ACUTE APPENDICITIS

Guidelines for Medical Students
Approved at the meeting of the surgical methodological commission of Danylo Halytsky Lviv National Medical University (Meeting report № 56 on May 16, 2019)

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I. Background

Acute appendicitis is inflammation of the vermiform appendix and remains the most common cause of the acute abdomen in young adults. This condition is urgent surgical illness with protean manifestations, generous overlap with other clinical syndromes, and significant morbidity, which increases with diagnostic delay. The incidence of acute appendicitis in general population is reported to be 0.1-0.2%. The mainstay of treatment is an appendectomy, and, consequently, this is one of the most common operations performed on the acute abdomen. However, appendicitis can be notoriously difficult to diagnose, and there exists a negative appendectomy rate of 10% – 20% despite the use of preoperative computed tomography (CT). In addition, as with all operations, postoperative complications exist, including wound infections, intra-abdominal abscesses, ileus and, in the longer term, adhesions.

Therefore, surgeon has an important and extremely difficult task to diagnose acute appendicitis in time, thereby warning the development of dangerous complications, and minimize the frequency of removal of the healthy appendix.

II. Learning Objectives

1. To study the etiological factors of disease, classification of acute appendicitis, clinical signs, diagnostic methods, treatment and complications (α = I).
2. To know the main causes of the disease, typical clinical course and complications, diagnostic value of laboratory and instrumental methods of examination and the principles of the modern conservative and surgical treatment (α = II).
3. To be able to collect and analyze the complaints and disease history, thoroughly perform physical examination, determine the order of the most informative examination methods and perform their interpretation, establish clinical diagnosis, justify the indications for surgery, choose adequate method of surgical intervention (α = III).
4. To develop creativity in solving complicated clinical tasks in patients with atypical clinical course or complications of acute appendicitis (α = IV).

III. Purpose of personality development

Development of professional skills of the future specialist, study of ethical and deontological aspects of physicians job, regarding communication with patients and colleagues, development of a sense of responsibility for independent decision making. To know modern methods of treatment of patients with acute appendicitis and its complications.

IV. Interdisciplinary integration

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**Future subjects**

**Anesthesiology and Critical Care Medicine**

| Clinical signs urgent conditions that occur in patients with complications of acute appendicitis, methods of diagnosis and pharmacotherapy | Determine the symptoms of urgent conditions, differential diagnosis and treatment |

**Intradisciplinary integration**

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V. Content of the topic and its structuring

ANATOMY AND PHYSIOLOGY

The appendix is a derivative of the midgut along with the ileum and ascending colon. In the adult, the average length of the appendix is 6-9 cm. Its outside diameter varies between 3 and 8 mm and the luminal diameter is between 1 and 3 mm. The tip of the appendix can be located anywhere in the right lower quadrant of the abdomen or pelvis. There are six locations of appendix regarding cecum: medial - the tip of the appendix is located medial to the cecum between the loops of the small intestine, lateral - appendix adjacent to the peritoneum covering the anterior abdominal wall laterally to the cecum, ascending (subhepatic) - the tip of the appendix is located under the liver, descending (pelvic) - appendix falls down to the small pelvis, retrocecal - appendix is located behind the cecum, retroperitoneal – is located retroperitonealy. In case of retrocecal location appendix has mesentery. It is pelvic in location in 30% and retroperitoneal in 2% of the population. The base of the appendix can be located by following the longitudinally oriented tenia coli to their confluence at the cecum.

The appendix receives its arterial supply from the appendicular branch of the ileocolic artery. This artery originates posterior to the terminal ileum, entering the mesoappendix close to the base of the appendix. A small arterial branch arises at this point that runs to the cecal artery. The lymphatic drainage of the appendix flows into lymph nodes that lie along the ileocolic artery. Innervation of the appendix is derived from sympathetic elements contributed by the superior mesenteric plexus (T10–L1) and solar plexus, afferents from parasympathetic elements brought in via the vagus nerve.

In women from the base of the appendix to the right broad ligament of the uterus goes fold of peritoneum, known as ligament Clado (lig. appendico-ovaricum), in which the blood and lymph vessels go. This explains the spread of infection from the appendix on the female internal genitalia and vice versa.

