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Capsule endoscopy interpretation: The role of physician extenders

I. Fernández-Urién, E. Espinet, N. Pérez, M. Betés, M. Herráiz, C. Carretero and M. Muñoz-Navas

Department of Gastroenterology. University Clinic of Navarra. Pamplona, Spain

RESUMEN

Introducción y objetivos: la cápsula endoscópica (CE) ha supuesto una nueva era en el estudio del intestino delgado. No obstante, el tiempo empleado por el gastroenterólogo en este procedimiento es mayor del deseable y no se han evaluado completamente alternativas al personal especializado. El objetivo de este estudio es evaluar la precisión de personal no especializado en la interpretación de la CE.

Material y métodos: un gastroenterólogo con experiencia en CE y personal no especializado revisaron independientemente 20 procedimientos. Los hallazgos de cada participante eran desconocidos por el resto. Un consenso formado por los participantes y un segundo gastroenterólogo fue empleado como *gold standard*. Se analizaron número, tipo y localización de las imágenes seleccionadas y tiempo de evacuación gástrica (tEG), tiempo de tránsito en intestino delgado (tTID) y tiempo empleado por los participantes.

Resultados: la sensibilidad y la especificidad global fueron del 79 y 99% para el gastroenterólogo; del 86 y 43% para la enfermera; y del 80 y 57% para el residente. Las 34 lesiones "mayores" consideradas por consenso fueron detectadas por los tres participantes. El acuerdo entre consenso y participantes para clasificar e interpretar las imágenes fue de buena a excelente (κ de 0,55 a 1). No se encontraron diferencias estadísticamente significativas en el tEG y tTID obtenido por consenso y participantes. El gastroenterólogo fue el más rápido en revisar los procedimientos (51,9 ± 13,5 minutos *versus* 62,2 ± 19 y 60,9 ± 17,1 para enfermera y residente, respectivamente; $p < 0,05$).

Conclusiones: el personal no especializado podría ser el complemento perfecto al gastroenterólogo en la interpretación de la CE, aunque este debería supervisar sus hallazgos. Los beneficios de esta alternativa deberían ser contrastados en el futuro por análisis coste-efectividad.

Palabras clave: Cápsula endoscópica. Enfermera. Residente. Personal no especializado.

ABSTRACT

Background and aims: capsule endoscopy (CE) allows for a new era in small-bowel examination. Nevertheless, physicians' time for CE-interpretation remains longer than desirable. Alternative strategies to physicians have not been widely investigated. The aim of this study was to evaluate the accuracy of physician extenders in CE-interpretation.

Material and methods: one CE-experienced gastroenterologist and two physician extenders reviewed independently 20 CE-procedures. Each reader was blinded to the findings of their colleagues. A consensus formed by the readers and a second CE-experienced gastroenterologist was used as gold standard. Number, type and location of images selected, character of CE-exams and their relationship with indications were recorded. Gastric emptying time (GEt), small-bowel transit time (SBTt) and time spent by readers were also noted.

Results: sensitivity and specificity for "overall" lesions was 79 and 99% for the gastroenterologist; 86 and 43% for the nurse; and 80 and 57% for the resident. All 34 "major" lesions considered by consensus were found by the readers. Agreement between consensus and readers for images classification and procedures interpretation was good to excellent (κ from 0.55 to 1). No significant differences were found in the GEt and SBTt obtained by consensus and readers. The gastroenterologist was faster than physician extenders (mean time spent was 51.9 ± 13.5 minutes *versus* 62.2 ± 19 and 60.9 ± 17.1 for nurse and resident, respectively; $p < 0.05$).

Conclusions: physician extenders could be the perfect complement to gastroenterologists for CE-interpretation but gastroenterologists should supervise their findings. Future cost-efficacy analyses are required to assess the benefits of this alternative.

Key words: Capsule endoscopy. Nurse. Resident. Physician extenders.

