AP&T Alimentary Pharmacology and Therapeutics

Impact of the Rome II paediatric criteria on the appropriateness of the upper and lower gastrointestinal endoscopy in children

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Publication data
Submitted 9 January 2010
First decision 26 January 2010
Resubmitted 21 May 2010
Accepted 25 May 2010
Epub Accepted Article 28 May 2010

SUMMARY

Background
The demand for paediatric gastrointestinal (GI) endoscopy has increased, resulting in a significant rise of overall costs.

Aim
To assess the clinical impact of the Rome II criteria for functional gastrointestinal disorders when selecting paediatric patients who underwent GI endoscopy.

Methods
The indications and findings of GI endoscopic procedures performed before and after the publication of the Rome II criteria were evaluated retrospectively.

Results
Upper GI endoscopy was performed in 1124 children, whereas colonoscopy was performed in 500 subjects. A total of 607 (54%) oesophago-gastroduodenoscopies (OGDs) were positive and 517 (46%) were negative, whereas 306 (61.1%) colonoscopies were positive and 194 (38.9%) were negative. Of the 1624 procedures, 26% were considered inappropriate according to the Rome II criteria. Inappropriate procedures decreased significantly after publication of the Rome II criteria (OR, 3.7; 95% CI, 1.8–7.5). Of 1202 appropriate GI endoscopies, 502 OGD (62.7%) were significantly contributive, compared with only 105 (32.5%) of the 323 inappropriate procedures (OR, 3.5; 95% CI, 2.6–4.6), whereas 265 (65.8%) colonoscopies were significantly contributive, compared with only 41 (42.3%) of the 97 inappropriate procedures (OR, 2.6; 95% CI, 1.6–4.1).

Conclusions
The use of the criteria for functional gastrointestinal disorders makes a significant positive impact, they should reduce unnecessary paediatric GI endoscopy.

Aliment Pharmacol Ther 2010; **32:** 582–590

doi:10.1111/j.1365-2036.2010.04383.x

INTRODUCTION

Functional gastrointestinal disorders (FGIDs) are defined as a variable combination of chronic or recurrent gastrointestinal symptoms unexplained by structural or biochemical abnormalities. In 1997, a paediatric working team met in Rome to standardize the diagnostic criteria for various FGIDs in children. The first paediatric criteria for FGIDs were published in 1999 as the Rome II criteria.[1] These criteria were created as a diagnostic tool and as a way to advance empirical research, providing clinicians with a positive approach to treating paediatric patients. Recently, in light of emerging scientific research and on the basis of clinical experience, the Rome II paediatric criteria have been updated and revised. The Rome III paediatric criteria represent an evolution from Rome II and should prove useful for both clinicians and researchers dealing with childhood FGIDs.[2, 3]

The demand for gastrointestinal endoscopy has increased in most developed countries, resulting in a significant rise in overall costs for endoscopic procedures.[4] During the past few years, various organizations have tried to develop criteria for selecting patients most likely to benefit from gastrointestinal endoscopy.[5] Official recommendations on the appropriate use of endoscopy in adults have been released.[6, 7] Although few studies have compared the efficiency of gastrointestinal endoscopy to other diagnostic procedures in paediatric patients, recommendations were issued in 1996 by the North American Society of Pediatric Gastoenterology, Hepatology and Nutrition (NASPGHAN).[8] In addition, a technical report by NASPGHAN concluded that, in the evaluation of chronic abdominal pain 'there is little evidence to suggest that use of endoscopy and biopsy in the absence of alarm symptoms has a significant yield of organic disease'.[9]

Adult studies suggest, however, that alarm features may not discriminate functional from organic disease.[10] There are few studies examining the diagnostic outcomes of gastrointestinal endoscopy in children.[11] The diagnostic yield of oesophago-gastro-duodenoscopy (OGD) in children with abdominal pain was 3.6% in the existing literature, but this data were based on studies which were compromised by small simple size, variable findings, selection bias and the use of not standardized diagnostic criteria.[11] None of the studies used the Rome II paediatric criteria for functional abdominal pain. Few of them examined the predictive value of blood work obtained prior to endoscopy and none of them analysed the association of alarm symptoms or signs to diagnostic yield.[11] To our knowledge, there are no studies evaluating appropriateness and diagnostic yield of colonoscopy in the management of children with gastrointestinal disorders.

The main purpose of this study was to assess the impact of the Rome II paediatric criteria for FGIDs in selecting paediatric patients who underwent upper or lower gastrointestinal endoscopy. The secondary objectives were to evaluate the association of alarm symptoms or signs to diagnostic yield and the predictive value of blood work obtained prior to endoscopy.