The histological features of the appendix include the following: first, the muscularis layers are not well defined and may be deficient in some locations; second, in the submucosa and mucosa, lymphoid aggregates occur with or without the typical structure of a germinal center. Lymph vessels are prominent in regions
underlying these lymphoid aggregates. Third, the mucosa is like that of the large intestine, except for the density of the lymphoid follicles. The crypts are irregularly sized and shaped, in contrast to the more uniform appearance of the crypts in the colon. Neuroendocrine complexes composed of ganglion cells, Schwann cells, neural fibers, and neurosecretory cells are positioned just below the crypts. Serotonin is a prominent secretory product and has been implicated in mediating pain arising from the noninflamed appendix. These complexes may be the source of carcinoid tumors, for which the appendix is known to be the most common site of origin.

With regard to function, the widely held notion that the appendix is a vestigial organ is not consistent with the facts. Curiously, the appendix seems more highly developed in the higher primates, and it is possible that the appendix may play a role in immune surveillance. In addition, although the unique function of the appendix remains unclear, the mucosa of the appendix, like any mucosal layer, is capable of secreting fluid, mucin, and proteolytic enzymes.

HISTORY

Although appendicitis has been a common problem for century years it was not until the early 19th century that the appendix recognized as an organ capable of causing disease. There was continued debate through the mid 1800s about the cause of right lower quadrant inflammation with terms such as perityphlitis and paratyphlitis commonly used. In 1827, Melier described several autopsy cases of appendicitis and clearly stated the opinion that the appendix was the likely cause, including the presumed patho-physiology that is accepted today. However, a strongly opposing position by Dupuytren, the most eminent surgeon of the time, caused Melier's views to not gain widespread acceptance. Continued work in Britain and Germany pointed to the appendix as a potential source of disease, and indeed, the number of publications on diseases of the appendix began to increase significantly by 1860. By 1880, both Matterstock in Germany and With in Norway published papers that clearly point to the appendix as a significant cause of iliac fossa inflammation. In 1886, Reginald Fitz of Boston made a landmark contribution by discussing the appendix as the primary cause of right lower quadrant inflammation. He coined the term appendicitis and, importantly, recommended early surgical treatment of the disease. By 1886, the widespread availability of anesthesia and the growing acceptance of antisepsis set the stage for the rapid application of these recommendations, with several U.S. surgeons making important contributions.

Before 1886, a number of cases of intervention for appendicitis had been reported. However, most of these patients underwent surgery well after the disease was established, with the primary goal to drain the infection. Several papers of note were published in the ensuing years. In 1889, Chester McBurney described the migratory pain as well as the finger point localization of pain between 1,5 and 2 inches from the anterior iliac spine on an oblique line to the umbilicus. He incorrectly stated that this was an almost constant finding in patients with appendicitis. McBurney in New York and McArthur in Chicago described a right lower quadrant muscle splitting incision for surgical treatment in 1894. It is interesting to
note that McBurney kept his patients on bed rest for at least 4 weeks after surgery! In 1905, Murphy clearly described the appropriate sequence of symptoms of pain followed by nausea and vomiting with fever and exaggerated local tenderness in the position occupied by the appendix. There continued to be significant improvements in survival, so by the time penicillin became routinely available in the late 1940s, the mortality rate for appendicitis was less than 2%. Further advances in the management of appendicitis have included the recognition of the polymicrobial flora, improved diagnostic studies, and interventional radiologic procedures for treatment of abscesses. The mortality rate for appendicitis is 0.2-0.8%. Appendicitis occurs infrequently in very young children and elderly persons. The disease has a maximal incidence in patients in their late teens and 20s. There is a slight increased prevalence in males versus females.

**ETIOLOGY AND PATHOGENESIS**

**ROLE OF ENVIRONMENT: DIET AND HYGIENE.** Given the relatively lower frequency of appendicitis and other bowel disorders among peoples with high fiber diets, it has been proposed that low-fiber diets contribute to changes in motility, flora, or luminal conditions that predispose to development of fecaliths. Striking, however, is the observation that most patients with acute appendicitis do not have obvious fecalith or stone in either population group.