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Correspondence: Ignacio Fernández-Urién. Unidad de Endoscopia. Clínica Universitaria de Navarra. Avda. Pío XII, 36. 31080 Pamplona, Navarra. e-mail: ifurien@unav.es

INTRODUCTION

Capsule endoscopy (CE) has opened up a new era in small-bowel examination. It appears to have a higher diagnostic yield than small-bowel follow-through (SBFT), entero-CT, or push-enteroscopy (PE) as shown in recent studies (1-10). Presently, CE interpretation is limited to physicians, and the time spent on each procedure remains variable. It apparently depends on the experience and concentration of the reader, as well as on the number of pathological images observed. It usually takes over 1 hour, ranging from 30 to 120 minutes in reported series (1-3,6,9), which seems longer than desirable. The role of physician extenders in CE interpretation has not been studied widely, and could be beneficial. Our hypothesis is that well-trained physician extenders could become first reviewers while gastroenterologists review only selected images. This should mean time saved for physicians, and probably cost-efficiency. Our aims were to evaluate the accuracy of physician extenders in reviewing and interpreting CE procedures, and to compare times as spent by them and a CE-experienced gastroenterologist.

MATERIAL AND METHODS

Patients and CE procedures

A total of 20 CE procedures were included in the study. CE procedures were performed with a PillCam™ SB system (Given Imaging Ltd., Yoqneam, Israel). All patients fasted overnight before swallowing the capsule and a previous laxative or prokinetic preparation was not used.

Readers and training

CE procedures were read independently at no standard frame rate by one CE-experienced gastroenterologist and two physician extenders: A gastroenterology resident and a registered nurse. The same clinical data were given to each reader, and they were "blinded" to the findings of their colleagues. At the time of the study the gastroenterologist had a CE-experience of more than 150 examinations. Neither the resident nor the nurse had CE-experience before the study. Specific measures for standardized training in CE have not yet been widely described. Thus, training requirements as suggested by the ASGE guidelines for credentialing and granting privileges for CE were considered for physician extenders (11). Both nurses and residents had endoscopic imaging experience including small-bowel imaging. They also completed a CE hands-on course, which emphasized the hardware and software system management as well as lesion recognition and characterization. Prior to study onset physician extenders reviewed 15 CE procedures under the direct supervision of a CE-experienced gastroenterologist, who assessed their competency in CE. In addition, readers were permitted visiting the Given Imaging web site (www.givenimaging.com) and the *Atlas of Capsule Endoscopy* (12) during CE-procedures.

Variables

Variables included for the study and standardized criteria for their classification are shown in tables I and II (13). All suspicious images were selected and classified by readers according to their type and location. Readers also classified CE procedures according to their character, and noted the relationship between indications and global findings. Gastric emptying time (GEt), small-bowel transit time (SBTt), and total time (Rt) spent by readers for CE examination were also recorded. Note that all participants were familiar with these criteria since their training period.

Table I. Variables derived from images selected and criteria followed for their classification

Number	*Number of images selected by each reader*
Type*	
Vascular	Defined as those appearing as red spots, generally small, flat and sometimes spider like
Inflammatory	Defined as those appearing as mucosal thickening with edema, erythema, or nodularity
Erosion-ulcer	Defined as those appearing with loss of superficial mucosa in a localized area, usually associated with erythema and/or irregular surrounding mucosa
Polyp-neoplasia	Defined as those appearing as polypoid, vegetant, or submucosal masses, whether ulcerated or not, with normal surrounding mucosa
Active bleeding	Defined as those with active bleeding with/without an underlying source
Minimal	Defined as those smaller than 4 mm (on screen) regardless of type
Other	Defined as the rest of lesions found (mosaic pattern of mucosa, lymphoid hyperplasia, xanthoma,...)
Location	
Duodenum	Mucosa between the pylorus and Treitz's ligament (left-superior quadrant on the localization drawing). Short and very fast transit (usually < 15 min). Other criteria for duodenal location were bile streaming, ampulla visualization, obvious villous pattern, absence of visible vascularization, and presence of images such as lymphangiectasia
Jejunum	Mucosa between Treitz's ligament and the ileum (see ileum), far away from first duodenal and cecal images. Large and slow transit (usually > 60 min). Other criteria for jejunal location were less conspicuous villous pattern, obvious vascular pattern, no bile, and evident peristalsis
Ileum	Mucosa between the jejunum (see jejunum) and first cecal image. Short and slow transit (usually > 30 min). Other criteria for ileal location were no evident villous pattern, obvious vascular pattern (fine vessels), frequent fecaloid residues, conspicuous peristalsis, and images such as lymphoid hyperplasia
Other	Images located in the esophagus, stomach, and colon
Intensity	
Major	Defined as > 7 mm**, active bleeding or diffuse lesions
Non-minimal	Defined as ranging between 4 and 7 mm**
Minimal	Defined as smaller than 4 mm** regardless of type

*Modified from CE-Minimal Standard Terminology (CE-MST) (13); **Lesion size was measured on screen.

