



# The increased intestinal tone in acute appendicitis is an example of a reaction to local inflammation. Hypothesis.

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## ABSTRACT

The purpose of the study is to determine the reaction of different parts of the digestive tract to inflammation in the appendix. It analyzes the medical history of 250 children aged 0.5 to 15 years with suspicion of acute appendicitis (AA). Patients were divided into three groups depending on the method of study. In patients with AA of the first group an increase in the tone of the caecum, ileum and sigmoid was found when using a barium enema. In patients of the second group on anal manometry, basal and reactive pressures were significantly higher in patients operated compared with non-operated children. In patients of the third group, the size of the stomach and its gas bubble with high reliability was less in AA appendicitis compared with unoperated children. Our study shows that local non-specific inflammation in the intestine leads to an increase in the tone of all parts of the digestive tract. This hypothesis allows us to understand the pathological physiology of many diseases. For example, the pain in the epigastric region and vomiting in the early stages of AA occurs because of a sharp reduction in the volume of the stomach. The high doses of Senna cannot be effective, since increased peristalsis is accompanied by an increase in the tone of the anal canal, which prevents defecation. Hypersecretion of hydrochloric acid causes an inflammatory reaction in the esophagus, which can cause pain of different localization, as well as constipation, and diarrhea. Further testing of this hypothesis is needed.

**Keywords:** Acute appendicitis; anal canal pressure; tone of the digestive system; volume of the stomach; hypothesis; chronic pelvic pain

## INTRODUCTION

Shafik's research with co-workers has shown that in healthy volunteers the motor function of various parts of the digestive tract interacts with each other. For example, they found that the decline of the intestinal (jejunal and ileal) pressure upon rectal distension in healthy volunteers was reproducible and absent on distension of the anesthetized rectum.<sup>1</sup> At urge rectal distension,

the left colonic pressure showed a significant rise ( $p < 0.001$ ), while the right colon revealed no response ( $p > 0.05$ ). Rectal distension during rectal or colonic anesthetization effected no colonic pressure response ( $p > 0.05$ ).<sup>2</sup> With the same methodological pedantry, lower esophageal sphincter and pyloric sphincter contraction and esophageal and gastric relaxation during rectal distension were found.<sup>3</sup> Interaction of intestinal segments can be both retrograde and antegrade. When food gets introduced

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into the stomach, a coordinated response via stretch receptors, neuropeptides, and the enteric nervous system activates the gastrocolic reflex, which in turn increases the motility in the colon to make room for more food.<sup>4</sup> At the same time distension of the LES was accompanied by a significant rectal pressure increase ( $p < 0.001$ ).<sup>5</sup> These and other works by Shafik<sup>1-5</sup> indicate that the digestive system functions as a single organ and the motility of each of the departments are in coordination with others. It is natural to assume that a pathological process in any of the departments will cause a change in function in the entire system.

In the literature, acute appendicitis (AA) is considered only as a local process. However, there is reason to believe that the entire digestive tract, including the stomach, colon, and anal canal, reacts in response to local inflammation in the appendix (AX). And such non-specific reaction is probably present not only with purulent inflammation in other organs but also with inflammation and irritation of the intestinal wall. To determine the reaction of different parts of the digestive tract to inflammation in the AX.

