Abdominal pain among children re-evaluation of a diagnostic algorithm

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Abstract
AIM: To re-evaluate the algorithm that has been used for over 40 years for diagnosis of acute abdominal pain among children.

METHODS: Among the 937 cases admitted to the surgical emergency ward in 2000, 656 cases of acute appendicitis were studied to evaluate the usefulness of the present algorithm for its calculated accuracy, false positive and false negative rates, the sensitivity and specificity in the instant diagnosis of various types of acute appendicitis in different age groups. The algorithm used was established in 1958 and revised for this study in 1999. It includes a 3-step analysis of clinical presentations, i.e.: firstly, a diagnosis of surgical pain by definite organic abdominal signs; then a diagnosis of the subgroup of surgical condition by special signs; and finally the diagnosis of the present disease by specific signs. A footnote describes a “comparative technique” of abdominal examination in non-cooperative children.

RESULTS: The general accuracy of diagnosis was 92.8 %, overall mortality 0.1 % among 973 cases of abdominal pain in 2000. 373 attending surgeons and 241 residents including trainees joined the diagnosis and treatment with no remarkable difference in the results. The incidence of acute appendicitis, 656 in 973 cases, was 67.4 % representing the majority of abdominal pain. In the series of 656 cases, the accuracy of diagnosis of acute appendicitis was 93.6 %, false positive 6.4 %, false negative 0.9 %, sensitivity at first visit 82.7 %, specificity for appendicitis 98.0 %, no death or documentary complication.

CONCLUSION: The present algorithm used for diagnosis of acute abdominal pain is effective and preferable in reducing misdiagnosis and maltreatment at emergency. The use of some modern technology should be further explored.

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INTRODUCTION
In recent literature, the incidence of perforated appendicitis seems to be rising, and most of the late cases are due to misdiagnosis[1,2]. In China, we have not yet had the similar poor impression[3]. For many years, we’ve achieved good results in the management of acute appendicitis in pediatric surgery[4]. The best results as reported by Beijing Children’s Hospital (BCH) are: no death in 20 years in 10 000 consecutive cases of acute appendicitis[5], no death in 3 years in 100 consecutive cases of strangulated intestinal obstruction including all those cases that came in shock state[6], and over 90 % of cases of early intussusception that were reduced without emergency surgery even in county hospitals[7,8]. In 1958, a systematical analysis method, the algorithm, for diagnosis of acute abdominal pain among children was published[9], and popularized in many places of China. It has been generally followed, with timely revisions, for over 40 years. However, with the rapid progress of the modern diagnostic tools in recent years, it is necessary to have a re-evaluation of the above mentioned diagnostic algorithm for abdominal pain among children and try to find out some reasonable modern technology to make it further improved and popularized.

MATERIALS AND METHODS
This is a prospective study of the diagnostic algorithm, which was established in 1958. With the improvement of medical sciences, and changes in the incidence of common diseases in pediatric surgical emergency clinic, the algorithm has been revised many times. Generally, for over 40 years, it has been proved helpful in the diagnosis of acute abdomen of children. For this study, the algorithm was revised again in 1999 as shown in Table 1.

Table 1 Algorithm for diagnosis of abdominal pain

| Abdominal Pain | Acute abdomen (long time pain definite signs) | Non-acute abdomen (short pain no definite sign) |
|----------------|---------------------------------------------|-----------------------------------------------|
| 1 Focal inflammation | 2 Intestinal obstruction | 1 Primary enterospasm (allergic idiopathic) |
| (1) Local tenderness (appendicitis, etc.) | (1) Intestinal pattern (adhesive obstruction) | (1) Weaning colic |
| (2) Tender mass (tension ovarian cyst) | (2) movable mass (intussusception) | (2) School-boy colic |
| 3 generalized peritonitis (full and silent abdomen) | | 2 secondary enterospasm (organic, non-acute) |
| (1) spreading peritonitis (infamed organ) | (2) gangrenous peritonitis (strangulation) | (1) chronic G-I ulcer |
| (3) perforating peritonitis (peptic ulcer, typhoid) | (4) primary peritonitis (bacteremia, vaginitis) | (2) Pancreatic colic |
| (4) Chronic gastritis | (3) chronic gastritis | |
| (5) Hematothorax | (4) cerebrospinal colic | |
| (6) Metabolic disease | (5) hem-vascular disease | |
| (7)Auto-immune disorder | (6) metabolic disease | |
| (8) Intoxication | | |

