Incomplete small bowel capsule endoscopy: Risk factors and cost-effectiveness of real-time viewing

Authors

Matilde Topa[1], Alessandro Rimondi[2], Andrea Sorge[1], Veronica Smania[1], Lucia Scaramella[3], Nicoletta Nandi[1], Flaminia Cavallaro[3], Maurizio Vecchi[1,3], Luca Elli[3], Gian Eugenio Tontini[1,3]

Institutions

1 Department of Pathophysiology and Transplantation, Università degli Studi di Milano, Milan, Italy

2 Post graduate Specialization in Gastrointestinal Diseases, Università degli Studi di Milano, Milan, Italy

3 Gastroenterology and Endoscopy Unit, Foundation IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

Corresponding author

Prof. Gian Eugenio Tontini, Università degli Studi di Milano, Department of Pathophysiology and Transplantation, Milan, Italy

gianeugenio.tontini@policlinico.mi.it

ABSTRACT

Background and study aims International guidelines recommend real-time viewing (RTV) in capsule endoscopy for gastric emptying monitoring, yet it is often overlooked in clinical practice. We aimed to assess risk factors for incomplete small bowel capsule endoscopy (SBCE) and evaluate the clinical relevance and cost-effectiveness of RTV implementation.

Methods We included consecutive SBCEs from 2013 to 2020. RTV was not applied per local protocol. We used multivariate logistic regression to identify risk factors for incomplete SBCE, including prolonged gastric transit time (GTT) and prolonged small bowel transit time (SBTT).

Results Analyzing 858 SBCEs, we observed a completion rate of 94.6%. Prolonged GTT and SBTT were present in 4.9% and 18.2% of complete SBCEs, and in 13% ($P=0.03$) and 10.8% ($P=0.24$) of incomplete SBCEs, respectively. Only 0.7% (6 of 858) had incomplete SBCE with prolonged GTT. In both univariate and multivariate analysis, a modifiable (prolonged GTT odds ratio [OR] 2.9; 95% confidence interval [CI] 1.1–7.5) and two unmodifiable risk factors (inpatient status OR 2.3; 95% CI 1.1–4.5) and history of incomplete SBCE (OR 4.2; 95% CI 1.3–13.7) were independently linked to higher incomplete SBCE rates. The pretest completion probability was 90.5% and 95.8% in patients with and without unmodifiable risk factors, respectively (P <0.01). The direct cost of systematic RTV adoption and prokinetics administration would be €5059, aiming to identify and treat each case of prolonged GTT associated with incomplete SBCE.

Conclusions Modern devices make incomplete SBCE rare, usually not tied to prolonged GTT. In a low-incidence scenario, widespread RTV use brings high costs and uncertain effectiveness.

Introduction

Incomplete small bowel capsule endoscopy (SBCE) refers to small bowel examinations in which the device fails to reach the cecum and, therefore, the entire surface of the small bowel is not explored. Available evidence suggests that the inpatient status is associated with SBCE incompleteness [1, 2]. Comorbidities, drugs that decrease small bowel motility, and reduced physical activity may explain the higher rate of SBCE incompleteness among inpatients [3]. Another risk factor for incomplete

SBCE is delayed gastric emptying, which may result in gastric capsule retention or battery depletion [4,5,6]. In previous studies, prolonged SBCE gastric transit time (GTT) was defined as failure of the capsule to reach the small bowel within 1 or 2 hours from ingestion [4,5,6].