## MATERIAL AND METHODS

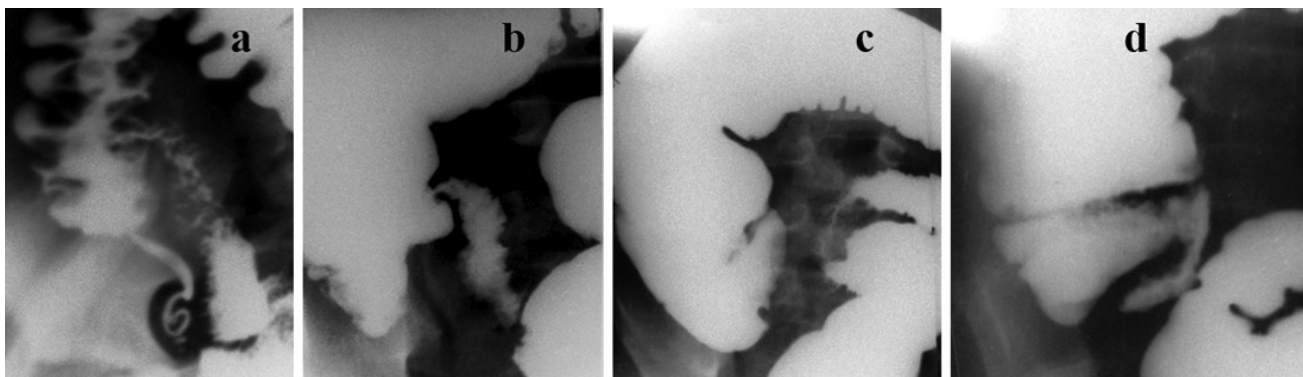
The present work is a review of three own studies<sup>6-8</sup> devoted to various aspects of the etiology and pathogenesis of AA. It analyzes the medical history of 250 children aged 0.5 to 15 years who applied to the Belarusian Children's Surgery Center with sus study. The first group consisted of 111 patients admitted from January 1984 to August 1985, in whom the clinical symptoms of AA were questionable. A barium enema was performed to clarify the diagnosis.<sup>6</sup> At the time, a barium enema was considered useful for diagnosing AA.<sup>9-12</sup> At the beginning of the study, the liquid level of the barium in the bag was 60 cm from the deck

of the X-ray table. Filling of the colon continued until the onset of barium reflux into the ileum. At this moment, the liquid level in the bag was about 30 cm from the table surface. *The second group includes fifty-two patients aged 7-10 years with complaints of pain in the lower right quadrant of the abdomen, in which anal canal pressure was measured. The measurement was performed using an endotracheal tube with a latex cuff, which was connected to a manometer.<sup>7</sup> The obtained data were compared with the results of anal manometry of 20 children of the same age who entered the hospital for scheduled operations (control group).<sup>13</sup>* The third group consisted of 87 patients aged 7-15 years, hospitalized with suspected AA. The radiograph of the abdomen was done in an upright position 10 minutes after taking 50 mL of a warm barium. On the radiographs, we determined the areas of the stomach and its gas bubble, their perimeters, the shape factors (the degree of difference of the measured area with the area of the circle), and the maximum and minimum diameters. The contours from the radiographs were taken with the help of a coordinate graph with subsequent computer statistical analysis.<sup>8</sup> Statistical analysis was performed by the method of the Student's t-test. The level of significance was set as  $p < 0.05$ .

## RESULTS

In 78 (70%) of 111 patients, AA was excluded based on barium enema. The lumen of AX was equally narrow with a length of at least 6 cm. Its contours were parallel and it itself was convoluted (Figure 1). The dome of the cecum had convex contours, and its height corresponded to the age norm, which we established in the previous study.<sup>14</sup>

In 4 out of 78 cases where AA was excluded, appendectomy was performed, but pathology in the AX was not found. In 21



**Figure 1.** X-ray signs of acute appendicitis, (a). The AX is uniformly and deeply filled with barium. Acute appendicitis is excluded, (b). Concavity of the inner part of the dome of the cecum in the patient with acute appendicitis. The ileum and sigma are removed from the cecum. This is a symptom of the “window”. An omentum occupies the distance between cecum and sigma, (c). The inner contour of the cecum is slightly concave and uneven. Spasm of sigma located opposite the cecum, (d). There is a concavity of the inner contour of the cecum in combination with a sharp shortening of the dome. The spasm of the terminal ileum and symptom of the “window” make the diagnosis of AA obvious.