**ROLE OF OBSTRUCTION.** Early descriptions conceptualized acute appendicitis as a closed-loop obstruction with the obstruction usually being caused by a fecalith. More recently, it has become dogma that, in the absence of a fecalith, many cases of obstruction are caused by hyperplasia of lymphoid tissue in the mucosa and submucosa. In a very small percentage of cases, perhaps 2%, obstruction is caused by neoplasm (carcinoma or carcinoid tumor) or, very rarely, a foreign body. In the evolution of acute appendicitis, the following sequence of events is envisioned: first, luminal obstruction leads to secretion of mucus and fluid, with a consequent rise in luminal pressure; second, when the rise in luminal pressure exceeds pressure within the submucosal venules and lymphatics, outflow of blood and lymph is obstructed, leading to increases in pressure within the appendiceal wall; and third, when capillary pressure is exceeded, mucosal ischemia, inflammation, and ulceration are the result. Eventually, bacterial overgrowth within the lumen and bacterial invasion into the mucosa and submucosa lead to transmural inflammation, edema, vascular stasis, and necrosis of the muscularis. Perforation ensues. Accompanying the local changes within the appendix is a regional inflammatory response mediated by the mesothelium and blood vessels in the parietal peritoneum and serosa of nearby visceral structures. This leads to formation of a walled-off, periappendiceal abscess. Alternatively, if surrounding structures fail to wall off the evolving phlegmon, perforation of the appendix would cause spillage into the peritoneal cavity, leading to spreading peritonitis, massive third-spacing of fluid, shock, prostration, and then death. Although it is widely accepted that obstruction is the inciting event in most cases of acute appendicitis, it is worth pointing out some observations that are not consistent with this hypothesis. The first observation is that impacted fecaliths have
been observed with no accompanying local inflammation or syndrome of appendicitis. In addition, fecalith impaction or functional evidence of obstruction cannot be demonstrated in a substantial number, up to half, of cases. Thus obstruction may be just one of many factors involved in the etiology and pathogenesis of acute appendicitis.

**ROLE OF NORMAL COLONIC FLORA.** The flora of the inflamed appendix differs from that of the normal appendix. About 60% of aspirates of inflamed appendices have anaerobes, compared to 25% of aspirates from normal appendices. Presumably, the lumen is the source of organisms that invade the mucosa when mucosal integrity is compromised by increased luminal pressure or intramural ischemia. Tissue specimens from the inflamed appendix wall (not luminal aspirates) virtually all culture out *E. coli* and *Bacteroides* species. In fact, studies indicate that invasion of tissue by *Bacteroides* elicits specific humoral responses. Moreover, as is discussed next, in many cases in which acute appendicitis is highly likely, antibiotic therapy alone can reverse the evolving clinical syndrome and permit individuals to get well without an operation. Thus, the normal colonic flora play a key role in the evolution of acute appendicitis to gangrene and perforation.

**CLASSIFICATION**

For more than a century of the history of study of acute appendicitis offered a large number of its classifications. Some of them have only historical value (Albers, Rokytanskyi, Pirogov, Weinberg, Sonnenberg, Sprengel, and others). While others retain their practical value. Today there is no single classification of acute appendicitis because it is virtually impossible to bring all the clinical features of the disease under one classification.

We consider that best of all reflects the clinical course of disease classification proposed by V.I. Kolesov (1972):

1. Appendicular colic;
2. Simple appendicitis (superficial, catarrhal);
3. Destructive appendicitis: phlegmonous, gangrenous, perforating;

**CLINICAL PICTURE**

**NATURAL HISTORY AND COMPLICATIONS**

As classically conceptualized, acute appendicitis progresses inexorably, from obstruction to mucosal and then transmural inflammation, necrosis, and then gangrene with local inflammatory responses from the visceral and parietal peritoneum, to perforation with local abscess formation or spreading peritonitis. One time-honored observation has been that perforation is not common if symptoms have been present for less than 24 h. In one recent study, 1895 consecutive adult patients with symptoms and signs of acute appendicitis were monitored prospectively. Fifteen patients ultimately were shown to have a perforation. Of these, 3 (20%) developed
perforation earlier than 24 h after onset of symptoms; in 1 patient, perforation occurred as early as 10 h after the onset of symptoms. Average time from onset of symptoms to perforation was 64 h. Once necrotic or perforated, other complications can result. What should be emphasized about such complications is that they are observed generally in the very young and the very old. In other words, these complications occur in patients who cannot speak for themselves or infirm patients who do not experience the acute lower abdominal symptoms that would ordinarily motivate the patient to see a physician more quickly.