PATIENTS AND METHODS

The study was a retrospective, single-centre, cross-sectional study of 1624 consecutive children who underwent upper or lower GI endoscopy at the Department of Pediatrics of the University of Naples 'Federico II' from January 1998 to December 2006. To avoid repeated measures from patients with multiple examinations during the study period, only the patients' first procedure was eligible for the study. No patient was excluded on the grounds of having a concomitant chronic disease.

A chart review was performed on all patients who met inclusion criteria. Procedure note, pathology report, laboratory reports, and history and physical examination performed up to 1 month prior to the procedure were considered. For those patients who lacked a qualifying history and physical examination, ICD9 codes were reviewed in the electronic medical record. Clinical information was collected prior to the procedure information to mask the reviewer to the outcome of the endoscopy. A review of laboratory tests, which had been obtained up to 1 month prior to the procedure, included haemoglobin level, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), albumin and faecal calprotectin. Alarm symptoms or signs were evaluated included involuntary weight loss, deceleration of linear growth, gastrointestinal blood loss, vomiting, chronic severe diarrhoea, persistent right upper or right lower quadrant pain.[12] Chronic diarrhoea was defined as the passage of three or more watery stool per day for at least 2 weeks.[13]

The decision to perform endoscopy was made by the hospital-based paediatric gastroenterologist who evaluated symptoms reported by the parents or family and applied the Rome II paediatric diagnostic criteria after their publication.

Endoscopic examination was carried out using standard, forward-viewing pediatric Olympus endoscopes (Europe GMBH, Hamburg, Germany) by experienced paediatric gastroenterologists (EM, AS). The upper or lower GI endoscopies were performed in either an endoscopy room or an operating room. Those patients

who underwent the procedure in an endoscopy room were sedated, while those in the operating room were put under general anaesthesia. The decision between these two modalities was based on patient age, reason for endoscopy, and medical history. Sedation, when used, consisted of midazolam, administered intravenously (0.1 mg/kg). During the colonoscopy, three biopsies were taken from the ileum and subsequently a minimum of two biopsies was taken from every segment of the colon. In the case of an OGD, biopsies were taken from the duodenum, anthrum, corpus and oesophagus.

Endoscopic findings were reported according to internationally accepted terms and definitions whenever possible. Review of the final pathology report provided the data source for histological diagnosis. Endoscopic procedures were considered positive if they had direct impact on treatment (i.e. gross abnormalities, clinically relevant biopsy findings such as coeliac disease and inflammatory bowel disease). They were considered negative if their findings were normal or showed abnormalities that did not affect treatment, such as non-specific endoscopic findings (e.g. erythema, increase or loss vascularity and pallor) and descriptive histological changes (e.g. reactive changes, oedema, mild inflammatory changes).[14, 15]

Based on the symptoms, endoscopic procedures were considered inappropriate if the Rome criteria had been met and appropriate if they had not been met. Two investigators (EG and AT), who were unaware of the endoscopic findings judged the appropriateness of the indication of the endoscopic findings, according to the Rome II paediatric criteria. To evaluate the effect of the Rome II paediatric criteria on practices, indications and findings of GI endoscopic procedures, performed before the publication of the FGIDs, diagnostic criteria were compared with those procedures performed under them.[1] The Rome II diagnostic criteria are summarized in Table S1.

Means and medians were calculated for dimensional variables after controlling for normality of distribution. The Student's *t* test for normally distributed variables and the Mann–Whitney *U*-test and chi-square test and Fisher exact tests for categorical variables were used where appropriate.

Logistic regression analysis has been used to estimate the probability of positive events occurring in upper as well as lower GI endoscopy. The probability of the event occurring was obtained by the linear combination of the contribution of the following indicator variables which significantly contributed, positively as well as negatively, to the prediction of the event: deceleration of linear growth, gastrointestinal blood loss, significant vomiting, persistent right upper or right lower quadrant pain involuntary weight loss, chronic severe diarrhoea. The sign of the regression coefficient suggests positive or negative contribution: the coefficient can be interpreted as the change in the log odds associated with one-unit in the independent variables. A forward stepwise selection was adopted. Odds ratio and accompanying 95% C.I. were calculated using maximum likelihood ratio method.

Statistical analysis was carried out using SPSS statistical software package for Windows (13.0, SPSS Inc., Chicago, IL, USA). The study was approved by the Institutional Review Board of the University of Naples 'Federico II'.