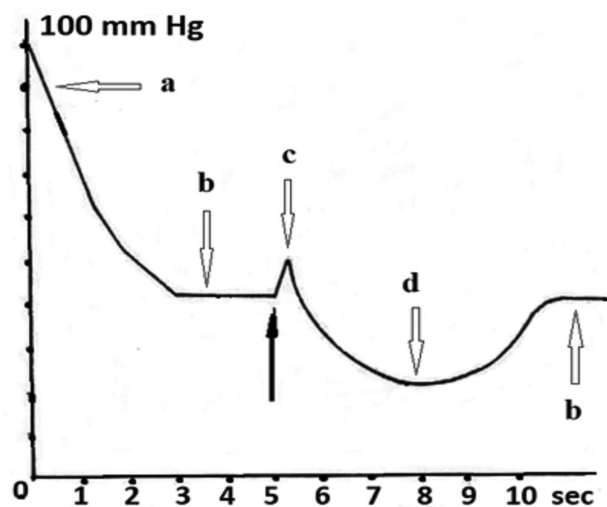
AA: acute appendicitis; AX: appendix

**Table 1. Results of the anal canal manometry in children with suspected AA**

Anal canal pressure	Subgroup A (1)	Subgroup B (2)	Subgroup C (3)	p
Basal pressure	45-60 53.6±1.1	60-80 69.3±1.7	55-90 73.0±3.4	P1-2<0.001 P1-3<0.001 P2-3>0.2
Reactive pressure	45-75 58.5±2.5	70-130 91.0±2.7	70-150 111.3±5.8	P1-2<0.001 P1-3<0.001 P2-3<0.01

AA: acute appendicitis

(19%) patients, based on the data of barium enema a conclusion was made about the presence of AA. In 20 of them, AA was revealed during the surgery. In one patient, the abdominal pain disappeared after the barium enema, which made it possible to abandon the operation. In 12 (11%) patients, the radiographic data were inconclusive, because the AX was not filled with a contrast agent, while the dome of the cecum and the adjacent intestinal sections had standard dimensions and configuration. Eight patients were operated on. In 2 patients a destructive appendicitis was revealed, in 2 a chronic process was detected. At 2 there was uncomplicated appendicitis, and in 2 observations of inflammatory changes in the AX were not found. Lack of contrast in the AX or partial filling of the AX with a contrast agent may be the result of mechanical blockage of its lumen and is therefore it is suspicious on AA. In AA, unlike the norm, an increase in the tone of the intestinal segments in the lower right quadrant was found, which were not always in contact with the AX.<sup>1</sup> The pronounced concavity of the inner contour of the cecum was generally not due to mechanical pressure, since in most cases the inflamed AX was not in contact with the caecum.<sup>2</sup> A significant shortening of the dome of the cecum compared to the norm can only be explained by the contraction of its muscular layer.<sup>3</sup> It appears that a sharp narrowing of the sigmoid colon and terminal ileum located near the cecum is due to muscular contraction. *The second group, in children of the control group, immediately after lowering the endotracheal tube with an inflated balloon from the rectum into the anal canal, the pressure was raised to 80-100 mm Hg. This so-called reflex pressure is caused by the reflex contraction of the external anal sphincter in response to the stretching of the anal canal wall. Within 0.5-1 min, the pressure progressively decreased and was established stably in the range 43.0±0.8 mm Hg. This pressure, called basal pressure, is mediated by a tonic contraction of the internal anal sphincter. After injecting 50 cm<sup>3</sup> of air into the rectum through the channel of the measuring device, a slight increase in pressure to 55-60 mm Hg was immediately observed. We called it reactive pressure. After this, the pressure slowly declined by 10-15 mm Hg. below the basal level with a gradual recovery to the basal level for 4-11 seconds. The drop-in pressure below the basal level is due to*



**Figure 2.** Pressure profile of anal manometry, (a). Reflex pressure, (b). Basal pressure, (c). Reactive pressure, (d). Rectoanal inhibitory reflex. A large solid arrow indicates the moment of air injection into the rectum

*the reflex relaxation of the internal anal sphincter, which is always accompanied by contraction of the external anal sphincter and puborectalis muscle (rectoanal inhibitory reflex) (Figure 2).*<sup>13,15</sup>

In 19 out of 52 children with complaints of pain in the right iliac region, the diagnosis of AA was excluded (subgroup A). In 15 (45%) of the 33 operated children, a simple AA was found (subgroup B). In 15 (45%) patients, destructive AA was found (subgroup C). In three cases, no pathological changes in the AX are found (Table 1).