Capsule endoscopy real-time viewing (RTV) allows on-demand real-time monitoring of gastric emptying, thus enabling prompt administration of prokinetics or endoscopic delivery of the capsule into the duodenum in case of prolonged GTT to prevent incomplete SBCE examinations. Data from previous studies have suggested that the completion rate for SBCE with RTV and subsequent possible interventions (i.e., drug administration and endoscopic capsule placement) was higher compared with examinations without RTV [4,5,6,7]. Therefore, the latest European Society of Gastrointestinal Endoscopy (ESGE) technical review for SBCE recommends use of the RTV, particularly in patients at risk of delayed gastric emptying who may experience gastric capsule retention and incomplete SBCE [8]. However, this recommendation was based on low-quality evidence. Further, a recent ESGE survey revealed poor implementation of RTV in clinical practice because only 73.2% of European physicians routinely used RTV [9]. In fact, the available studies on SBCE RTV were performed using old-generation endoscopic capsules, with shorter battery life compared with modern devices. A short battery life could negatively affect the completion rate for SBCE, therefore increasing the rationale for use of RTV. On the contrary, the longer battery life (≥ 8 hours) of modern capsule endoscopy devices can positively affect the completion rate for SBCE, therefore reducing the need for RTV. Moreover, routine use of RTV is burdened by costs related to the resources required, such as trained staff, drugs, and dedicated rooms. In case of prolonged GTT, costs of peripheral venous catheter placement and prokinetics administration or endoscopically assisted capsule delivery should be added. To the best of our knowledge, there are no large cohort studies evaluating performance of SBCE without systematic use of RTV in large cohorts. Moreover, the cost-effectiveness of RTV during SBCE performed with new-generation devices remains unknown. To address this knowledge gap, we aimed to evaluate risk factors for incomplete SBCE and cost-effectiveness of routine use of the RTV during SBCE.

Patients and methods

Patients

We retrospectively included consecutive SBCEs performed with PillCam SB3 (Medtronic, Minneapolis, United States) in a tertiary referral center for enteroscopy (Foundation IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy) from 2013 to 2020. During this period, RTV was not performed according to local protocol, considering the low level of evidence supporting this practice. Included SBCEs were performed for different indications according to ESGE guidelines, such as suspected, overt or occult small bowel bleeding, Crohn's disease, complicated celiac disease, suspected neoplasia, and other gastrointestinal symptoms.

▶ Table 1 Direct costs of RTV and prokinetics administration.

Invoice	Cost
Nurse time (1hxpt)	24.59 Euro/hour[14]
Dedicated room (1hxpt)	10.28 Euro/hour [13]
Drug (metoclopramide) (1xpt_pgtt)	0.38 Euro
IV catheter (1xpt_pgtt)	6.15 Euro [15]
Total	41.4 Euro

RTV, real-time viewing; 1hxpt, 1-hour RTV per patient; 1hpt_pgtt, 1 per patient with prolonged gastric transit time.

Patients were instructed to fast for at least 12 hours and to stop any oral iron supplements 5 days before the procedure. After capsule ingestion, patients were allowed to drink clear liquids 2 hours later and eat food 4 hours later.

Demographic and clinical data were prospectively collected by reviewing medical records. They included patient age, gender, drugs, and comorbidities that can affect gastric and intestinal transit time (e.g., diabetes, chronic kidney disease, small bowel Crohn's disease, neurological disorders, psychotropic medications), small bowel transit time (SBTT), GTT, history of previous SBCE, and inpatient status. All endoscopic findings were classified according to clinical significance, in relation to the indication for the procedure as previously defined in literature [10]. Prolonged GTT was defined when the capsule crossed the pylorus >2 hours from ingestion, and prolonged SBTT when the cecum was not reached within 6 hours from pylorus crossing [11,12].

Exclusion criteria were capsule retention, endoscopic delivery of the capsule, and major technical issues (i.e., eating within 2 hours after capsule ingestion or recording issues).

Cost analysis

We calculated direct costs of routine use of RTV in endoscopy facilities by identifying time, equipment, and medications needed to monitor a single SBCE. We excluded from our analysis indirect costs of endoscopic service not directly accountable to the procedure (e.g., administrative and cleaning staff, capsule endoscopy equipment maintenance, patient time out of work) and structural costs of the hospital (e.g., hospital management, human resources, informatics systems). Direct costs of 1-hour RTV and of the appropriate intervention in case of prolonged GTT were estimated including the cost of a dedicated room [13] and nurse [14], and administration of metoclopramide through a peripheral venous catheter [15] in case of prolonged GTT (▶ Table 1). When different costs were available in the literature for the same element, we considered the most recent ones for our analysis.