Table II. Variables derived from explorations and criteria followed for their classification

Character	
Normal	Defined as CE procedures without pathologic findings
Abnormal	Defined as CE procedures with pathologic findings
Relationship between findings and CE indication	
Probable	Defined by the presence of active, recent bleeding, and/or potential bleeding lesions when indication was *OGIB*
	Defined by the presence of multiple or coalescent ulcers, skip, and/or stenotic lesions on altered surrounding mucosa when indication was suspected *IBD*
	Defined by the presence of IBD criteria, solitary erosions-ulcers, and/or neoplastic lesions when indication was *chronic abdominal pain*
	Defined by the presence of IBD criteria, irregular folds, long atrophic areas, and/or mosaic pattern of mucosa when indication was *chronic diarrhea*
	Defined by the presence of vegetant, ulcerated, and/or submucosal mass when indication was suspected *neoplasia*
Unlikely probable	Defined by findings that did not meet "probable" criteria
Times	
Readers' time (Rt)	Defined as the time spent by readers in CE procedures
Gastric emptying time (GEt)	Defined as the time measured from first gastric to first duodenal image
Small bowel transit time (SBTt)	Defined as the time measured from first duodenal to first cecal image

Gold standard and statistical analysis

In the absence of a gold standard for comparisons, a Consensus formed by the original participants and other CE-experienced gastroenterologist (MMN) was created. They performed a one-by-one revision of images selected by the readers. Then, they discussed whether the images selected were pathologic, and also their type, location, and intensity. Similarly, this was performed with variables related to explorations. The Consensus opinion as assisted by clinical and laboratory data was considered the gold standard. Readers' accuracy for pathologic images was then analyzed. Image selection and characterization, as well as procedure characterization and time spent by the readers were compared using ANOVA, with *post-hoc* comparisons performed by Dunnett's test (when possible). A p value < 0.05 was considered statistically significant. Agreement between the Consensus and readers for image selection and image-procedure classification was analyzed by means of a kappa index (κ), and the benchmarks for κ values suggested by Fleiss (14) were accepted (< 0.40 poor agreement; 0.40-0.75 good agreement; > 0.75 excellent agreement). ANOVA analyses data are given as mean ± standard deviation (SD), and κ values are presented with their 95% confidence intervals (95% CI). Statistical analyses were performed using the SPSS version 12.0 software for Windows (SPSS Inc. Chicago, Illinois, USA), and the SISA online statistical analysis (http://home.clara.net/sisa/index.htm).

RESULTS

Image selection

Images considered pathologic by the Consensus and readers, and also their characterization as well as ANOVA and Dunnett test results are shown in table III. Kappa values for Consensus and reader agreement are summarized in table IV.