Only basal and reactive pressures were significantly higher in patients operated on for, both simple and destructive AA, compared with non-operated children. In patients with destructive appendicitis, the pressure was higher than with a simple one. But statistically significant was the reactive pressure increase.

Third group, in 30 out of 87 children with suspected AA, destructive appendicitis was diagnosed after the operation. In 14 cases, superficial inflammation was detected. In 43 remaining patients, the diagnosis AA was excluded, and they were discharged without surgery. All the parameters, including

the area of the stomach and its gas bubble, their perimeters, and shape factors, as well as the maximum and minimum diameters with high reliability ( $p < 0.001$ ) were less with destructive appendicitis compared with unoperated children. Differences between the parameters of patients with destructive and simple AA were not significant ( $p > 0.5$ ).

## DISCUSSION

The concavity of the inner contour of the cecum and the narrowing of the lumen of the sigmoid colon and ileum cannot be explained by the pressure of the masses, as some researchers have claimed.<sup>10</sup> With intra-operative verification of radiologic symptoms, we found that these signs do not depend on the location of these bowel segments from AX. We believe that these symptoms, as well as the decrease in the height of the cecal dome, is described by us, are due to an increase in the tone of the smooth muscle of these parts in response to the irritation emanating from the inflammatory focus.<sup>6</sup> We found that increased tonus extends to other parts of the digestive tract. Basal and reactive anal pressures were significantly higher ( $p < 0.001$ ) in patients with AA compared to non-operated children. In destructive appendicitis, the pressure was higher than with a simple one. However, this difference was significant ( $p < 0.02$ ) only for reactive pressure.<sup>7</sup> Since the internal anal sphincter is a thickened continuation of the circular layer of the colon, it can be concluded that its tone reflects the tonic state of all gut.

On the radiographs of the stomach with barium, a highly reliable decrease in the area of the stomach and the gas bubble, their perimeters, shape factors, as well as the maximum and minimum diameters in destructive appendicitis were compared with non-operated children were found. These results indicate an increase in the tone of the stomach in AA. In this way, the appearance of vomiting and pain in the epigastrium in the first hours of the disease can be explained by the contraction of the stomach, because of increasing its tone.

Based on the studies described above, we concluded that the inflammatory process in AX leads to an increase in the tone of the entire digestive tract. Moreover, the closer the intestinal segment is to the inflammation focus, the higher its tone. It is likely that the described phenomenon is not strictly specific to AA. Since the reaction of the intestine, although to a lesser extent, is observed with catarrhal, i.e., not purulent, inflammation, it can be assumed that inflammation in the different parts of the intestine (ulcers of the stomach and duodenum, esophagitis, gastritis, duodenitis, enteritis colitis) can lead to increasing the

tone of the entire digestive tract. Our data are consistent with the results of Shafik's with co-worker's study which showed that the motor function of different parts of the digestive tract interacts with each other.<sup>1-3,5</sup>

The described pattern can explain some pathological phenomena and combinations of symptoms from different parts of the digestive tract. For example, several studies have indicated an overlap between gastroesophageal reflux disease (GERD) and functional dyspepsia (FD), and irritable bowel syndrome (IBS). The GERD-IBS overlap ranges from 3-79% in questionnaire-based studies and from 10-74% when GERD has been diagnosed endoscopically.<sup>16</sup> Analysis of the literature and the present study allows us to hypothesize that hypersecretion of hydrochloric acid causes a chronic inflammatory process in the esophagus, resulting in a stable change in the motor function of the small and large intestine through the intestinal intramural nervous system, i.e., GERD, FD, and IBS are a consequence of hypersecretion of hydrochloric acid.