Statistical analysis

Data related to patient clinical and demographic characteristics and technical details of each SBCE were analyzed descriptively, producing sums and percentages for categorical and mean variables and standard deviations for continuous variables. Catego-

rical variables were compared with Fisher's exact test or with the χ2 or McNemar's test, yielding the odds ratio (OR) and its confidence interval. Continuous variables were compared with Student's t-test, in the case of normal distribution, and with the Kruskal–Wallis test or Mann–Whitney U test in the case of non-normal distribution. Both univariate and multivariate logistic regression analyses were built to find significant risk factors associated with incomplete SBCE. $P < 0.05$ was considered statistically significant. All statistical analyses were carried out with IBM SPSS Statistic (release 23; IBM, United States).

Ethics

The study was carried out in accordance with the Declaration of Helsinki, adopted in 1964 and incorporating all later amendments. Patient data were treated confidentially, in compliance with the most recent national and European privacy laws (protocol number 137/2021, Comitato Etico Milano Area 2). Reporting of this study conforms to the STROBE statement (Supplementary Material) [16].

Results

A total of 865 SBCEs were performed during the study period at our hospital. We excluded two cases for capsule retention, two for endoscopic delivery, and three for major technical issues (i. e., ingested food within a standard GTT of the capsule, major recording issues). The remaining 858 SBCEs were included in the study population (▶ Fig. 1). Baseline characteristics of patients are described in ▶ Table 2.

Most of the procedures were performed for suspected small bowel bleeding (451 SBCEs, 52.6%), followed by suspected or established complicated celiac disease (269 SBCEs, 31.4%), other gastrointestinal symptoms (60 SBCEs, 7%), small bowel Crohn's disease (51 SBCEs, 5.9%) and suspected neoplasia (27 SBCEs, 3.1%). The SBCE completion rate was 94.6% and the diagnostic yield was 50%. SBCE technical data are reported in ▶ Table 3. Patients with complete and incomplete SBCE did not differ in terms of demographic features and comorbidities (▶ Table 4). Prolonged GTT and prolonged SBTT were found in 46 (5.4%) and 153 (17.8%) procedures, respectively. In patients with incomplete SBCE (n = 46), we observed an increased rate of prolonged GTT compared with complete procedures (13% *vs.* 4.9%, $P = 0.03$), whereas prolonged SBTT was comparable (10.8% *vs.* 18.2%, $P = 0.24$) between the two groups. However, only six of 858 patients (0.7%) had incomplete SBCE and prolonged GTT (▶ Fig. 2). Completion rate, GTT, and SBTT were not significantly different between patients with different indications for SBCE. At univariate logistic regression, prolonged GTT, previous incomplete SBCE, and inpatient status were associated with a higher rate of incomplete SBCE. Notably, prolonged SBTT was not associated with incomplete SBCE. To confirm the described correlation, we built a multivariate analysis including these three significant factors; one modifiable (prolonged GTT OR 2.9; 95% CI 1.1–7.5, $P = 0.03$) and two unmodifiable risk factors – inpatient status (OR 2.3; 95% CI 1.1–4.5, $P = 0.01$) and history of incomplete SBCE OR 4.2; 95% CI 1.3–13.7, $P = 0.02$) — were independently associated with a higher rate of
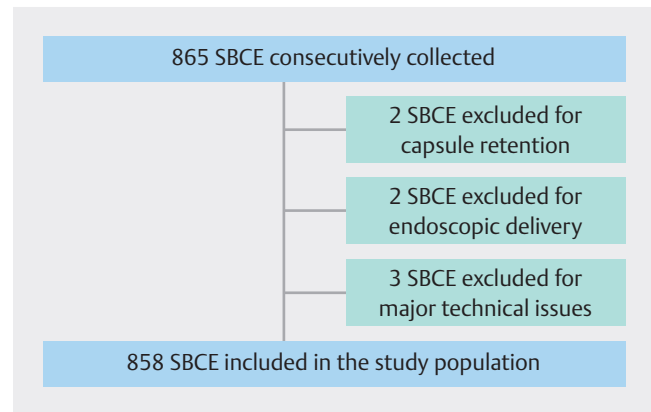
▶ **Fig. 1** Prisma flowchart diagram.

▶ **Table 2** Patient baseline characteristics.