CLINICAL PRESENTATION

SYMPTOMS

At the onset of the episode, the patient typically reports crampy (colicky) abdominal pain. This quality of the pain is attributable to the initial response of the muscularis of the appendix (or any hollow-lumen organ) to obstruction. The pain is described as diffuse or perhaps centered about the umbilicus or epigastric region; this is because the appendix arises from the midgut, an embryonic midline structure that derives its innervation from autonomic afferents related to the spinal cord centered around T10 (solar plexus). Typically, this pain does not radiate, nor do the patients describe it as being exacerbated by changes in body position, meals, urination, or defecation. As the response to luminal obstruction evolves to include luminal distension, intramural edema, and ischemia, the pain becomes constant and is located in right lower quadrant (sign of pain migration Kocher-Volkovych). Single vomiting is often reported by younger patients but is not a prominent symptom in mature adult and aged patients. In general, patients with appendicitis report nausea and loss of appetite; a patient reporting a normal appetite is very uncommon.

SIGNS

The invasion of bacteria with ensuing inflammatory response within the appendiceal wall and the surrounding visceral structures leads to appearance of pain and tenderness localized to the area of parietal peritoneum overlying the inflamed tissue (“phlegmon”). Fever above 38.2°C rarely occurs early in the appendicitis syndrome and usually appears after the time when localizing tenderness appears. In many cases, the localized pain and tenderness are accompanied by peritoneal findings that are localized to the right lower quadrant of the abdomen. These symptoms include rebound tenderness (Blumberg’s sign – the abdominal wall is compressed slowly and then rapidly released, presence of pain makes the sign positive), referred tenderness, and involuntary guarding in the area overlying the phlegmon. Although its predictive power is disputed, McBurney’s point is supposed to be the place where the appendix lies and therefore the place of maximum tenderness. When the inflamed portion of the appendix (usually the tip) is not located near the parietal peritoneum, the place of maximal tenderness is not necessarily in the right lower quadrant. In fact, there may be no localizing area of tenderness when the appendix is located in a retroperitoneal or retroileal position or in the true pelvis. Theoretically, an acutely inflamed appendix in the true pelvis can be suspected by means of rectal examination when the examiner elicits localized tenderness or palpates a mass. Classic texts also recognize three diagnostic maneuvers: Rovsing’s sign left hand presses on the
anterior abdominal wall in the left iliac area in the projection of the descending colon, right hand presses on the anterior abdominal wall above the left hand. Increased pain in the right iliac region indicates the presence of inflammation of the appendix; the mechanism of symptom is associated with the movement of gases through colon towards the cecum and stretching of appendix. The psoas sign is elicited by positioning the patient on the left side and extending the right hip. Pain produced with this maneuver reflects irritation of the right psoas muscle and indicates retrocecal and retroperitoneal irritation from a phlegmon or an abscess. The obturator sign is produced by positioning the patient supine and then rotating the flexed right thigh internally, from lateral to medial. Pain produced with this maneuver indicates inflammation near the obturator muscle in the true pelvis. It should be recognized that each of these “signs” is sought as a way of establishing the location of the inflamed or perforated appendix. It is only in the context of a characteristic history and examination that the diagnosis of appendicitis itself is made. These considerations emphasize that no one symptom or finding, observed at any single point in time, reliably establishes or excludes the diagnosis of acute appendicitis: It is the overall clinical picture that counts.

Other signs:

Voskresenski’s sign - the doctor sits down to the right near the patient, with his left hand stretches patients shirt, fingertips of his right and slips from the right costal arch to the right iliac area. If the patient feels a sharp pain at the end of slide, the sign is positive;

Rozdolsky’s sign – pain at percussion in the right iliac region, resulting from shaking the parietal peritoneum in the area of inflammation.