RESULTS

During the study period, 1916 GI endoscopic procedures were performed in 1713 patients of which 292 were excluded. Ninety-six were excluded because of repeated endoscopies, 136 because they had undergone incomplete procedures, and 60 were excluded because their data were incomplete. Thus, this study was based on 1624 procedures, each performed in an individual patient. The patients' mean age was 7.4 years (range: 2 months–18 years; 732 boys and 892 girls). OGD was performed in 1124 children, whereas colonoscopy was performed in 500 subjects. A total of 269 (23%) upper GI endoscopies and 64 colonoscopies (12.8%) were performed before the September 1999 publication of the Rome II criteria in Gut.[1] Table 1 details the indications or symptoms for which endoscopy was performed. A total of 607 (54%) OGDs were positive and 517 (46%) were negative (155 with normal appearance, and 362 with non-specific endoscopic findings), whereas 306 (61.1%) colonoscopies were positive and 194 (38.9%) were negative (46 with normal appearance and 152 with non-specific endosocopic findings). Diagnoses of the upper and lower GI endoscopies are reported in the Table 2.

Gender and age were not predictors of diagnostic yield OR = 1, 95% CI, 0.8–1.3, $\chi^2 = 0.2$, $P = 0.33$; OR = 1.2, 95% CI, 0.9–1.5, $\chi^2 = 0.4$, $P = 0.54$) (Table 3).

Patients with one or more alarm symptoms who underwent OGD did not have significantly better diagnostic yield than those without (53.4% vs. 56.6%, $P = 0.43$). All patients who underwent colonoscopy had at least one alarm symptom. Among alarm symptoms, deceleration of linear growth was associated with increased diagnostic yield of OGD (OR, 2.5; 95% CI, 1.7–3.7; $\chi^2 = 21.1$; $P = 0.0001$), whereas gastrointestinal blood loss, vomiting, chronic severe diarrhoea and persistent right upper or lower quadrant pain were

Table 1 | Indications or symptoms for upper and lower gastrointestinal endoscopy

	Before Rome II criteria		After Rome II criteria		All subjects*	
	n. 333		*n.* 1291		*n.* 1624	
	N	(%)	*N*	(%)	*N*	(%)
Failure to thrive	36	(10.8)	121	(9.3)	157	(9.6)
Unexplained weight loss	92	(27.6)	392	(30.3)	484	(29.8)
Dysphagia	74	(22.2)	266	(20.6)	340	(20.9)
Recurrent abdominal pain	236	(70.8)	572	(44.3)	808	(49.7)
Vomiting/Regurgitation	132	(39.6)	189	(14.6)	321	(19.7)
Bleeding from GI tract	99	(29.7)	436	(33.7)	535	(32.9)
Chronic diarrhoea	88	(26.4)	323	(25.1)	411	(25.3)
Anaemia	32	(9.6)	152	(11.7)	184	(11.3)
Suspected oesophageal varices	19	(5.7)	78	(6.0)	97	(5.8)
Coeliac disease	30	(9)	376	(29.1)	406	(25)

* More than one indication or symptom was reported in some subjects.

significantly associated with a negative diagnostic yield of OGD (OR, 0.2; 95% CI, 0.1–0.3; $\chi^2 = 45$, $P = 0.0001$; OR, 0.5; 95% CI, 0.4–0.7; $\chi^2 = 26$, $P = 0.0001$; OR, 0.3; 95% CI, 0.2–0.5; $\chi^2 = 33$, $P = 0.001$; OR, 0.7; 95% CI, 0.6–0.9; $\chi^2 = 6.6$, $P = 0.01$, respectively) (Table 4). As regards colonoscopy weight loss, deceleration of linear growth, gastrointestinal blood loss, chronic severe diarrhoea and persistent right upper or lower quadrant pain resulted significantly associated with increased diagnostic yield (OR, 8.4; 95% CI, 5.1–14; $\chi^2 = 82$, $P = 0.0001$; OR, 2; 95% CI, 1.1–3.5; $\chi^2 = 6.7$, $P = 0.01$; OR, 2.5; 95% CI, 1.5–4; $\chi^2 = 16$, $P = 0.0001$; OR, 4.6; 95% CI, 3–7; $\chi^2 = 63$, $P = 0.001$; OR, 5.5; 95% CI, 3.6–8.6; $\chi^2 = 64$, $P = 0.01$ respectively).