Baseline characteristics	SBCE N = 858
Age, median (IQR, years)	59 (42–71)
Female, n (%)	520 (60.6)
Risk factors	
Diabetes, n (%)	84 (9.8)
Narcotics, n (%)	46 (5.4)
End-stage kidney disease, n (%)	48 (5.6)
Neurological disorders, n (%)	35 (4.1)
Crohn's disease, n (%)	10 (1.2)
Previous incomplete SBCE, n (%)	21 (2.4)
Previous SBCE with prolonged gastric transit time, n (%)	19 (2.2)
Previous SBCE with prolonged small bowel transit time, n (%)	38 (4.4)
Inpatient, n (%)	173 (20.2)
Previous incomplete SBCE and/or inpatient, n (%)	189 (22)

SBCE, small bowel capsule endoscopy; IQR, interquartile range.

▶ **Table 3** SBCE technical data.

SBCE	N = 858
Gastric transit time, mean (±SD)	00:33:30 (00:47:11)
Small bowel transit time, mean (±SD)	04:39:58 (01:44:39)
Prolonged gastric transit time, n (%)	46 (5.4)
Prolonged small bowel transit time, n (%)	153 (17.8)
Incomplete SBCE, n (%)	46 (5.4)
Incomplete SBCE with prolonged gastric transit time, n (%)	6 (0.7)
Diagnostic yield, %	50

SBCE, small bowel capsule endoscopy.

▶ **Table 4** Comparison between complete and incomplete SBCE at univariate and multivariate analyses.

	Incomplete SBCE Patients number = 46	Complete SBCE Patients number = 812	Univariate analysis, *P* value	Multivariate analysis, OR (IC95%)	Multivariate analysis, *P* value
Age, mean (± SD)	56.3 (18.2)	59.5 (15.7)	0.42	**2.3 (1.1–4.5)**	**0.01**
▪ Female, n (%)	28 (60.9)	491 (60.6)	1		
▪ Inpatient*, n (%)	**17 (36.9)**	**156 (19.2)**	**<0.01**		
SSBB, n (%)	26 (56.5)	425 (52.3)	0.65		
Complicated coeliac disease, n (%)	9 (19.6)	260 (32)	0.10		
Other gastrointestinal symptoms, n (%)	5 (10.9)	55 (6.8)	0.25		
SB Crohn's disease, n (%)	4 (8.7)	47 (5.8)	0.34		
Suspected neoplasia, n (%)	2 (4.3)	25 (3.1)	0.65		
Diabetes, n (%)	5 (10.9)	79 (9.7)	0.80		
Narcotics, n (%)	4 (8.7)	42 (5.2)	0.30		
End-stage kidney disease, n (%)	1 (2.2)	47 (5.8)	0.51		
Neurological disorders, n (%)	2 (4.3)	33 (4.1)	0.71		
Small bowel Crohn's disease, n (%)	1 (2.2)	9 (1.1)	0.42		
Prolonged gastric transit time, n (%)	**6 (13)**	**40 (4.9)**	**0.03**	**2.9 (1.1–7.5)**	**0.03**
Prolonged small bowel transit time, n (%)	5 (10.8)	148 (18.2)	0.24		
Previous incomplete SBCE*, n (%)	**4 (8.7)**	**17 (2.1)**	**0.02**	**4.2 (1.3–13.7)**	**0.02**

