loop, the number of images per second increases from two to six. The filming of a greater mucosal surface in these situations thus limits the risk of a lesion being missed. Using this new system, the number of images to process is theoretically greater, however the reading time does not appear to be any longer. This can be explained by a decrease in the number of "stops" or "image replays" needed during the reading, due to a better overall image quality (sharpness, brightness, and contrast), with wider angles of vision and a better depth of field.

The PillCam ® Recorder DR3

The DR3 recorder captures images continuously and is equipped with an LCD screen that allows real-time viewing of the film taken by the capsule. It is no longer necessary to connect a computer to the recorder to identify the location of the capsule.

The PillCam ® Sensor Belt SB3

The Sensor Belt makes the procedure simpler and faster. It helps to improve patient comfort (especially for patients for whom shaving is necessary before electrodes can be attached with skin patches).

The RAPID ® for Pillcam Software v8.0 associated with the PillCam SB 3 ® system

The new reading software, RAPID ® 8, associated with this capsule has a modified user interface and improved software ergonomics. The ribbon, which is an element of the Microsoft user interface, has been designed to help readers to find the software commands quickly. Basic functions are facilitated, such as, for example, drafting a report or identifying a patient. The video-processing algorithm has been improved and the creation of a video is now faster. New reading support tools are available and the «Progress Indicator» program has been improved. In the "QuickView" mode, also available in the previous version of the software, images that are considered to be identical can be removed from the film, allowing the reading of a film containing only the images that the software identifies as relevant. This algorithm has been evaluated in the literature and ensures a very good sensitivity [1]. The

"Complementary QuickView" mode proposed in the new version allows the visualization of all of the images, including those that have been excluded in the QuickView mode. The "Mosaic" mode shows, as a matrix, all the images selected by an algorithm. Only the relevant part of the image is displayed, allowing an easier visualization of the entire video.

The "SBI" (Suspected Blood Indicator) mode automatically flags suspicious images of bleeding when they contain a red spot consistent with blood. The sensitivity, positive predictive value, and accuracy of this function for the detection of active bleeding in the small intestine are 81%, 81%, and 83%, respectively [2]. This analysis represents an aid to the diagnosis of hemorrhagic lesions during the examination but a full reading of the film taken by the capsule remains indispensable.

The utilization of virtual chromoendoscopy (FICE: Flexible Intelligent Color Enhancement) makes it possible to increase the contrast and to better detect certain types of flat lesions, such as angiodysplasias, which will have an enhanced color, or small flat polyps, for which the surface relief is increased. The benefit of this feature has already been investigated using the previous PillCam system [3].

The software contains a large database of Pillcam capsule endoscopy images that allows the comparison of a pathological image found during a reading with the images in the atlas (f*igure 3*).

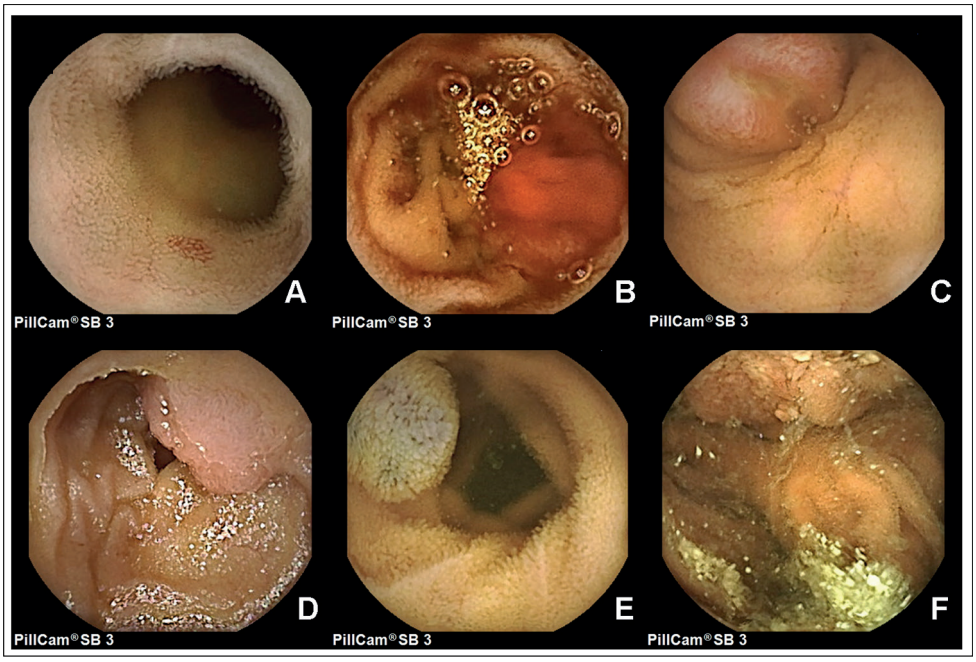

Figure 3. Examples of pathological images identified by the SB3 ® capsule. A: typical angiodysplasia; B: active bleeding with a blood clot in the intestinal lumen; C: suspicious nodular ulceration corresponding to the histology of an adenocarcinoma in the small intestine; D: small submucosal tumor corresponding to a carcinoid tumor; E: jejunal varix in the context of segmental portal hypertension; F: hamartomatous polyp (at the top of the image) in the context of Peutz-Jeghers syndrome.

Conclusion

This new small-bowel video capsule system represents a technological advancement, with the following advantages:
1. increase in the ease and speed of capsule reading;
2. increased diagnostic yield through superior film quality and adaptation of the image capture to the speed of progression of the capsule through the small intestine.
The potential future developments of the capsule are numerous: a "remote-controlled" capsule, a "therapeutic" capsule delivering an active substance in the small intestine, a more efficient method of locating the capsule in the small intestine, visualization of the film in 3D, etc.

Conflicts of interest

None.

References

1. Saurin JC, Lapalus MG, Cholet F, *et al*. Can we shorten the small-bowel capsule reading time with the «Quick-view» image detection system? D*ig Liver Dis* 2012 ; 44 : 477-81. doi : 10.1016/j.dld.2011.12.021
2. Liangpunsakul S, Mays L, Rex DK. Performance of Given suspected blood indicator. *Am J Gastroenterol* 2003 ; 98 : 2676-8.
3. Imagawa H, Oka S,Tanaka S, *et al*. Improved visibility of lesions of the small intestine via capsule endoscopy with computed virtual chromoendoscopy. *Gastrointest Endosc* 2011 ; 73 : 299-306. doi : 10.1016/j.gie.2010.10.016