Laboratory parameters including haematocrit, albumin, ESR, CRP and faecal calprotectin were not predictive of diagnostic yield of OGD ($\chi^2 = 0.09$, $P = 0.4$; $\chi^2 = 0.04$, $P = 0.5$; $\chi^2 = 0.003$, $P = 0.5$; $\chi^2 = 0.2$, $P = 0.3$; $\chi^2 = 0.3$, $P = 0.3$). However, we found a predictive value of the diagnostic yield of colonoscopy for haematocrit, CRP and of faecal calprotectin ($\chi^2 = 34$, $P = 0.02$; $\chi^2 = 65$, $P = 0.001$; $\chi^2 = 56$, $P = 0.007$).

Of the 1624 procedures, 26% were considered inappropriate according to the Rome II paediatric criteria. Kappa coefficient between the two investigators resulted 0.91 (95% CI: 0.88–0.93; agreement: 0.97; SE: 0.01).

A total of 420 children satisfied the Rome II criteria for the various FGIDs (Table S2). The number of inappropriate procedures as a percentage of the total number of procedures performed decreased significantly (from 38% to 14%) after publication of the Rome II paediatric criteria (OR, 3.7; 95% CI, 1.8–7.5; $P < 0.001$). The probability of finding a clinically relevant lesion was significantly higher in appropriate endoscopies compared with those that were inappropriate according to the Rome II paediatric criteria. Of 1202 appropriate upper or lower GI endoscopies (801 OGD; 500 colonoscopies), 502 OGD (62.7%) were significantly contributive, compared with only 105 (32.5%) of the 323 inappropriate procedures (OR, 3.5; 95% CI, 2.6–4.6; $P < 0.001$), whereas 265 (65.8%) colonoscopies were significantly contributive, compared with only 41 (42.3%) of the 97 inappropriate procedures (OR, 2.6; 95% CI, 1.6–4.1; $P < 0.001$).

After the publication of the Rome II paediatric criteria, the proportion of upper GI endoscopy performed for coeliac disease was significantly higher than that before the publication of the criteria (42.9% vs. 21.4%; $\chi^2 = 123$; $P = 0.00001$); no significant difference was observed in the proportion of the procedures performed for peptic ulcer disease (21.7% vs. 20.6%; $\chi^2 = 0.18$; $P = 0.6$); whereas a significant decrease in the proportion of negative upper GI endoscopy was found (56.8% vs. 36.4%;$\chi^2 = 44.9$; $P = 0.00001$). A significant increase in the proportion of lower GI endoscopy for inflammatory bowel disease (IBD) was observed when performed under the Rome II paediatric criteria (22.9% vs. 63.9%; $\chi^2 = 38$; $P = 0.00001$). Because of the difference in distribution, we also found a significant decrease in the

Table 2 | Diagnoses and appropriateness according to the Rome II criteria of upper and lower gastrointestinal endoscopy

Oesophago-gastro-duodenoscopy			
	Subjects	Appropriate	Inappropriate
	n. 607 (%)	*n.* 504 (83)	*n.* 103 (17)
Coeliac disease	325 (53.5)	301 (92.6)	24 (7.4)
Reflux oesophagitis	157 (25.9)	109 (69.4)	48 (31.6)
Helicobacter pylori infection	83 (13.7)	61 (73.5)	22 (26.5)
Eosinophilic oesophagitis	25 (4.1)	18 (72)	7 (28)
Focal gastritis or duodenal inflammation	12 (2)	9 (75)	3 (25)
Crohn's disease	5 (0.8)	4 (80)	1 (20)
Colonoscopy			
	Subjects	Appropriate	Inappropriate
	n. 306 (%)	*n.* 265 (86.6)	*n.* 41 (13.4)
Inflammatory bowel disease	133 (43.4)	122 (91.7)	11 (8.3)
Ulcerative colitis	71 (53.4)		
Crohn's disease	53 (39.8)		
Indeterminate colitis	9 (6.8)		
Polyps	40 (13)	34 (85)	6 (15)
Allergic colitis	30 (9.8)	25 (83.3)	5 (16.7)
Infectious	6 (2)	6 (100)	0 (0)
Lymphonodular hyperplasia	39 (13)	32 (82.1)	7 (17.9)
Eosinophilic colitis	18 (5.8)	15 (83.3)	3 (16.7)
Focal colitis	40 (13)	31 (77.5)	9 (22.5)

Table 3 | Clinical characteristics of children undergone upper and lower GI endoscopy