*The pretest probability of SBCE completion was 90.5% and 95.8% in patients with and without unmodifiable risk factors, respectively (*P* < 0.01). OR, odds ratio; SBCE, small bowel capsule endoscopy; SSBB, suspected small bowel bleeding; SB, small bowel.
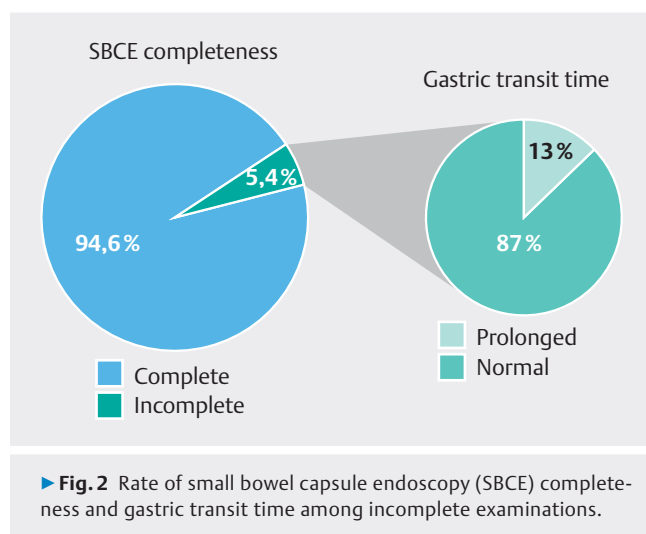
▶ **Fig. 2** Rate of small bowel capsule endoscopy (SBCE) completeness and gastric transit time among incomplete examinations.

incomplete SBCE (▶ Table 4). Furthermore, we built another multivariate analysis including these three risk factors and other possible confounders (e.g., diabetes, CKD, narcotics, neurological disorders), which confirmed the results of the previous analyses, showing that no confounding factor significantly impacted the correlation between each of the three significant risk factors and SBCE completeness. A total of 189 patients had either one of the two identified unmodifiable risk factors.

Pretest probability of SBCE completion was 90.5% and 95.8% in patients with and without unmodifiable risk factors, respectively (*P* <0.01).

Among the 46 incomplete SBCEs (5.4% of the total), there were 12 examinations (26.1%) with registration lasting < 9 hours and two (4.3%) with registration lasting <6 hours.

The direct cost for 1-hour real-time monitoring (i.e., dedicated room and nurse) was estimated at €34,87. In case of prolonged GTT, the additional direct cost of €6.53 for metoclopramide injection and peripheral venous catheter should be added (▶ Table 1).

If RTV was systematically performed during the study period, the overall direct cost for RTV would have been equal to €30,030 (i.e., €4290 per year), and those for prokinetics administration in the 46 cases of prolonged GTT would have been equal to €322, with a total of €30,352. Considering that in our cohort only six patients with prolonged GTT had an incomplete SBCE, the direct cost for systematic adoption of RTV to identify and treat with prokinetics each case of prolonged GTT associated with incomplete SBCE would have been equal to €5059. On the contrary, if RTV had been performed only in patients with pretest risk factors for incomplete SBCE (previous incomplete SBCE and/or inpatients = 189), the direct cost for RTV would have been equal to €6615 (i.e., €945 per year) and that for administration of prokinetics in the 13 cases with prolonged GTT would have been €91, with a total of €6706. In this

subgroup, two patients with prolonged GTT had an incomplete SBCE. Therefore, the direct cost for RTV adopted in patients with risk factors for incomplete SBCE to identify and treat with prokinetics each case of prolonged GTT associated with incomplete SBCE would have been equal to €3353. Notably, this second strategy based on a pretest risk stratification could have saved €23,646 but it could lead to a missed intervention with prokinetics in four prolonged GTTs associated with incomplete SBCE.

Discussion

Routine use of RTV during SBCE and performance of subsequent interventions, despite being recommended by current guidelines, are debated among experts and not commonly implemented in clinical practice [8, 9].