Table III. Image selection and classification

	Number of images selected/$\bar{X}$ (SD)				
	C	*G*	*N*	*R*	*p*
Overall	300/15 (7.31)	*237/11.85 (7.10)**	307/15.35 (7.03)	277/13.85 (6.49)	*< 0.001*
Intensity					
"Major" lesions	32/1.60 (1.78)	32/1.60 (1.78)	32/1.60 (1.78)	32/1.60 (1.78)	§
"Non-minimal" lesions	174/8.70 (5.33)	161/8.05 (5.51)	169/8.45 (5.02)	158/7.90 (4.95)	0.326
"Minimal" lesions	94/4.70 (3.75)	*44/2.20 (2.76)**	106/5.30 (3.72)	87/4.35 (2.96)	*< 0.001*
Type					
Vascular	54/2.70 (2.83)	52/2.60 (2.85)	51/2.55 (2.72)	47/2.35 (2.49)	0.298
Inflammatory	40/2 (1.89)	34/1.70 (1.89)	44/2.20 (2.19)	40/2 (2.53)	0.145
Erosion-ulcer	41/2.05 (2.32)	41/2.05 (2.48)	34/1.70 (1.89)	39/1.95 (1.84)	0.447
Polyp-neoplasia	14/0.70 (1.26)	15/0.75 (1.25)	15/0.75 (1.40)	13/0.65 (1.22)	0.871
Active bleeding	4/0.20 (0.52)	4/0.20 (0.52)	4/0.20 (0.52)	4/0.20 (0.52)	§
Minimal	94/4.70 (3.75)	*44/2.20 (2.76)**	106/5.30 (3.72)	87/4.35 (3.01)	*< 0.001*
Other	53/2.65 (2.15)	47/2.35 (1.95)	53/2.65 (2.13)	47/2.35 (1.89)	0.24
Location					
Duodenum	47/2.35 (1.75)	38/1.90 (1.91)	54/2.70 (1.80)	51/2.55 (2.16)	0.054
Jeyunum	139/6.95 (4.35)	*113/5.65 (3.85)**	155/7.75 (4.75)	141/7.05 (4.33)	*0.016*
Ileum	85/4.25 (4.16)	61/3.05 (3.50)	71/3.55 (2.89)	61/3.05 (3.23)	0.144
Other	29/1.45 (1.23)	25/1.25 (1.11)	27/1.35 (1.04)	24/1.20 (0.89)	0.103

C: Consensus; G: Gastroenterologist; N: Nurse; R: Resident; *p:* Signification of ANOVA (comparison of means). *Statistically significant differences between Consensus and Reader (Dunett test was performed when p was < 0.05). §: Total agreement (variance = 0).

Table IV. Interobserver agreement

	κ values (95% CI)		
	C-G	*C-N*	*C-R*
Overall	*0.61 (0.53-0.70)*	*0.30 (0.18-0.40)*	*0.33 (0.22-0.43)*
Intensity			
"Major" lesions	*1*	*1*	*1*
"Non-minimal" lesions	0.73 (0.60-0.86)	0.51 (0.34-0.68)	0.18 (0.01-0.34)
"Minimal" lesions	0.31 (0.13-0.48)	0.05 (0-0.21)	0.30 (0.14-0.45)
Type			
Overall	*0.79 (0.74-0.82)*	*0.64 (0.59-0.69)*	*0.64 (0.59-0.69)*
Vascular	0.98 (0.95-1)	0.85 (0.78-0.93)	0.85 (0.77-0.93)
Inflammatory	0.91 (0.83-0.98)	0.78 (0.68-0.88)	0.75 (0.63-0.86)
Erosion-ulcer	0.94 (0.89-0.99)	0.77 (0.67-0.88)	0.77 (0.67-0.88)
Polyp-neoplasia	0.96 (0.89-1)	0.82 (0.66-0.97)	0.81 (0.64-0.97)
Active bleeding	1	1	1
Minimal	0.57 (0.46-0.67)	0.48 (0.38-0.58)	0.59 (0.49-0.68)
Other	0.91 (0.86-0.97)	0.89 (0.82-0.95)	0.79 (0.70-0.88)
Location			
Overall	*0.76 (0.71-0.81)*	*0.57 (0.51-0.63)*	*0.55 (0.49-0.61)*
Duodenum	0.88 (0.80-0.95)	0.67 (0.56-0.78)	0.67 (0.56-0.78)
Jeyunum	0.77 (0.71-0.84)	0.58 (0.50-0.66)	0.56 (0.47-0.65)
Ileum	0.80 (0.72-0.87)	0.60 (0.50-0.70)	0.61 (0.51-0.71)
Other	0.92 (0.84-1)	0.96 (0.90-1)	0.81 (0.70-0.93)

C: Consensus; G: Gastroenterologist; N: Nurse; R: Resident. 95% CI: 95% confidence interval. Benchmarks for κ values (14): < 0.40 poor; 0.40-0.75 good; > 0.75 excellent.