	Appropriate	Inappropriate
Oesophago-gastro-duodenoscopy		
Subjects	801	323
Mean age (years, range)	6.7 (0 to18)	7.5 (0 to18)
Gender		
Male	318	120
Female	483	203
Positive	501	106
Negative	299	218
Colonoscopy		
Subjects	403	97
Mean age (years, range)	10.3 (2 to18)	10.2 (2 to 18)
Gender		
Male	206	50
Female	197	47
Positive	265	41
Negative	138	56

proportion of lower endoscopy performed for GI polyps (18.5 vs. 7.3%; $\chi^2 = 7.68$; $P = 0.051$), as well as a significant decrease in the proportion of negative colonoscopies (58.5% vs. 28.7%; $\chi^2 = 20$; $P = 0.00006$).

To determine which alarm symptoms were significant predictors of diagnostic yield exploratory multivariate conditional logistic regression was conducted in SPSS. Data were screened for predictors as involuntary weight loss, deceleration of linear growth, gastrointestinal blood loss, vomiting, chronic severe diarrhoea, persistent right upper or right lower quadrant pain. Deceleration of the linear growth was independently correlated with an increased diagnostic yield of OGD, while vomiting, gastrointestinal blood loss (haematemesis, haematochezia, occult lower GI bleeding) and persistent right upper or right lower quadrant pain predicted a negative diagnostic yield of OGD. As regards colonoscopy, involuntary weight loss, chronic diarrhoea, persistent right upper or right lower quadrant pain and gastrointestinal blood loss (haematochezia, occult lower GI bleeding) remained independently associated with an increased diagnostic yield (Table 5).

DISCUSSION

Gastrointestinal endoscopy is an essential tool for the evaluation of gastrointestinal disorders in children. Upper and lower endoscopic procedures may be useful if the physician suspects organic pathology, such as inflammatory bowel disease, allergic/eosinophilic gastrointestinal disease or peptic ulcer disease. These disorders may also present with additional alarm symptoms or signs such as involuntary weight loss, growth failure, gastrointestinal bleeding, chronic diarrhoea, unexplained fever, vomiting, or family history of inflammatory bowel disease.[9] A recent systematic review demonstrated that the diagnostic yield of OGD in children with unexplained

Table 4 | Diagnostic yield of upper and lower gastrointestinal endoscopy for alarm symptoms*[8]

	Upper GI endoscopy			Colonoscopy		
	Positive (%)	Negative (%)	*P*	Positive (%)	Negative (%)	*P*
Subjects						
Any alarm symptom						
Present	491 (80.9)	428 (83)	0.43	222 (72.7)	385 (26.3)	NA
Absent	116 (19.1)	89 (17)				
Weight loss						
Present	164 (27)	143 (27.6)	0.73	153 (50)	21 (10.8)	0.0001
Absent	443 (73)	374 (72.4)		153 (50)	173 (89.2)	
Deceleration of linear growth						
Present	96 (15.8)	36 (7)	0.0001	52 (17)	19 (10)	0.01
Absent	511 (84.2)	481 (93)		254 (83)	175 (90)	
Gastrointestinal blood loss						
Present	29 (4.8)	89 (17.2)	0.0001	267 (87.5)	150 (77.7)	0.0001
Absent	578 (95.2)	428 (82.8)		39 (12.5)	44 (22.3)	
Significant vomiting						
Present	164 (27)	214 (41.4)	0.0001			
Absent	443 (73)	303 (58.6)				
Chronic severe diarrhoea						
Present	38 (6.3)	89 (17.2)	0.0001	216 (70.8)	68 (22.2)	0.001
Absent	569 (93.7)	428 (82.8)		90 (29.2)	238 (77.8)	
Persistent right upper or right lower quadrant pain						
Present	308 (50.8)	302 (58.6)	0.01	267 (87.5)	107 (55.5)	0.0001
Absent	299 (49.2)	215 (41.4)		39 (12.5)	87 (44.5)	

* More than one finding was reported in some subjects.

abdominal pain is low; however existing studies are insufficient. The effect of OGD on change in treatment, quality of life, improvement of abdominal pain and cost-effectiveness is unknown. The predictors of significant findings are unclear.[11]

A retrospective study suggested that colonoscopy is the investigative method of choice in children with prolonged rectal bleeding. In patients presenting with accompanying complaints such as abdominal pain or diarrhoea, it is advisable to perform ileocolonoscopy combined with OGD. This combines a high diagnostic yield with a safe procedure.[16]