This hypothesis makes it possible to understand why the long-term use of large doses of drugs that stimulate peristalsis is not only ineffective but also dangerous. Senna is an FDA-approved non-prescription medicine. It can cause some side effects including stomach discomfort, cramps, and diarrhea. It is likely safe for most adults when used for up to 1 week or in doses not above 34.4 mg sennosides twice daily. Long-term use can cause the bowels to stop functioning normally and might cause dependence on laxatives. Long-term use can also cause liver damage and other harmful effects. The FDA limits the maximum dosage for children from 2 to 6 years-1 tablet (8.6 mg) twice a day (18 mg): For children 6 to under 12 years-2 tablets twice a day (36 mg).<sup>17</sup> The stimulating laxatives, increasing the peristalsis of the rectum to expel feces, simultaneously cause an increase in the tone of the anal canal, which prevents bowel emptying. Therefore, the large doses of Senna do not alleviate bowel movements, but cause harmful effects, up to and including damage to colon function.<sup>18</sup>

## CONCLUSION

The present study proves that local abdominal inflammation causes an increase in tone in all parts of the digestive tube. This hypothesis may bring us closer to understanding the pathological physiology of functional diseases of the digestive tract.

## ETHICS

**Peer-review:** Internally and externally peer-reviewed.

## DISCLOSURES

**Financial Disclosure:** The author declared that this study received no financial support.

## REFERENCES

- Shafik A. Effect of rectal distension on the small intestine with evidence of a recto-enteric reflex. *Hepatogastroenterology* 2000; 47: 1030-3.
- Shafik A. Recto-colic reflex: role in the defecation mechanism. *Int Surg* 1996; 81: 292-4.
- Shafik A, El-Sibai O. Esophageal and gastric motile response to rectal distension with identification of a recto-esophagogastric reflex. *Int J Surg Investig* 2000; 1: 373-9.
- Malone JC, Aravind Thavamani A. Physiology, Gastrocolic Reflex. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan. 2020 Jul 10.
- Shafik A. Esophago-rectal reflex. Description and clinical significance. *Int Surg* 1993; 78: 83-5.
- Misharev OS, Levin MD, Shuan SI. [X-ray diagnosis of acute appendicitis by measured hydrostatic irrigoscopy]. *Khirurgiia (Mosk)* 1986; 61-5.
- Levin MD, Misharev OS, Al'khimovich VN. [Anal manometry in acute appendicitis]. *Klin Khir (1962)* 1986; 35-8.
- Levin MD, Khomich VM, Nalibotskiĭ BV. [The possibility of x-ray diagnosis of acute appendicitis in children]. *Klin Khir (1962)* 1989; 38-40.
- Fee Jr HJ, Jones PC, Kadell B, O'Connell TX. Radiologic diagnosis of appendicitis. *Arch Surg* 1977; 112: 742-4.
- Hatch Jr EI, Naffis D, Chandler NW. Pitfalls in the use of barium enema in early appendicitis in children. *J Pediatr Surg* 1981; 16: 309-12.
- Jona JZ, Belin RP, Selke AC. Barium enema as a diagnostic aid in children with abdominal pain. *Surg Gynecol Obstet* 1977; 144: 351-5.
- Lewin GA, Mikity V, Wingert WA. Barium enema: an outpatient procedure in the early diagnosis of acute appendicitis. *J Pediatr* 1978; 92: 451-3.
- Levin MD. [Roentgenofunctional studies of feces retention and defecation]. *Pediatrica* 1983; 49-52.
- Levin MD. [Roentgenologic anatomy of the colon and rectum in children]. *Vestn Rentgenol Radiol* 1985; 40-5.
- Levin MD. Anatomy and physiology of anorectum: the hypothesis of fecal retention, and defecation. *Pelviperineology* 2021; 40: 50-7.
- de Bortoli N, Tolone S, Frazzoni M, et al. Gastroesophageal reflux disease, functional dyspepsia and irritable bowel syndrome: common overlapping gastrointestinal disorders. *Ann Gastroenterol*. 2018; 31: 639-48.
- FDA (Senna recommendations). Available from: <https://www.drugs.com/pro/sennagen.html>
- Levin MD. Why and when does an enema provoke abdominal pain? Reaction to the article by Peña et al. *J Pediatr Surg* 2021; 56: 1252-3.