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Original Article

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Systemic Classification for a New Diagnostic Approach to Acute Abdominal Pain in Children

Ji Hoi Kim, Hyun Sik Kang, Kyung Hee Han, Seung Hyo Kim, Kyung-Sue Shin, Mu Suk Lee*, In Ho Jeong†, Young Sil Kim‡ and Ki-Soo Kang

*Departments of Pediatrics, *Radiology, †Surgery, and ‡Pathology, Jeju National University School of Medicine, Jeju, Korea*

Purpose: With previous methods based on only age and location, there are many difficulties in identifying the etiology of acute abdominal pain in children. We sought to develop a new systematic classification of acute abdominal pain and to give some helps to physicians encountering difficulties in diagnoses.
Methods: From March 2005 to May 2010, clinical data were collected retrospectively from 442 children hospitalized due to acute abdominal pain with no apparent underlying disease. According to the final diagnoses, diseases that caused acute abdominal pain were classified into nine groups.
Results: The nine groups were group I "catastrophic surgical abdomen" (7 patients, 1.6%), group II "acute appendicitis and mesenteric lymphadenitis" (56 patients, 12.7%), group III "intestinal obstruction" (57 patients, 12.9%), group IV "viral and bacterial acute gastroenteritis" (90 patients, 20.4%), group V "peptic ulcer and gastroduodenitis" (66 patients, 14.9%), group VI "hepatobiliary and pancreatic disease" (14 patients, 3.2%), group VII "febrile viral illness and extraintestinal infection" (69 patients, 15.6%), group VIII "functional gastrointestinal disorder (acute manifestation)" (20 patients, 4.5%), and group IX "unclassified acute abdominal pain" (63 patients, 14.3%). Four patients were enrolled in two disease groups each.
Conclusion: Patients were distributed unevenly across the nine groups of acute abdominal pain. In particular, the "unclassified abdominal pain" only group was not uncommon. Considering a systemic classification for acute abdominal pain may be helpful in the diagnostic approach in children.

Key Words: Acute abdominal pain, Child, Classification

INTRODUCTION

According to Scholer et al.'s study [1], the incidence of acute abdominal pain in children visiting pediatric and emergency departments was 5%. Many patients improve without serious problems. However,

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Corresponding author: Ki-Soo Kang, Department of Pediatrics, Jeju National University School of Medicine, 15 Aran 13-gil, Jeju 690-767, Korea. Tel: +82-64-754-8146, Fax: +82-64-717-1131, E-mail: kskang@jejunu.ac.kr

because surgical abdomen or serious medical diseases can also develop occasionally, physicians need to pay careful attention to such patients.

Acute abdominal pain in children often causes physician embarrassment clinically. Because many children are not helpful in expressing their symptoms accurately, the diagnostic approach and treatment are more difficult than with adults. The conventional approach to acute abdominal pain of children is to start with accurate history taking and a physical examination [2-4]. The next step is the differential diagnosis of the many variable etiologies, based on age, location, accompanying symptoms, and 'red flag signs' or 'danger signs' [5-7]. These conventional approaches are the most effective and confirmed method to diagnose etiologies of acute abdominal pain in children.

Nevertheless, primary physicians and trainees in pediatrics often meet patients who are difficult to diagnose and cannot explain well to their parents the etiology of their acute abdominal pain. This conventional method is insufficient to deal with patients who potentially have a wide spectrum of etiologies. It is necessary to approach to acute abdominal pain with a systemic concept and see each disease of acute abdominal pain as not only 'a tree' but also 'a forest'.