Standardized symptom-based criteria were introduced in 1999 with the publication of the Rome II criteria for FGIDs in children.[1] Since their publication, the Rome II criteria have been used to assess the prevalence of FGIDs in community settings[17, 18] and have served as selection criteria in laboratory studies of paediatric FGIDs.[19] Several empirical studies have used the Rome II criteria to estimate the rates of various FGIDs among children with primary symptoms of abdominal pain.[20–22]

To our knowledge, this is the first study examining the appropriate use of upper and lower gastrointestinal endoscopy in children using the Rome II paediatric criteria.[1] A retrospective design was used as one of our objectives was to compare the periods before and after publication of the Rome II paediatric criteria and this is why we did not apply the Rome III criteria published in 2006.[2] A potential source of error inherent in the retrospective design of this study could be that some of the patients included may have had symptoms that were not recorded in the medical charts.

Table 5 | Potential predictors associated with diagnostic yield of OGD and colonoscopy in a multivariate analysis

	Regression coefficient	Odds ratio	95% CI
OGD			
Deceleration of linear growth	0.17	1.24	1.16–1.32
Gastrointestinal blood loss	−0.15	0.85	0.78–0.93
Significant vomiting	−0.07	0.93	0.89–0.96
Persistent right upper or right lower quadrant pain	−0.09	0.9	0.82–0.95
Colonoscopy			
Involuntary weight loss	0.27	1.21	1.13–1.3
Gastrointestinal blood loss	0.16	1.2	1.11–1.3
Chronic severe diarrhoea	0.22	1.19	1.13–1.27
Persistent right upper or right lower quadrant pain and	0.2	1.28	1.2–1.37

In this study, the overall yield was 54% for OGD and 61.1% for colonoscopy, similar to what others have found in paediatric and adult series, with coeliac disease (53.3%), reflux oesophagitis (25.9%), *H. pylori* infection (13.7%) and inflammatory bowel disease (43.4%) being the most frequent findings.[23–25]

After the Rome II paediatric criteria were instituted, the proportion of OGDs performed for coeliac disease significantly increased and the presentation has changed. According to the previous studies, an increasingly large proportion of children are presenting with nongastrointestinal symptoms, with almost one in four children being diagnosed by targeted screening.[26]

According to a previous paediatric study, IBD was the most common cause in children referred for colonoscopy both before and after the institution of Rome II paediatric criteria.[16] This finding confirms the rise in incidence of IBD in childhood.[27]

The probability of the endoscopic detection of a clinically relevant finding was higher in those examinations judged as appropriate compared with those deemed inappropriate, according to the Rome II paediatric criteria. However, the low specificity of the Rome II criteria could be indicated by the presence of patients who underwent an appropriate procedure that resulted in a negative finding, as well as by the presence of those patients who underwent an inappropriate endoscopic procedure that resulted in a positive finding.[1] By comparing endoscopic procedures performed before the publication of the diagnostic criteria with those procedures performed after its publication, we found that the Rome criteria significantly reduced the proportion of negative endoscopies. Nevertheless, the value of a negative endoscopy should not be overlooked, as it can influence the subsequent management of the patients, and allows unnecessary therapies to be excluded. In a previous study, 67% of the negative endoscopies in adult patients were judged to have influenced patient management.[28]

The mean number of GI endoscopies was 166.5 per year before the publication of Rome II criteria, while it increased to 236 per year after the publication of the diagnostic criteria. This data could be explained by several factors. The higher number of procedures could be attributed to an increased visibility of our GI endoscopy centre. However, the number of inappropriate endoscopies significantly decreased, according to the hypothesis that primary care physicians may be using Rome II paediatric criteria to filter their referrals. During the study period, no systemic/procedural changes occurred that may have resulted in improved appropriateness of endoscopy over time, except from experience of paediatric gastroenterologists.

The role of alarm symptoms in predicting endoscopic findings is still controversial. Alarm symptoms are traditionally thought to be associated with organic disease.[10] A technical report by the American Academy of Pediatrics and NASPGHAN suggested that alarm symptoms should be used to screen children for endoscopy (Evidence D).[9] By contrast, Ashorn and Maki noted that endoscopic abnormalities in their patients did not correlate with the symptoms associated with chronic abdominal pain.[29] In addition, a recent study by Thakkar *et al.* found that several alarm symptoms other than vomiting were not significantly predictive of diagnostic yield.[30] In our cohort, alarm symptoms (apart from deceleration of linear growth) were predictive of decreased diagnostic yield. On the basis of these results, alarm symptoms seem to be inaccurate and should not be used for deciding who to select for OGD among paediatric patients with upper GI symptoms. However, our retrospective study has the potential for recall bias that may result in overestimation of the prevalence of 'alarm' symptoms prior to endoscopy. The situation regarding lower gastrointestinal pathology appears more promising.[10, 16] In addition, laboratory parameters including haematocrit, albumin, ESR, C-reactive protein (CRP) and faecal calprotectin were not predictive of OGD diagnostic yield, whereas a predictive value of ESR, CRP and faecal calprotectin has been observed for colonoscopy in the previous paediatric studies.[31–33]