In our study of consecutive 858 SBCEs, we demonstrated that the rate of complete examinations is extremely high (94.6%), despite absence of RTV and prokinetics administration. The rate of incomplete SBCE, prolonged GTT, and prolonged SBTT did not differ among SBCEs performed for suspected small bowel bleeding, complicated celiac disease, or other indications. The completion rate for SBCE in our cohort was higher or comparable to previously published studies performed with use of RTV and prokinetics administration in case of prolonged GTT [4, 5, 6, 17]. Most of these studies were performed with old-generation SBCE devices [4, 5, 6], with a retrospective design [6], or in extremely small cohorts [4, 5]. To the best of our knowledge, data are lacking supporting the effectiveness of this approach when new-generation SBCE devices with longer battery life (from 8 to 12 hours) are used [8, 18]. This technological improvement can potentially limit the effect of battery depletion on SBCE completeness induced by prolonged GTT and, consequently, the role of RTV may not be as relevant as previously reported. In fact, the completion rate for our cohort was comparable to that in a recently published Portuguese study of 957 SBCEs (91.1%) performed with modern devices and RTV-guided domperidone administration and/or endoscopic delivery of the capsule in case of prolonged GTT [17]. The data in that study showed that prolonged GTT was not associated with a higher rate of SBCE incompleteness. These findings raise doubts regarding the causal relationship between prolonged GTT and SBCE completeness. Therefore, RTV and the interventions aimed at treating patients with prolonged GTT could not be as effective as believed in increasing the SBCE completion rate and diagnostic yield. These results are consistent with a previous meta-analysis that showed no beneficial effect on SBCE diagnostic yield from prokinetics administration in patients with prolonged GTT detected by RTV, even when associated with an increased completion rate [19]. Furthermore, use of prokinetics may potentially reduce SBCE diagnostic yield in a subgroup of patients, considering that a longer SBTT was related to increased detection of significant lesions in suspected small bowel bleeding [20].

Another remarkable result of this study was the extremely low rate (0.6%) of patients (6/865) with incomplete SBCE and prolonged GTT. Therefore, only one patient in every 144 SBCEs

would require prokinetics administration, even if the benefit of this practice on completeness rate and, most importantly, the diagnostic yield of capsule endoscopy performed with modern devices still remains to be convincingly proved.

Our study did not focus on risk factors for prolonged GTT, which was a post-hoc result. Rather, we focused on risk factors that may predict incomplete SBCE, thereby suggesting the need for a patient-tailored approach for early intervention in case of prolonged GTT based on use of RTV. In our cohort, there was a low rate of prolonged GTT and a higher rate of prolonged SBTT (5.4% and 17.8%, respectively), with a statistically significant difference between complete and incomplete SBCEs only for GTT. Independent risk factors for incomplete SBCE were inpatient status, prolonged GTT, and previous incomplete SBCE. Among them, the only modifiable risk factor was prolonged GTT, whereas inpatient status and a history of incomplete SBCE were unmodifiable and had the advantage of being available a priori. According to this difference, we hypothesized two scenarios: one in which only the patients with at least one pretest risk factor for incomplete SBCE would undergo RTV and selective intervention, compared with another scenario in which RTV was systematically adopted. According to our analyses, one in every 14.5 patients with pretest risk factors for incomplete SBCE would benefit from RTV to identify and target early intervention for prolonged GTT, compared with one in every 20.1 patients without risk factors.

We also performed a cost-effectiveness analysis to represent the differences in more practical terms.

Considering that the direct cost for 1-hour RTV is equal to €35 and the additional cost of prokinetics administration is €7, we estimated €5059 as the direct cost for systematic adoption of RTV to identify and treat with prokinetics each case of prolonged GTT associated with incomplete SBCE. Therefore, the potential and largely unproven beneficial effect of RTV on SBCE completeness and diagnostic yield should be weighed against the high costs of its systematic adoption. On the contrary, when adopting RTV only in patients with at least one pretest high-risk feature for incomplete SBCE, this amount would be reduced to €3353. It should be noted that the strategy based on a pretest risk stratification would have saved €3378 per year, when compared with systematic adoption of RTV. Still, it would also have missed the intervention with prokinetics in four of six SBCEs with prolonged GTT associated with incomplete SBCE in an overall cohort of 858 SBCE examinations.

Use of oral rather than intravenous metoclopramide can significantly reduce this cost factor. Nonetheless, intravenous administration is most often adopted because it is believed to be more efficient than oral administration based on pharmacokinetic issues.

Artificial intelligence-assisted RTV is expected to be available soon in many capsule systems, thereby facilitating adoption of RTV-based strategies. Nonetheless, direct and indirect costs resulting from the systematic adoption of RTV will only be partially influenced by this technological progress.

In our analysis, we excluded two cases of capsule endoscopic placement because they would not allow for GTT evaluation. Furthermore, in a setting of low incidence of incomplete SBCEs,

the economic impact of capsule endoscopic placement would be negligible; moreover, the cost analysis would vary significantly according to the organization of the endoscopic unit (e. g., on-call endoscopic team, dedicated room). However, a recent multicenter retrospective analysis of a large cohort of adult patients showed that capsule endoscopic placement has very good outcomes in terms of feasibility, safety, and completion rate, specifically with capsule delivery in the duodenum [21].