Boyle [8] suggested a diagnostic approach, including six steps to acute abdominal pain in children. The six steps started with a question "Is there evidence of a catastrophic event requiring emergency surgery?", followed by the second question "Does a viral syndrome (upper respiratory infection or gastroenteritis) make sense?", the third "Should a work-up of intestinal obstruction be pursued?", the fourth "Should appendicitis be considered?", the fifth "Does the pain presentation suggest a hepatobiliary disorder or pancreatitis?", and the last "Is the pain a manifestation of a functional bowel disorder?". The diagnostic approach of acute abdominal pain in children suggested by Boyle is based on similarities of clinical symptoms and progression in the initial period, to overcome shortcomings of the conventional approach.

We tried a systemic classification of acute abdominal pain, using a method modified from Boyle's suggestion [8]. We modified 'the six step approach' of Boyle to an approach by a new systemic classification, including nine groups. To give some help to physicians encountering difficulties in diagnoses, we sought to develop a new systematic classification of the etiologies of acute abdominal pain in children.

MATERIALS AND METHODS

Patients

Between March 2005 and May 2010, clinical data were collected retrospectively from 498 children admitted to Jeju National University Hospital with acute abdominal pain as a major symptom. The clinical data included age, gender, duration of abdominal pain prior to admission, location of pain, continuity of the pain, other symptoms accompanying the pain, laboratory results, radiological and endoscopic findings, and the final diagnosis.

Acute abdominal pain was defined as paroxysmal pain in the abdomen that occurred within 7 days before visiting the hospital. Patients who had a known underlying disease or abdominal trauma were excluded. Finally, 442 patients were enrolled. The age of the patients was 7.61±4.12 years (mean±2standard deviation; range, 14 days to 16 years). The gender distribution was 253 males and 189 females.

Methods

Based on final diagnoses of the patients, the acute abdominal pain etiologies were classified systemically into nine groups (Table 1). Nine groups were defined in accordance with a method modified from Boyle's suggestion [8] for a diagnostic approach to acute abdominal pain, which is based on similarities of clinical symptoms and progression in the initial period of acute abdominal pain.

Group I, "catastrophic surgical abdomen," included diseases that can progress to septic shock or death without immediate surgery. Group II is "acute appendicitis and mesenteric lymphadenitis." The two diseases have similar clinical manifestations, but should be differentiated from each other. Group

Table 1. Demographic Characteristics according to the Systemic Classification of Acute Abdominal Pain in 442 Children

Group	The systematic classification	Age (y)	Sex (male/female)
I	Catastrophic surgical abdomen	2.72±2.56	2/5
II	Acute appendicitis and mesenteric lymphadenitis	8.44±3.52	37/19
III	Intestinal obstruction	2.80±3.52	39/18
IV	Viral and bacterial acute gastroenteritis	7.77±4.02	50/40
V	Peptic ulcer and gastroduodenitis	8.78±3.33	35/31
VI	Hepatobiliary and pancreatic disease	12.00±2.85	10/4
VII	Febrile viral illness and extraintestinal infection	8.08±3.00	35/34
VIII	Functional gastrointestinal disorder	9.40±3.52	7/13
IX	Unclassified acute abdominal pain	8.36±3.85	38/25
	Total	7.62±4.11	253/189

Values are presented as mean±standard deviation or number only.

III, "intestinal obstruction," includes diseases that involve or can cause partial or complete obstruction of the intestine. Group IV is "viral and bacterial acute gastroenteritis (AGE)." The two diseases share similar symptoms and need to be distinguished from each other. Group V, "peptic ulcer and gastroduodenitis," include diseases characterized by peptic ulcer-like symptoms. Group VI is "hepatobiliary and pancreatic disease." Group VII, "febrile viral illness and extraintestinal infection," cover diseases that originate from febrile illness due to a viral infection and organs other than the gastrointestinal tract, respectively. Group VIII is "functional gastrointestinal disorder (FGID) (acute manifestation)," characterized by acute manifestations of chronic recurrent abdominal pain with no evidence of organic causes. Group IX is "unclassified acute abdominal pain," which involves abdominal pain alone and cannot be included in any other group. The patients in group IX had only an episode of acute abdominal pain and not followed by additional episodes of abdominal pain.