Perforation of the appendix is caused by purulent destruction of the wall in phlegmonous appendicitis or gangrenous necrosis, and accompanied by a sharpintensification of pain in the right iliac area and spread it around the abdomen. This increased pain is especially noticeable on the background of calming down in the case of his gangrenous appendicitis. The patient develops diffuse peritonitis, anterior abdominal wall is not involved in the act of breathing, positive Blumberg's sign in all parts of the abdomen. Oftenly develops high hectic fever.

Acute appendicitis with pelvic location of the appendix is characterized by poor clinical picture and atypical course. The pain is localized and expressed slightly in the lower abdomen above the pubis. Often the patients have diarrhea and frequent urge to painful defecation (tenesmus), if the appendix tip is adjacent to the front wall of the rectum, or dysuria if the appendix is adjacent to the bladder. Symptoms of peritoneal irritation are not expressed. A rectal or vaginal study (in women) define pain, hanging right wall of the rectum or vagina.

LABORATORY FINDINGS

Routine laboratory studies are helpful in diagnosing acute appendicitis, largely through exclusion of other conditions. Perhaps the only truly routine study is the leukocyte count. It is well recognized that the white blood cell (WBC) count is usually elevated in bona fide cases of appendicitis. However, a substantial number of
patients have the diagnosis and a normal WBC count. Depending on the clinical circumstances, three other types of studies should be performed routinely. First, urine analysis with microscopic examination should be performed in all patients with suspected appendicitis. The goal of performing the test is to exclude ureteral stones (hematuria) and to evaluate the possibility of urinary tract infection (pyuria, bacteruria) as a cause of lower abdominal pain, particularly in elderly diabetic patients. The presence of UTI thus does not exclude acute appendicitis, but does need to be identified. The newer “dipsticks” that contain indicators for bacterial infection can be used to supplant the microscopic examination. Second, measurement of serum liver enzymes and amylase levels can be very helpful in diagnosing liver, gallbladder, or pancreatic inflammation if the pain is described as being more in the midabdomen or even right upper quadrant. Serum amylase levels are reported elevated in 3% to 10% of patients with acute appendicitis or acute lower abdominal pain not attributable to pancreatitis. If pancreatitis is the cause, the pattern of amylase elevation is usually higher and is accompanied by elevations of serum lipase. Measurements of serum amylase are not recommended for all patients with abdominal pain, but should be considered in patients with atypical clinical features. Third, serum HCG (human chorionic gonadotropin) levels should be measured in women of childbearing years if there is any possibility of pregnancy.

**IMAGING STUDIES**

Four types of imaging studies may assist in the diagnosis of acute appendicitis. Plain abdominal films have been used regularly in evaluation of patients with acute abdominal pain. The finding most commonly associated with acute appendicitis is the fecalith. However, although fecaliths are found in 10%–40% of patients with appendicitis, it is difficult to formulate estimates of the sensitivity and specificity of the finding of a fecalith. It would appear, however, that in the setting of acute abdominal pain, the presence of fecalith is likely to be associated with acute appendicitis about 90% of the time. It may thus be regarded as a sensitive sign of acute appendicitis and predictive of a high likelihood of progression to perforation.

In older patients, where perforated viscus is a major part of the differential diagnosis, it is difficult to argue against the plain film as the initial imaging study. In younger patients, the low likelihood of finding a fecalith suggests that obtaining plain films is not cost-effective. If such films are done, it is best to obtain a complete series of plain films, including flat and upright views.

A follow-up barium enema can be helpful but is not more helpful than other modalities. Ultrasound examination of the abdomen has become increasingly popular in recent years. Key findings of this study include (1) thickening of the wall and loss of the normal layers (“target” sign); (2) loss of wall compressibility; (3) increased echogenicity of the surrounding fat; and (4) loculated pericecal fluid. Although this test has a relatively low sensitivity level (80%), it has a relatively high specificity (90%). This imaging modality is very helpful in excluding other causes of abdominal pain in women, particularly those in their childbearing years. When gynecological
causes of pain are difficult to exclude, vaginal ultrasound may be a useful adjunct in these patients.