Looking beyond the need for risk stratification, this study identified low battery life as an overlooked risk factor for incomplete SBCE with an impact that may be particularly relevant in high-volume centers. Remarkably, among the incomplete SBCEs observed in our cohort (46/858, 5.4%), we identified suboptimal registration time in over a quarter of SBCEs (12/46, 26.1%) because of battery life <9 hours. This time frame is well below the technical standards of the SB3 system (12 hours). In two cases of incomplete SBCE (4.3%), the registration lasted <6 hours. To the best of our knowledge, there is no official protocol for monitoring capsule recorder performance and device replacement is currently recommended after evidence of capacity decay in clinical practice, thereby introducing a certain amount of subjectivity and risk of incomplete SBCE examinations.

The main strength of our study is the high number of SBCEs analyzed, which is far higher than in studies upon which current guidelines were based [4,5,6]. To the best of our knowledge, this is the largest cohort showing technical outcomes of SBCEs performed with modern devices and without RTV. We showed that SBCE performed without RTV achieved a high completion rate and a diagnostic yield comparable to previous studies, therefore making it an effective and more financially, socially, and environmentally sustainable examination [22,23]. We identified modifiable pretest risk factors that can significantly affect SBCE completeness and showed an extremely low rate of incomplete SBCEs with a prolonged GTT.

Furthermore, we explored the possibility of using RTV in a limited cohort of patients with a high risk of SBCE incompleteness, to detect and act on prolonged GTT, the only modifiable risk factor for incomplete SBCE identified by our analysis. Lastly, this was the first direct cost analysis of RTV in SBCE available in the literature.

Our study has some limitations. First, it was a retrospective analysis of data prospectively collected in a single center. Moreover, the number of SBCEs performed for suspected or known Crohn's disease was relatively small, given that a dedicated type of capsule endoscopy device was often used in this subset of patients. This selection could have potentially influenced our completeness rate, leading to overestimation.

Conclusions

In conclusion, incomplete SBCE occurs only occasionally using modern devices without RTV and in most cases, it is not associated with prolonged GTT or prolonged SBTT. Inpatient status, prolonged GTT, and a previous incomplete SBCE are risk factors for incomplete SBCE. Capsule recorder battery life is an overlooked risk factor for incomplete SBCE examinations. According to our direct cost analysis, in a low-incidence scenario for incomplete SBCE, use of RTV in all patients is burdened by high costs and unproven effectiveness with modern SBCE devices. Further, evidence is required to confirm our results and potentially identify subsets of patients who would significantly benefit from RTV.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Yazici C, Losurdo J, Brown MD et al. Inpatient capsule endoscopy leads to frequent incomplete small bowel examinations. World J Gastroenterol 2012; 18: 5051 doi:10.3748/wjg.v18.i36.5051

[2] Robinson CA, Jackson C, Condon D et al. Impact of inpatient status and gender on small-bowel capsule endoscopy findings. Gastrointest Endosc 2011; 74: 1061–1066 doi:10.1016/j.gie.2011.07.019

[3] Shibuya T, Mori H, Takeda T et al. The relationship between physical activity level and completion rate of small bowel examination in patients undergoing capsule endoscopy. Intern Med 2012; 51: 997–1001

[4] Ogata H, Kumai K, Imaeda H et al. Clinical impact of a newly developed capsule endoscope: usefulness of a real-time image viewer for gastric transit abnormality. J Gastroenterol 2008; 43: 186–192 doi:10.1007/s00535-007-2140-y

[5] Hosono K, Endo H, Sakai E et al. Optimal approach for small bowel capsule endoscopy using polyethylene glycol and metoclopramide with the assistance of a real-time viewer. Digestion 2011; 84: 119–125

[6] Shiotani A, Honda K, Kawakami M et al. Use of an external real-time image viewer coupled with prespecified actions enhanced the complete examinations for capsule endoscopy. J Gastroenterol Hepatol 2011; 26: 1270–1274