In conclusion, this is the first paediatric, retrospective, observational study, evaluating the impact of the Rome II paediatric criteria on the appropriateness of GI endoscopy. The study finds that the use of the criteria for FGIDs makes a significant positive impact in reducing unnecessary GI endoscopic procedures, improving the diagnostic yield and the cost-effectiveness of paediatric endoscopy. However, further refinement and clarification of the Rome paediatric criteria may be needed to improve diagnostic agreement. Further steps are required to update and standardize the guidelines for gastrointestinal paediatric endoscopy and to promote educational programmes for paediatric gastroenterologists.

ACKNOWLEDGEMENT

Declaration of personal and funding interests: None.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Table S1. FGIDs: Rome II Diagnostic Criteria.

Table S2. FGIDs in the studied population according to the Rome II criteria.

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REFERENCES

1. Rasquin-Weber A, Hyman PE, Cucchiara S, *et al.* Childhood functional gastrointestinal disorders. *Gut* 1999; **45**(Suppl 2): II60–8.
2. Hyman PE, Milla PJ, Benninga MA, Davidson JP, Fleisher DF, Taminiau J. Childhood functional gastrointestinal disorders: neonate/toddler. *Gastroenterology* 2006; **130**: 1519–26.
3. Rasquin A, Di Lorenzo C, Forbes D, *et al.* Childhood Functional Gastrointestinal Disorders: Child/Adolescent. *Gastroenterology* 2006; **130**: 1527–37.
4. Hassan C, Bersani G, Buri L, *et al.* Appropriateness of upper-GI endoscopy: an Italian survey on behalf of the Italian Society of Digestive Endoscopy. *Gastrointest Endosc* 2007; **65**: 767–74.
5. Burnand B, Harris JK, Wietlisbach V, *et al.* Use, appropriateness, and diagnostic yield of screening colonoscopy: an international observational study (EPAGE). *Gastrointest Endosc* 2006; **63**: 1018–26.
6. American Society for Gastrointestinal Endoscopy. Appropriate use of gastrointestinal endoscopy. *Gastrointest Endosc* 2000; **52**: 831–7.
7. Axon AT, Bell GD, Jones RH, *et al.* Guidelines on appropriate indications for upper gastrointestinal endoscopy Working Party of the Joint Committee of the Royal College of Physicians of London, Royal College of Surgeons of England, Royal College of Anaestesists, Association of Surgeons, the British Society of Gatsroenterology, and the Thoracic Society of Great Britain. *BMJ* 1995; **310**: 853–6.
8. Squires RH Jr, Colletti RB. Indications for pediatric gastrointestinal endoscopy: a medical position statement of the North American Society for Pediatric Gastroenterology and Nutrition. *J Pediatr Gastroenterol Nutr* 1996; **23**: 107–10.
9. Di Lorenzo C, Colletti RB, Lehmann HP, *et al.* Chronic abdominal pain in children: a technical report of the American Academy of pediatrics and the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. *J Pediatr Gastroenterol Nutr* 2005; **40**: 245–61.
10. Hammer J, Eslick GD, Howell SC, *et al.* Diagnostic yield of alarm features in irritable bowel syndrome and functional dyspepsia. *Gut* 2004; **53**: 666–72.
11. Thakkar K, Gilger MA, Shulman RJ, *et al.* EGD in children with abdominal pain: a systematic review. *Am J Gastroenterol* 2007; **102**: 654–61.
12. American Society for Gastrointestinal Endoscopy and North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. Modifications in endoscopic practice for pediatric patients. *Gastrointest Endosc* 2008; **67**: 1–9.
13. Bhutta ZA, Ghishan F, Lindley K, *et al.* Persistent and chronic diarrhea and malbsorption: Working Group report of the second World Congress of Pediatric Gastroenterology, Hepatology, and Nutrtition. *J Pediatr Gastroenterol Nutr* 2004; **39**: S711–6.
14. Hassall E. Macroscopic versus microscopic diagnosis of reflux esophagitis: erosions or eosinophils? *J Pediatr Gastroenterol Nutr* 1996; **22**: 321–5.
15. Rudolph CD, Mazur LJ, Liptak GS, *et al.* North American Society for Pediatric Gastroenterology and Nutrition. Guidelines for evaluation and treatment of gastroesophageal reflux in infants and children: recommendations of the North American Society for Pediatric Gastroenterology and Nutrition. *J Pediatr Gastroenterol Nutr* 2001; **32**: S1–31.
16. de Ridder L, van Lingen AV, Taminiau JA, Benninga MA. Rectal bleeding in children: endoscopic evaluation revisited. *Eur J Gastroenterol Hepatol* 2007; **19**: 317–20.
17. Miele E, Simeone D, Marino A, *et al.* Functional gastrointestinal disorders in children: an Italian prospective study. *Pediatrics* 2004; **114**: 73–8.
18. Uc A, Hyman PE, Walker LS. Functional gastrointestinal disorders in African American children in primary care. *J Pediatr Gastroenterol Nutr* 2006; **42**: 270–4.
19. Faure C, Wieckowska A. Somatic referral of visceral sensations and rectal senosy threshold for pain in children with functional gastrointestinal disorders. *J Pediatr* 2007; **150**: 66–71.
20. Walker LS, Lipani TA, Greene JW, *et al.* Recurrent abdominal pain : symptom subtypes based on the Rome II criteria for pediatric functional gastrointestinal disorders. *J Pediatr Gastroenterol Nutr* 2004; **38**: 187–91.
21. Caplan A, Walker LS, Rasquin A. Validation of the pediatric Rome II criteria for functional gastrointestinal disorders using the questionnaire on pediatric gastrointestinal symptoms. *J Pediatr Gastroenterol Nutr* 2005; **41**: 3105–16.
22. Shurman JV, Friesen CA, Danda CE, *et al.* Diagnosing functional abdominal pain with the Rome II criteria : parent, child, and clinician agreement. *J Pediatr Gastroenterol Nutr* 2005; **41**: 291–5.
23. Jantchou P, Schirrer J, Bocquet A. Appropriateness of upper gastrointestinal endoscopy in children: a retrospective