This study was reviewed and approved by the institutional review board of the Jeju National University Hospital (IRB No. JNUH 2013-09-003). Data were analyzed using the PASW Statistics ver. 18.0 (IBM Co., Armonk, NY, USA). Parameters such as demographic data and laboratory findings were analyzed using the Kruskal-Wallis test. p-values <0.05 were considered to indicate statistical significance. We also made post hoc comparisons using the Mann-Whitney U-test and Bonferroni correction (significance at $p<0.0018$) to evaluate differences between the groups.

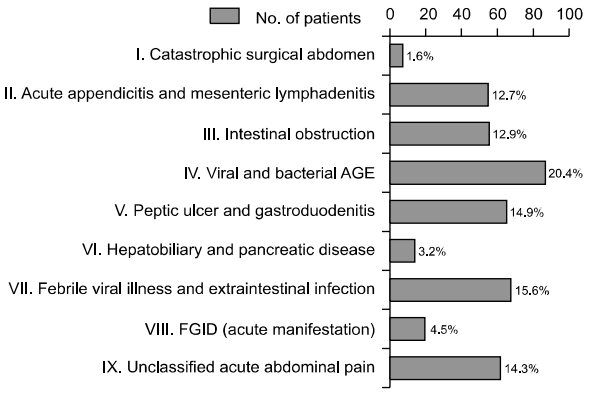

Fig. 1. The incidence of each acute abdominal pain group was variable among the 442 enrolled patients. Group IV, "viral and bacterial acute gastroenteritis (AGE)," was the most common, followed by groups V, IX, VII, II, III, VIII, X, VI, and group I. Group IX, "unclassified acute abdominal pain," showed a relatively high incidence of 14.3%. Group I, "catastrophic surgical abdomen," was rare, with an incidence of 1.7%. FGID: functional gastrointestinal disorder.

RESULTS

The distributions of patient age and gender for each of the nine groups are shown in Table 1. The numbers of the 442 patients in each group were as follows (Fig. 1). Group I (catastrophic surgical abdomen) had 7 (1.6%) patients, group II (acute appendicitis and mesenteric lymphadenitis) 56 (12.7%), group III (intestinal obstruction) 57 (12.9%), group

IV (viral and bacterial AGE) 90 (20.4%), group V (peptic ulcer and gastroduodenitis) 66 (14.9%), group VI (hepatobiliary and pancreatic disease) 14 (3.2%), group VII (febrile viral illness and extra-intestinal infection) 69 (15.6%), group VIII (FGID) (acute manifestation) 20 (4.5%), and group IX (unclassified abdominal pain) 63 (14.3%). Four patients were enrolled in two disease groups each.

The disease distribution in each group is described in Table 2. Group I, "catastrophic surgical abdomen," included panperitonitis caused by perforated appendicitis or bowel perforation, resulting from multiple magnet ingestion and adhesion, and intussusceptions with failure of non-surgical reduction. Group II, "acute appendicitis and mesenteric lymphadenitis," involved 34 patients with mesenteric lymphadenitis

Table 2. Distributions of Diseases Which Are Included in Each 9 Groups according to the Systemic Classification of Acute Abdominal Pain in 442 Children