*Footnote: (1) “comparative technique” of abdominal palpation, watching different reaction of the child on different part of abdomen. (2) “dynamic comparison” of clinical presentation, is today better or worse than yesterday?
It consists of a 3-step analysis of clinical presentations. The first step is to make the diagnosis of a surgical abdomen by finding definite abdominal signs indicating organic lesion, i.e. tenderness, spasm, intestinal pattern and mass. The second step is to make the diagnosis of the subgroup of surgical abdomen, namely organ inflammation, intestinal obstruction and generalized peritonitis by their special signs respectively. The third step is to make the diagnosis of the present disease, like acute appendicitis or intussusception by their specific cardinal signs. In the footnote, the “comparative technique” of abdominal examination for non-cooperative children and its “comparative dynamic evaluation” are described.

Strictly following the above algorithm, 973 cases of acute abdominal pain admitted to the surgical emergency ward of BCH in 2000 (Table 2) were reviewed. The overall rate of misdiagnosis and a general status of the diagnosis and result of treatment were studied (Table 3). In order to make a differential evaluation, 614 cases of acute appendicitis which is the representative disease occupying 68.0 % in 2000 (Table 4) were investigated in detail. The accuracy of diagnosis, the false positives, false negatives, the sensitivity and the specificity of the use of the diagnostic algorithm were calculated accordingly. Different-level doctors concerned in making diagnosis were also recorded.

**Table 2** Came with abdominal pain to emergency ward, BCH, 2000

| Category                      | n  | %   |
|-------------------------------|----|-----|
| Organ inflammation<sup>a</sup> | 637| 65.5|
| Intestinal obstruction<sup>a</sup> | 160| 16.5|
| Traumatic abdomen             | 28 | 2.9 |
| GI hemorrhage                 | 38 | 3.9 |
| Primary peritonitis           | 5  | 0.5 |
| Perforation peritonitis       | 8  | 0.8 |
| Tumor twisting or rupturing   | 14 | 1.4 |
| Torsion testes or appendage   | 8  | 0.8 |
| Other organic lesion          | 5  | 0.5 |
| Non organic pain              | 70 | 7.2 |
| Total                         | 973| 100.0 |

<sup>a</sup> Included 614 appendicitis  
<sup>b</sup> Included 57 intussusception

**Table 3** Outcome of 973 cases of acute abdominal pain admitted to surgical emergency ward in 2000

| Outcome                      | n  | %   |
|------------------------------|----|-----|
| Cure                         | 894| 91.9|
| Improved<sup>a</sup>         | 67 | 6.9 |
| Unimproved<sup>a</sup>       | 11 | 1.1 |
| Died                         | 1  | 0.1 |
| Total                        | 973| 100.0 |

<sup>a</sup> Most are chronic traumatic, inflammatory, and malignancy cases with acute pain

**Table 4** Number of operated patients of common surgical abdomen, 2000

| Disease                   | n  | %   |
|---------------------------|----|-----|
| Acute appendicitis        | 614| 68.0|
| Intussusception<sup>a</sup> | 57 | 6.3 |
| Incarcerated hernia       | 45 | 5.0 |
| Traumatic abdomen         | 28 | 3.1 |
| Adhesive obstruction      | 25 | 2.8 |
| Fecalith obstruction      | 19 | 2.1 |
| Miscellaneous             | 115| 12.7|
| Total                     | 903| 100.0 |