Number of images selected

There were significant differences in the "overall" number of images considered pathologic by the Consensus and readers ($p < 0.001$). *Post-hoc* comparisons (using Dunnett's test) showed that the gastroenterologist was the only reader who selected significantly fewer "overall" images than the Consensus ($p < 0.05$). Nevertheless, a good Consensus-gastroenterologist ($\kappa = 0.61$), and a poor Consensus-physician extender (κ of 0.30 and 0.33 for nurse and resident, respectively) agreement was observed. When lesions were classified according to their intensity, it was seen that only the number of "minimal" lesions selected by the Consensus and readers was statistically different ($p < 0.001$). The gastroenterologist was again the one reader that selected significantly fewer "minimal" lesions than the Consensus ($p < 0.05$). In addition, poor agreement between the Consensus and each reader was observed for these lesions (κ values ranged from 0.05 to 0.31). On the other hand, no significant differences were seen in the number of "major" and "non-minimal" lesions selected by the Consensus and each reader. There was absolute agreement for "major" lesions ($\kappa = 1$), and good to poor agreement for "non-minimal" lesions ($\kappa = 0.73$ for Consensus-gastroenterologist; $\kappa = 0.51$ for Consensus-nurse and $\kappa = 0.18$ for Consensus-resident).

Type and location of images selected

There were no significant differences between the Consensus and readers in the number of images selected according to their type and location, except for the "minimal" type ($p < 0.001$) and lesions located in the jejunum ($p < 0.05$). These differences were due to the gastroenterologist's selection, as demonstrated by *post-hoc* comparisons. He selected fewer "minimal" lesions as well as fewer lesions located in the jejunum than the Consensus (both $p < 0.05$). Overall agreement for lesion type was excellent for Consensus-gastroenterologist ($\kappa = 0.79$), and good for Consensus-physician extenders ($\kappa = 0.64$ for both nurse and resident). Readers always obtained κ values over 0.75 (excellent agreement) for all types except "minimal" lesions (κ values ranged from 0.48 to 0.59). Overall agreement for lesion location was excellent for Consensus-gastroenterologist ($\kappa = 0.76$), and good for Consensus-physician extenders ($\kappa = 0.57$ and $\kappa = 0.55$ for nurse and resident, respectively). Consensus-gastroenterologist agreement was excellent for all locations (κ values ranged from 0.77 to 0.92). Consensus-physician extenders agreement was excellent for "other" locations ($\kappa = 0.89$ and $\kappa = 0.79$ for nurse and resident, respectively) and good for lesions located in the duodenum, jejunum, and ileum (κ values ranged from 0.56 to 0.69).

Readers' diagnostic accuracy

Sensitivity for "overall" lesions was higher for physician extenders (86 and 80% for nurse and resident *versus* 79% for the gastroenterologist) but specificity was lower (99% for the gastroenterologist *versus* 43% and 57% for nurse and resident). As previously shown, the 3 readers selected all 34 "major" lesions considered by the Consensus, resulting in a sensitivity and specificity of 1. For "non-minimal" lesions, sensitivity was over 80% for each reader, and the gastroenterologist's specificity was again higher than nurse's and resident's (96 *versus* 59 and 41%, respectively). Sensitivity for "minimal" lesions was poor but higher for both nurse and resident (67 and 69%, respectively *versus* 42% for the gastroenterologist), and specificity was 1 for the gastroenterologist, 39% for the nurse, and 61% for the resident. More details on reader accuracy are shown in table V.

Table V. Readers' accuracy for lesion detection

	S (CI 95%)	*E (CI 95%)*	*J*	*LR + (CI 95%)*	*LR - (CI 95%)*
Overall lesions					
G	0.79 (0.74-0.83)	*0.99 (0.97-1.01)*	*0.78*	69.23 (9.85-486.44)	0.22 (0.17-0.27)
E	*0.86 (0.82-0.90)*	0.43 (0.33-0.54)	0.29	1.51 (1.25-1.82)	0.33 (0.23-0.48)
R	0.80 (0.75-0.84)	0.57 (0.46-0.67)	0.37	1.84 (1.44-2.36)	0.36 (0.27-0.48)
"Major" lesions					
G	1	1	1	∞	0
E	1	1	1	∞	0
R	1	1	1	∞	0
"Non-minimal" lesions					
G	0.92 (0.88-0.96)	*0.96 (0.89-1)*	*0.88*	24.83 (3.63-170)	0.08 (0.05-0.14)
E	*0.93 (0.89-0.97)*	0.59 (0.41-0.78)	0.52	2.29 (1.45-3.61)	0.12 (0.06-0.22)
R	0. 82 (0.76-0.87)	0.41 (0.22-0.59)	0.23	1.38 (1-1.90)	0.45 (0.26-0.78)
"Minimal" lesions					
G	0.42 (0.32-0.51)	*1*	*0.42*	∞	0.58 (0.50-0.69)
N	0.67 (0.58-0.77)	0.39 (0.27-0.51)	0.06	1.09 (0.86-1.39)	0.85 (0.56-1.30)
R	*0.69 (0.60-0.78)*	0.61 (0.49-0.73)	0.30	1.79 (1.27-2.51)	0.50 (0.35-0.72)