Group	The systematic classification	Disease	No.
I	Catastrophic surgical abdomen	Intussusception with reduction failure	3
		Panperitonitis by perforated appendicitis	1
		Abdominal abscess by perforated appendicitis	1
		Bowel perforation by multiple magnets	1
		Splenic infarction	1
II	Acute appendicitis and mesenteric lymphadenitis	Mesenteric lymphadenitis	34
		Acute appendicitis	22
III	Intestinal obstruction	Intussusception	40
		Other obstruction	8
		Abdominal distension	4
		Hirschsprung's disease	3
		Inguinal hernia	2
IV	Viral and bacterial acute gastroenteritis	Viral acute gastroenteritis	46
		Bacterial acute gastroenteritis	42
		Food poisoning	2
V	Peptic ulcer and gastroduodenitis	Henoch-Schonlein purpura	28
		Acute gastritis	15
		Peptic ulcer	8
		Helicobacter pylori gastritis	8
		Hemorrhagic gastritis	7
VI	Hepatobiliary and pancreatic disease	Acute pancreatitis	7
		Acute hepatitis A	6
		Unknown hepatitis	1
VII	Febrile viral illness and extraintestinal infection	Fibrile illness	38
		Urinary tract infection	13
		Mycoplasma pneumoniae infection	8
		Aseptic meningitis	3
		Acute sinusitis	1
		Ovarian cystic torsion	1
		Unspecified type of menstrual disorder	1
		Ureter stone	1
		Venous sinus thrombosis	1
		Retroperitoneal cystic lymphangioma	1
		Hemophagocytic lymphohistocytosis	1
VIII	Functional gastrointestinal disorder (acute manifestation)	Functional abdominal pain	18
		Constipation	2
IX	Unclassified acute abdominal pain	Abdominal pain alone, only one episode	63
	Total		442

Four patients were each enrolled in two disease groups simultaneously. Three patients had complicated acute pancreatitis in the context of bacterial gastroenteritis. One patient with Henoch-Schönlein purpura had been accompanied by intussusception.

and 22 patients with acute appendicitis. Group III, "intestinal obstruction," concerned 40 patients with intussusception, 3 patients with Hirschsprung's disease, 8 patients with other obstructions, 4 patients with abdominal distension, and 2 patients with an inguinal hernia. Group IV, "viral and bacterial AGE," consisted of 46 patients with viral gastroenteritis , 42 patients with bacterial gastroenteritis, and 2 patients with food poisoning. Group V, "peptic ulcer and gastroduodenitis," included 28 patients with Henoch-Schönlein purpura, 15 patients with acute gastritis, 8 patients with peptic ulcers, 8 patients with *Helicobacter pylori* gastritis, and 7 patients with hemorrhagic gastritis. Group VI, "hepatobiliary and pancreatic disease," consisted of 7 patients with acute pancreatitis, 6 patients with acute hepatitis A, and 1 patient with unknown hepatitis. Group VII, "febrile viral illness and extraintestinal infection," included 38 patients with febrile illness caused by a viral infection, 13 patients with urinary tract infection, 8 patients with *Mycoplasma pneumoniae* infection, 3 patients with aseptic meningitis, and 1 patient each with seven other diseases. Group VIII, "FGID (acute manifestation)" included 18 patients with functional abdominal pain and 2 patients with constipation. Group IX, "unclassified acute abdominal pain," consisted of 63 patients.

Patient demographic and laboratory parameters are shown in Table 3. The demographic parameters examined were age, gender, pain duration prior to admission, and body temperature. Laboratory parameters included white blood cells, erythrocyte sedimentation rate (ESR), and C-reactive protein. All parameters, except gender and ESR, differed significantly among the groups from group II to group IX ($p<0.001$). The mean age of group III, "intestinal obstruction," was significantly different and the lowest of all the groups. Mean duration of abdominal

Table 3. The Comparisions of Demographic and Laboratory Parameters among 9 Groups of Acute Abdominal Pain