<sup>a</sup> The other 90% of early cases cured in OPD by rectal insufflation

**RESULTS**

Among 973 cases in 2000, the overall mortality was 0.1 %. It was a boy aged 6 yr, who died of strangulation perforation of stomach in uncontrolled Crohn’s disease. There was still no death of acute appendicitis. The general accuracy of diagnosis of acute abdomen was 94.5 %. Concerning the 656 cases of acute appendicitis in 2000, the following figures were calculated: Diagnosis at discharge (614)/Diagnosis on admission (656)=93.6 % overall accuracy; Non-surgical abdomen (42)/Appendicitis admitted (656)=6.4 % false positive at admission; Admission after 2<sup>nd</sup> visit (196)/Appendicitis admitted (656)=29.9 % false negative at the 1<sup>st</sup> visit, mostly delayed in other hospital due to transfer; Second visits in BCH surgery (6)/Appendicitis admitted (656)=0.9 % false negative BCH; Admitted by 1<sup>st</sup> visit (258)/Appendicitis in 24 h (312)=82.7 % sensitivity (It means, 82.7 % of early appendicitis within 24 h can be diagnosed at first visit); Proved appendicitis (542)/Cases operated (553)=98.0 % specificity (It means, 98.0 % of appendicitis can be differentiated from other surgical conditions); Ratio between cases diagnosed at first visit by surgeons of high level and low level=373/241 cases in moderate postoperative morbidity. Pathology of 614 cases of acute appendicitis in 2000 is shown in Table 5.

**Table 5** Pathology of 614 cases of operated appendicitis (2000)

| Pathology | Simple | Suppurative | Gangrenous | Perforative | Recurrent | Abscess | Infiltrative | Total |
|-----------|--------|-------------|------------|------------|-----------|---------|-------------|-------|
| Cases     | 166    | 254         | 7          | 103        | 38        | 42      | 4           | 614   |
| %         | 27.0   | 41.4        | 1.1        | 16.8       | 6.2       | 6.8     | 0.7         | 100.0 |

<sup>a</sup> Simple drainage only

**DISCUSSION**

**Theoretic basis of the diagnostic algorithm**

Because the basic pathology of surgical conditions must be an organic lesion inside the abdomen, the chief symptoms and signs must be persistent and definite<sup>[11]</sup>. Acute pain shorter than
6 hours is hard to rule out from the more common abdominal pain due to functional intestinal spasm unless some specific abdominal signs are found[2-11]. By the term “definite”, it means definite pain, definite location and definite area involved. Therefore, the child has to be examined many times in an appropriate period of time. In BCH, people usually do the 1st time examination at the first visit, the 2nd examination after laboratory tests, and the 3rd repeat of examination before sending the patient to the ward or back home. Full agreement of the positive findings in the 3 examinations will make the final diagnosis. If negative sign appears in any one examination, further observation and re-examination should be made. The common positive abdominal signs indicating surgical condition are local tenderness, muscular spasm, palpable intestinal pattern and mass. By a soft flat abdomen without the above mentioned signs, people can rule out acute surgical abdomen.