[7] Cotter J, de Castro FD, Magalhães J et al. Finding the solution for incomplete small bowel capsule endoscopy. World J Gastrointest Endosc 2013; 5: 595–599 doi:10.4253/wjge.v5.i12.595

[8] Rondonotti E, Spada C, Adler S et al. Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel disorders: European Society of Gastrointestinal Endoscopy (ESGE) Technical Review. Endoscopy 2018; 50: 423–446 doi:10.1055/a-0576-0566

[9] Lazaridis LD, Tziatzios G, Toth E et al. Implementation of European Society of Gastrointestinal Endoscopy (ESGE) recommendations for small-bowel capsule endoscopy into clinical practice: Results of an official ESGE survey. Endoscopy 2021; 53: 970–980

[10] Topa M, Nandi N, Scaramella L et al. Clinical impact of videocapsule endoscopy and device-assisted enteroscopy in non-bleeding small bowel lesions. Therap Adv Gastroenterol 2023; 16: doi:10.1177/17562848231176424

[11] Ben-Soussan E, Savoye G, Antonietti M et al. Factors that affect gastric passage of video capsule. Gastrointest Endosc 2005; 62: 785–790

[12] Tontini GE, Wiedbrauck F, Cavallaro F et al. Small-bowel capsule endoscopy with panoramic view: results of the first multicenter, observational study (with videos). Gastrointest Endosc 2017; 85: 401–408.e2

[13] Pascual Torres D, Brú Budesca X. Costes de la endoscopia digestiva en un Hospital Universitario de nivel II. Gastroenterol Hepatol 2003; 26: 279–287

[14] Loras C, Mayor V, Fernández-Bañares F et al. Study of the standard direct costs of various techniques of advanced endoscopy. Comparison with surgical alternatives. Dig Liver Dis 2018; 50: 689–697

[15] Goldberg MJ, Kosinski L. Activity-based costing and management in a hospital-based GI unit. Clin Gastroenterol Hepatol 2011; 9: doi:10.1016/j.cgh.2011.08.010

[16] Elm E von, Altman DG, Egger M et al. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ 2007; 335: 806–808 doi:10.1016/j.jclinepi.2007.11.008

[17] Freitas M, Silva VM, Xavier S et al. Prolonged gastric transit time in small-bowel capsule endoscopy: Which patients are at risk and what are the implications? Turkish J Gastroenterol 2023; 34: 227–233 doi:10.5152/tjg.2023.22191

[18] Tontini GE, Manfredi G, Orlando S et al. Endoscopic ultrasonography and small-bowel endoscopy: Present and future. Dig Endosc 2019; 31: 627–643 doi:10.1111/den.13429

[19] Koulaouzidis A, Giannakou A, Yung DE et al. Do prokinetics influence the completion rate in small-bowel capsule endoscopy? A systematic review and meta-analysis Curr Med Res Opin 2013; 29: 1171–1185 doi:10.1185/03007995.2013.818532

[20] Girelli CM, Soncini M, Rondonotti E. Implications of small-bowel transit time in the detection rate of capsule endoscopy: A multivariable multicenter study of patients with obscure gastrointestinal bleeding. World J Gastroenterol 2017; 23: 697 doi:10.3748/wjg.v23.i4.697

[21] Ouazana S, Baltes P, Toth E et al. Endoscopic gastrointestinal placement of capsule endoscopy to investigate the small bowel: A multicentric European retrospective series of 630 procedures in adult patients. Gastrointest Endosc 2024: doi:10.1016/j.gie.2024.01.027

[22] Bortoluzzi F, Sorge A, Vassallo R et al. Sustainability in gastroenterology and digestive endoscopy: Position Paper from the Italian Association of Hospital Gastroenterologists and Digestive Endoscopists (AIGO). Dig Liver Dis 2022; 54: 1623–1629

[23] Sorge A, Tontini GE, Scaramella L et al. Could war and the supply chain crisis affect the sustainability of gastrointestinal endoscopy and single-use endoscopes? Gut Published Online First: 2023; 72: 407–408