Group	The systematic classification	Age (y)	Sex (male/female)	Duration (d)	Body temperature (°C)	WBC ($\times10^3/\mu$L)	ESR (mm/h)	CRP (mg/dL)
I	Catastrophic surgical abdomen	2.72	5/2	2.14	37.82	18.07	52.50	8.99
II	Acute appendicitis and mesenteric lymphadenitis	8.44±3.52	37/19	1.61±1.61	37.72±1.12§	12.19±6.50	18.65±21.27	3.16±6.18††
III	Intestinal obstruction	2.72±3.48*	39/18	1.58±1.81	36.95±0.59	11.90±3.60**	19.44±21.46	1.76±4.23§§
IV	Viral and bacterial acute gastroenteritis	7.77±4.02	50/40	2.07±1.66	38.00±1.10‖	10.81±5.21	16.37±13.39	3.84±4.90‖‖
V	Peptic ulcer and gastroduodenitis	8.78±3.33	35/31	3.13±2.32†	36.79±0.57	9.96±3.69	15.39±14.90	0.71±1.27¶¶
VI	Hepatobiliary and pancreatic disease	12.00†	10/4	3.15	37.49	7.05	11.75	3.48
VII	Febrile viral illness and extraintestinal infection	8.08±3.00	35/34	1.91±1.57	38.48±1.08¶	10.74±4.85	24.57±25.38	4.08±6.17****
VIII	Functional gastrointestinal disorder (acute manifestation)	9.40±3.52	7/12	2.39±2.52	36.82±0.49	7.33±2.13††	12.50±11.78	0.38±0.70
IX	Unclassified acute abdominal pain	8.36±3.85	38/25	2.49±2.24	36.70±0.38	9.36±3.83	12.17±10.21	0.52±0.90
	p-value	0.000	0.105	0.000	0.000	0.000	0.462	0.000

Values are presented as number only or mean±standard deviation.
WBC: white blood cell, ESR: erythrocyte sedimentation rate, CRP: C-reactive protein.
*,†,†,§,‖,¶,**,††,††,§§,‖‖,¶¶,****Post-hoc comparison by Mann-Whitney U-test and Bonferroni correction method ($p<0.0018$).
*Compared to group II-IX. †Compared to group II, IV, V, VII. †Compared to group II, III. §Compared to group III, V, IX. ‖Compared to group III, V, VIII, IX. ¶Compared to group II, III, V, VIII, IX. **Compared to group VI, VIII, IX. ††Compared to group III, IV. ††Compared to group VIII, IX. §§Compared to group IX. ‖‖Compared to group V, VIII, IX. ¶¶Compared to group IV, VII. ****Compared to group V, VIII, IX.
p-values by Kruskal-Wallis method, except group I.

pain until initial diagnosis in group V, "peptic ulcer and gastroduodenitis," was significantly longer than in groups II and III. Mean body temperature in group VII, "febrile viral illness and extraintestinal infection," was significantly higher than in groups II, III, V, VIII, and IX.

DISCUSSION

We developed a systemic classification of acute abdominal pain in children. This is a trial of a new systemic classification of acute abdominal pain, versus the conventional assessment, based only on the location of the pain and age. Nine groups were defined in accordance with a method modified from Boyle's suggestion [8] for a diagnostic approach to acute abdominal pain in children, which is based on similarities of clinical symptoms and progression in the initial period of acute abdominal pain. We modified 'the six step approach' of Boyle to an approach by a new systemic classification, including nine groups. The nine groups were group I, "catastrophic surgical abdomen," group II, "acute appendicitis and mesenteric lymphadenitis," group III, "intestinal obstruction," group IV, "viral and bacterial AGE," group V, "peptic ulcer and gastroduodenitis," group VI, "hepatobiliary and pancreatic disease," group VII, "febrile viral illness and extraintestinal infection," group VIII, "FGID (acute manifestation)", and group IX, "unclassified acute abdominal pain."

About 30 years ago, Roy et al. [9] first attempted an etiologic classification of 'acute abdomen' into three groups. The three groups were 'mechanical obstruction,' 'inflammatory diseases and infections,' and 'miscellaneous.' The first group, 'mechanical obstruction,' was further classified into subgroups of 'intraluminal' and 'extraluminal.' The second group, 'inflammatory disease and infections,' was divided into subgroups of 'gastrointestinal disease,' 'paralytic ileus,' and 'blunt trauma.' Reynolds and Jaffe [10] also classified the diagnoses of patients with acute abdominal pain into three groups: 'medical,' 'surgical,' and 'nonspecific.'