S: Sensitivity; E: Specificity; CI: Confidence interval; J: Youden Index; LR+/-: Likelihood ratio of positive/negative test; G: Gastroenterologist; N: Nurse; R: Resident.

Interpretation of global findings

The interpretation of global findings by the Consensus and readers is summarized in table VI.

Character of explorations

The Consensus and each one of the readers classified the same 19 of 20 procedures as "abnormal". Discrepancy for this variable was 0, and agreement between the Consensus and each reader was absolute (κ values of 1).

Table VI. Interpretation of global findings

	Readers' selection					*κ values (CI 95%)*		
	C	*G*	*N*	*R*	*Sig.*	*C-G*	*C-N*	*C-R*
Character								
Abnormal n (%)	19 (95%)	19 (95%)	19 (95%)	19 (95%)	§	1	1	1
Relationship								
Unlikely probable n (%)	11 (55%)	11 (55%)	11 (55%)	10 (50%)	0.39	1	1	0.90 (0.71-1)

C: Committee; G: Gastroenterologist; N: Nurse; R: Resident; *Sig.:* Signification of ANOVA (comparison of means); CI 95%: Confidence interval. Benchmarks for κ values (14): < 0.40 poor; 0.40-0.75 good; > 0.75 excellent. §: Total agreement (variance = 0).

Relationship between findings and CE-indications

No significant differences were observed between Consensus and readers when the relationship between findings and CE indications was classified as "probable" (11/20 procedures for both gastroenterologist and nurse; 10/20 for the resident; p = 0.39). Absolute agreement for both Consensus-gastroenterologist and Consensus-nurse (κ = 1), and excellent agreement for Consensus-resident (κ = 0.90; 95% CI: 0.71-1) were seen.

GEt, SBTt and Rt

Mean GEt measured by readers was 58.8 ± 75.6 minutes for the gastroenterologist, 58.9 ± 75.7 for the nurse, and 59.1 ± 75.7 for the resident (p = 0.47). Mean SBTt was 260 ± 84.9 minutes for both gastroenterologist and nurse, and 259.9 ± 84.8 for the resident (p = 0.58). Mean time spent per procedure by readers was 51.9 ± 13.5 minutes for the gastroenterologist, 62.2 ± 19.0 for the nurse, and 60.9 ± 17.1 for the resident (p < 0.05).