study. *J Pediatr Gastroenterol Nutr* 2007; **44**: 440–5.
24. Rossi A, Bersani G, Ricci G, *et al.* ASGE guidelines for the appropriate use of upper endoscopy: association with endoscopic findings. *Gastrointestinal Endosc* 2002; **56**: 714–9.
25. Manes G, Balzano A, Marone P, Lionello M, Mosca S. Appropriateness and diagnostic yield of upper gastrointestinal endoscopy in an open-access endoscopy system: a prospective observational study based on the Maastricht guidelines. *Aliment Pharmacol Ther* 2002; **16**: 105–10.
26. Ravikumara M, Tuthill DP, Jenkins HR. The changing clinical presentation of coeliac disease. *Arch Dis Child* 2006; **91**: 969–71.
27. Castro M, Papadatou B, Baldassarre M, *et al.* Inflammatory Bowel disease in children and adolescents in Italy: data from the pediatric national IBD register (1996-2003). *Inflamm Bowel Dis* 2008; **14**: 1246–52.
28. Naji SA, Brunt PW, Hagen S, *et al.* Improving the selection of patients for upper gastrointestinal endoscopy. *Gut* 1993; **34**: 187–91.
29. Ashorn M, Maki M. Upper gastrointestinal endoscopy in recurrentabdominal pain of childhood. *J Pediatr Gastroenterol Nutr* 1993; **16**: 273–7.
30. Thakkar K, Chen L, Tatevian N, *et al.* Diagnostic yield of oesophagogastroduodenoscopy in children with abdominal pain. *Aliment Pharmacol Ther* 2009; **30**: 662–9.
31. Boyle JT. Recurrent abdominal pain: an update. *Pediatr Rev* 1997; **18**: 310–20.
32. Khan K, Schwarzenberg SJ, Sharp H, Greenwood D, Weisdorf-Schindele S. Role of serology and routine laboratory tests in childhood inflammatory bowel disease. *Inflamm Bowel Dis* 2002; **8**: 325–9.
33. Berni Canani R, Rapacciuolo L, Romano MT, Tanturri de Horatio L, *et al.* Diagnostic value of faecal calprotectin in paediatric gastroenterology clinical practice. *Dig Liver Dis* 2004; **36**: 467–70.