Roy et al. [9] and Reynolds and Jaffe's classifications [10] are too simple and classified only etiologies of acute abdominal pain. They have shortcomings in use for an effective diagnosis of acute abdominal pain. It is necessary to see acute abdominal pain as not only 'a tree' but also 'a forest.' Nine groupings in this study include most characteristics of acute abdominal pain in children. When there are some difficulties in a diagnostic approach to acute abdominal pain, considering the nine groupings may be helpful in anticipating possible diagnoses.

Group I, "catastrophic surgical abdomen," includes panperitonitis or abdominal abscesses caused by perforated appendicitis, splenic infarction, bowel perforation due to multiple magnet ingestion with adhesion, and intussusceptions with failure on non-surgical reduction. This group was small, only 7 of 442 patients (1.6%). We suggest that the now advanced medical environment in South Korea may have affected this low incidence of "catastrophic surgical abdomen" in children.

Group II, "acute appendicitis and mesenteric lymphadenitis," showed a higher incidence, with 56 of 442 patients (12.7%). The importance of the differential diagnosis between these two diseases cannot be overemphasized. There are many reports about the effective different points between the diseases [2,11-14].

Group III, "intestinal obstruction," covers intussusception, Hirschsprung's disease, other obstruction, and abdominal distension. The incidence of this group was 57 of 442 patients (12.9%). Intussusception was most common, with 40 patients in this group. 'Other obstruction' diseases include bowel obstructions caused by Meckel's diverticulum, colon cancer, postoperative adhesion, paralytic ileus, and mechanical ileus. 'Abdominal distension' included cases of transient colonic pseudoobstruction in the younger infants.

Group IV, "viral and bacterial AGE," had the highest incidence, 90 of 442 patients (20.4%). The two diseases often appear similar but should be differentiated from each other. Scholer et al. [1] reported that acute gastroenterititis had a relatively high incidence in the children with acute abdominal pain.

Group V, "peptic ulcer and gastroduodenitis," had a high incidence, 66 of 442 patients (14.9%). This group consisted of 'acute gastritis,' 'Henoch-Schönlein purpura,' 'peptic ulcer,' 'hemorrhagic gastritis,' and '*H. pylori* gastritis.' In this group, 'Henoch-Schönlein purpura' was most common, 28 of 66 patients. All cases with 'Henoch-Schönlein purpura' had peptic ulcer-like symptoms and were identified with moderate-to-severe purpuric duodenitis, caused by vasculitis in the gastroduodenoscopy. About one-fifth of 'Henoch-Schönlein purpura' cases showed acute abdominal pain before the purpura appeared on the skin of the lower extremities (data not shown). 'Henoch-Schönlein purpura' cases usually have skin lesions before the development of abdominal pain. However, about one-fifth to half of the disease may show the reverse order [15-17]. Thus, in patients with peptic ulcer-like symptoms, 'Henoch-Schönlein purpura' should be considered.

Group VI, "hepatobiliary and pancreatic disease" had a low incidence, 14 of 442 patients (3.2%). This group included acute hepatitis A and acute pancreatitis. Acute hepatitis A can cause acute abdominal pain resulted from an acute bulging of the liver. Acute abdominal pain can develop during the initial period of the disease. If patients with acute abdominal pain show jaundice and hepatitis, acute hepatitis A should be suspected.