DISCUSSION

Physician time for CE interpretation remains longer than desirable, ranging from 30 to 120 minutes in published series (1-3,6,9). It appears to be one of the most costly parts of this procedure. Alternative strategies to physicians for CE interpretation, such as physician extenders, have not been widely studied. Our hypothesis is that physician extenders could become first reviewers screening for "pathological" images, while gastroenterologists review only selected images. It should mean time saved for physicians, and probably cost-efficiency. The ability of paramedical staff to perform endoscopic procedures has been demonstrated before (15-17). Recently a study has evaluated for the first time the accuracy of an endoscopy nurse in detecting clinically significant lesions during CE when compared to a CE-experienced gastroenterologist (18). Results revealed that the nurse detected 93% of the clinically significant lesions seen by the gastroenterologist, and conclude that physician extenders could pre-read CE procedures, allowing the gastroenterologist to explore only pathologic segments. The main objective of our study was to evaluate the accuracy of different physician extenders for reading CE exams. We have also evaluated their ability to interpret and characterize findings, and the time spent on this. Our results revealed that physician extenders selected more images than the gastroenterologist. Although their sensitivity for "overall" lesions was slightly higher, agreement with the Consensus was poorer. It can be explained because of the higher number of "non-pathological" images selected by physician extenders, which also resulted in a lower specificity. As clinical implications derived from missing significant lesions are greater, images selected were also classified by the Consensus according to their intensity as "major", "non-minimal", and "minimal" lesions. It allowed us to evaluate readers' accuracy for remarkable ("major") lesions. Reader sensitivity and specificity for "major" lesions was identical because they detected all 34 "major" lesions considered by the Consensus (absolute agreement). This is of great interest because in most cases the detection of these lesions is essential for diagnosis. Although "non-minimal" lesions were not considered as significant as "major" lesions, most of them were detected by these readers, resulting in a high and very similar sensitivity between them (> 80%). No significant differences were observed in the number of "non-minimal" lesions selected by readers, but good to poor agreement with the Consensus was seen because physician extenders included several "non-pathological" images into the "non-minimal" lesion group. It resulted in a lower strength of agreement with the Consensus, and also in lower specificity. "Minimal" lesions were defined as those smaller than 4 mm on screen regardless of type. These lesions are very frequent in CE exams, and they are usually of no significance for the diagnosis unless bleeding is involved (then considered "major" lesions). Due to their size and poor significance, it seems reasonable to miss them as demonstrated by our readers' sensitivity. There were significant differences in the number of "minimal" lesions selected by readers, which were not observed in "major" and "non-minimal" lesion selection. As seen for "non-minimal" lesions, all readers except the gastroenterologist included "non-pathologic" images in the "minimal" lesion group, resulting in poorer specificity. Obviously, Consensus-reader agreement for "minimal" lesions was poor (κ < 0.45 for each one of the readers). Single-frame images, polyp-looking small-bowel folds, and bile and food remnants (laxative

preparations were not used by patients) are some of the images erroneously considered lesions by the nurse and resident. We also evaluated the ability of physician extenders to characterize lesions as well as to interpret global findings. Overall agreement for lesion type was good to excellent. It was absolute for "active bleeding" lesions, and excellent for "vascular" and "erosion-ulcer" lesions, which are the most frequent lesions found in CE exams. Nurse and resident κ values, although acceptable, were slightly lower than those of the gastroenterologist. On the other hand, the location of lesions selected during CE is sometimes difficult for the examiner. There are no established parameters for this purpose, and anatomic references play an important role in this setting. Even though standardized criteria for lesion location were used during training sessions, as well as during the study, to avoid reader subjectivity, agreement for lesions located close to anatomic references, such as esophageal, gastric, duodenal, and ileal lesions, was better than for the rest. Although physician extenders obtained good to excellent agreements, κ values were somewhat lower than that for the gastroenterologist except for non-small bowel locations. These results demonstrate that most significant lesions are found and correctly characterized by physician extenders. However, this does not mean that such extenders appreciate the significance of findings in the context of explorations. For this purpose exploration nature and the relationship between indications and global findings were also noted. There was a perfect discrimination between "normal" and "abnormal" explorations by readers (absolute agreement), and they also correctly noted when lesions where probably related to indications (excellent agreement). On the other hand, there were no significant differences in mean gastric emptying and small-bowel transit times as measured by each reader. It suggests that first gastric, duodenal, and cecal image selection was similar among readers. This is of interest because this selection is needed to activate the suspected blood indicator (SBI) and capsule localization system. SBI is particularly helpful for locating bleeding lesions, and the capsule localization system is useful for assessing whether lesions are within range for a push enteroscope or for planning double-balloon enteroscopy and subsequent surgical procedures. Finally, the time spent by readers on CE procedures was compared, and it was observed that physician extenders were significantly slower than the gastroenterologist. This is probably due to a higher number of lesions selected. In summary, these results demonstrate that physician extenders, although slower, can detect most significant lesions during CE procedures. They can also correctly characterize and interpret findings. Their high sensitivity for lesions makes them a perfect complement to gastroenterologists for CE interpretation. Nevertheless, CE-experienced gastroenterologists should supervise their findings. Future cost-efficiency analyses are required to assess the benefits of this alternative.

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