According to common presentations of surgical abdomen, it can be classified into 3 sub-groups: (1) Definite local tenderness and spasm usually indicate a focal inflammation. (2) A palpable distended intestinal loop or a movable solid sausage mass indicates intestinal obstruction. (3) A resistant and silent abdomen indicates generalized peritonitis. These practically cover up all common diseases seen in children. (1) In the sub-group of focal inflammation, the diagnosis depends on the location of tenderness, e.g. in RLQ of abdomen which is usually acute appendicitis; pelvic rectal tenderness with mass is usually torsion of ovarian tumor; flank tenderness is usually renal colic or perinephritic abscess; (2) In the sub-group of intestinal obstruction, a distended intestinal pattern indicates extraluminal obstruction of intestine, e.g. adhesional strangulation, or a solid mass usually indicates intraluminal obstruction, e.g. intussusception or ascarsis bozor; (3) In the sub-group of generalized peritonitis: a marked tender point indicates the focus of spreading peritonitis, e.g. perforated appendicitis; a palpable loop or mass indicates gangrenous peritonitis, e.g. strangulated intestinal obstruction. Pneumoperitoneum by percussion or X-ray indicates perforating peritonitis, e.g. jejunal fistula of ileum herniation fossa or incarcerated inguinal hernia can be felt at the middle along the inguinal ligament from inferior by the endo-rectal examination finger[15,16]. It must be kept in mind that the pathology of an acute abdomen is continuously changing. Therefore dynamic comparative observation and evaluation are essential. For making an instant diagnosis in emergency clinic, the information from mother’s impression about baby’s appetite and general activity, whether today is better or worse than yesterday, will be very helpful in making decision of emergency surgery[17].

Supplementary diagnostic techniques (Table 5)

By quick plane X-ray film of erect position, especially in suspected intestinal obstruction, preferably with low pressure barium enema, perforating peritonitis, intestinal obstruction and intussusception can be well demonstrated (Figure 1, 2)[18]. By ultrasound, acute appendicitis and abscess, intussusception, perforational fluid, and ovarian cyst or tumor, and perinephritic lesions may be demonstrated (Figure 3, 4)[19-32]. By paracentesis, the abdominal puncture fluid may tell the peritonitis, strangulation of intestine, perforation of intestine or gall bladder[33,34]. Bloody aspirate always calls for an immediate surgical exploration. In case of fine needle puncture getting into intestine under pressure, don’t hurry, keeping on aspiration until negative pressure will prevent intestinal leakage after withdrawal of needle. CT, MRI, Scintiscanning and other fantastic modern tools are used only occasionally[35-38]. But dramatic improvement of the diagnosis of acute abdomen in children must depend on further exploration for the use of high technology. e.g. laparoscopy and portable ultrasound computerized[39,40].

Table 6 Confirmatory diagnostic method used in 973 admissions, 2000

| Diagnostic method       | n  | %  |
|-------------------------|----|----|
| Physical exam           | 630| 64.7|
| Paracentesis           | 58 | 6.0 |
| Imaging                | 285| 29.3|
| Plane film             | 93 |    |
| Rectal insufflation    | 48 |    |
| Barium enema           | 8  |    |
| Barium meal           | 33 |    |
| Sonography            | 90 |    |
| Tc99 scintiscan        | 13 |    |
| Total                  | 973| 100.0|

*After admission *Reduction failed cases in O.P.D.
We conclude that the algorithm has been used and accepted for more than 40 years in thousands of patients by hundreds of surgeons of different levels. It proves helpful in handling acute abdominal pain among children. The prospective study of appendicitis in 2000, has proved its accuracy, false positive, false negative, specificity and sensitivity, all being of acceptable value. However, there are still doubtful cases needing observation, especially in cases with 6 hrs duration without definite signs, partial intestinal obstruction without toxic reactions, and late appendicitis may not need operation. Besides, in the other half of the algorithm (Table1), non-surgical abdominal pain, it includes a large number of diseases needing systemic examination and investigation. However none of them need immediate surgical operation. The most common “school-boy colic” (or primary intestinal spasm) characterized by short pain in attacks, normal appetite and activities in intervals, repeated attacks for months without impairment of nutrition or growth occupies about 60 % of school-boy abdominal pain. Keep this in mind, and it may reduce the false positive diagnosis of acute abdomen.

**PROSPECTIVE TECHNOLOGY**

(1) Since this algorithm is simple and regular, it can be put into a software of computer to up-grade it into high technology; (2) Portable ultrasonography machine to be used on emergencies examination table could take place of manual palpation of abdomen for uncooperative kids, making the examination more objective; (3) Further improvement of laparoscopy, exploratory laparotomy in acute abdominal pain may be unnecessary.

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