Group VII, "febrile viral illness and extraintestinal infection," had a high incidence, 69 of 442 patients (15.6%). In this group, 'febrile illness from viral infection' was most common, 38 of 59 patients, followed by 'urinary tract infection' (13 patients) and '*M. pneumoniae* infection' (8 patients). Most of 'febrile illness from viral infection' was, in fact, acute pharyngitis caused by various viruses. There are a few other reports showing a high incidence of viral illness [1,10,18,19]. During an epidemic of *M. pneumoniae* infection, patients with acute abdominal pain will have to be differentiated from this disease. Other extraintestinal diseases included 'aseptic meningitis,' 'constipation,' food poisoning,' 'inguinal hernia,' 'venous sinus thrombosis,' 'retroperitoneal cystic lymphangioma,' 'unknown hepatitis,' 'ovarian cyst torsion,' 'unspecified-type menstrual disorder,' 'hemophagocytic lymphohistiocytosis,' 'acute sinusitis,' and 'ureter stone.' Although there are some reports with a low-to-moderate incidence of constipation [1,10,19], in this study, constipation was very rare, only 2 of 442 patients.

Group VIII, "FGID (acute manifestation)" could be seen despite a low incidence, 20 of 442 patients (4.5%). Most of these had acute manifestations of chronic recurrent abdominal pain. Repeated episodes of abdominal pain could be identified in the patients before or after acute abdominal pain. Although most patients with FGID- associated abdominal pain have mild clinical features, we could see some patients complaining of acute abdominal pain initially or in the middle of a longer-term duration condition.

Group IX, "unclassified acute abdominal pain," had a high incidence, 63 of 442 patients (14.3%). This disease had acute abdominal pain alone, with no other symptom. No evidence of organic causes could be found in this group. This group is similar to 'nonspecific abdominal pain,' which had a high incidence in children with acute abdominal pain in other reports [1,10,19,20].

Four patients were each enrolled in two disease groups simultaneously. Three patients had complicated acute pancreatitis in the context of bacterial gastroenteritis. One patient with Henoch-Schönlein purpura had accompanying intussusception.

Unfortunately, we could not analyze the risk factors for acute abdominal pain suggesting serious organic causes, because this was a retrospective study. Paying attention to the 'high risk factors' and 'danger signs' may also be an effective method in the diagnostic approach to patients with acute abdominal pain in children [7,19].

This study has several limitations. First, a problem of duplication may be present between groups I and III. However, this could not be avoided, because catastrophic problems can progress within surgical or obstructive diseases. Second, because this was a retrospective study, benefits of the systemic classification could not obviously be compared with the conven-

tional approach to acute abdominal pain. It is important to perform a prospective study about the benefits of adding a systemic classification to the conventional approach of acute abdominal pain in children. Third, of the patients in group IV, "febrile viral illness and extraintestinal infection," the viral etiologies were identified in only some patients. Viral infection was suspected if the patient had a fever, no clinical or laboratory evidence of a bacterial infection, and improved without the use of antibiotics.

The demographic and laboratory data showed many statistically significant differences between parameters among the nine groups (Table 3). However, they seem to be less important because they could not form a standard for the differential diagnosis between the groups.

In conclusion, nine groups were identified to classify the 442 children with acute abdominal pain; the incidences were variable. Group IV, "viral and bacterial AGE," was the most common. Other high-incidence groups were group V, "peptic ulcer and gastroduodenitis," group IX, "unclassified acute abdominal pain," group VII, "febrile viral illness and extraintestinal infection," group II, "acute appendicitis and mesenteric lymphadenitis," and group III, "intestinal obstruction." Low incidence groups were group VIII, "FGID (acute manifestation)", and group VI, "hepatobiliary and pancreatic disease." In contrast, group I, "catastrophic surgical abdomen," was rare. Additionally, 'Henoch- Schönlein purpura' should be included in the differential diagnosis of peptic ulcer-like symptoms and 'constipation' was a very rare etiology of acute abdominal pain in these patients. '*M. pneumonia* infection' may be suspected as a cause of acute abdominal pain during epidemics. Considering the nine groups of the systemic classification in children with acute abdominal pain, physicians may reach a diagnosis more readily. To verify the effectiveness of this systemic classification as a new diagnostic approach, a prospective study will be needed to compare the approach using this classification with the conventional approach to acute abdominal pain in children.

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