Computerized tomography (CT) may be considered the gold standard for noninvasive imaging of acute appendicitis. The CT scan can detect and localize inflammatory mass and abscess; if orally administered contrast fills the appendiceal lumen and no inflammatory changes are present, the diagnosis is essentially excluded. In addition, other abdominal pathology can be detected, including lesions in the pelvis. Although technological innovation has produced high-resolution images with standard or helical imaging protocols, a technique for focused helical CT of the appendix has recently been introduced as a means of saving time and cost without reducing accuracy. However, it is not clear that such cost savings can be realized in institutions that do not have access to this technology.

A number of clinical and laboratory based scoring systems have been devised to assist diagnosis. The most widely used is Alvarado score:

### Symptoms
- Migratory right iliac fossa pain: 1 point
- Anorexia: 1 point
- Nausea and vomiting: 1 point

### Signs
- Right iliac fossa tenderness: 2 points
- Rebound tenderness: 1 point
- Fever: 1 point

### Laboratory
- Leucocytosis: 2 points
- Shift to left (segmented neutrophils): 1 point

Total score: 10 points

A score below 5 is strongly against a diagnosis of appendicitis – patient should be observed during 24-48 h with WBC control, while a score of 7 or more is strongly predictive of acute appendicitis – patient is indicated appendectomy. In patients with an equivocal score of 5-6, CT scan should be performed to make correct diagnosis and reduce the rate of negative appendicectomy.

### Differential Diagnosis

Acute appendicitis often should be differentiated from acute kidney diseases, internal female genitalia and other abdominal organs pathology.

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<td>Inflammation of the ovaries and fallopian tubes</td>
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<td></td>
<td>Ectopic pregnancy</td>
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<td></td>
<td>Ruptured Graafian Follicle</td>
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<tr>
<td>Pathology</td>
<td>Conditions</td>
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<tr>
<td><strong>Gastroenterological pathology</strong></td>
<td>Twisted Ovarian Cyst, Endometriosis, Meckel’s diverticulitis, Crohn’s disease; Small bowel perforation, Gastroenteritis, Bowel obstruction, Acute pancreatitis, Acute cholecystitis, Peptic ulcer disease and its complications, Colon diverticulitis</td>
</tr>
<tr>
<td><strong>Urological pathology</strong></td>
<td>Renal colic, Acute pyelonephritis, Testicular torsion</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Infectious diseases (tuberculosis, yersiniosis), Lung and pleura diseases, Diabetes mellitus, Nonspecific pain in abdominal cavity</td>
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</table>

**EVALUATION AND MANAGEMENT**

**STRUCTURED AND HISTORY EXAMINATION**

A structured approach to the patient with acute abdominal pain improves diagnostic accuracy and accelerates the initiation of the correct management plan. Three points deserve repeat emphasis: first, the evolution of symptoms and signs is the key to correct diagnosis and one examination alone is not usually sufficient to render a diagnosis; second, the examination is incomplete unless digital rectal and (in women) speculum/bimanual examinations of the pelvis are performed; third, urine analysis and pregnancy test should be performed to avoid missing a diagnosis of urinary tract processes and pregnancy, as well as to prevent unknowing exposure of an unborn fetus to X-ray radiation.

**INDICATIONS FOR OPERATION**

When the diagnosis of appendicitis has been made with a reasonable degree of certainty (more than 7 point of Alvarado score), operation is indicated except in unusual circumstances. One such circumstance involves the patient in whom the acute illness has passed but is now complicated by formation of a well-circumscribed infiltration or abscess.

It should be pointed out that a number of clinicians have also evaluated the possibility of treating acute appendicitis, in its early phases, using intravenous antibiotics alone. However, limited data suggest that it would be difficult to argue that this nonoperative approach is a cost-effective approach in most clinical situations.

**PREOPERATIVE PREPARATION**

Once the diagnosis is made and operative management is chosen, the patient should be made comfortable with pain medication. Fluid status should be monitored.
closely, using clinical indicators (pulse, blood pressure, urine output). Electrolyte balance is not usually a problem, unless the illness has been prolonged and other complications (i.e., bowel obstruction) have supervened. If such imbalances are detected in the admitting serum chemistry evaluation, they should also be addressed.

When the decision to operate has been made, antibiotic therapy is started, usually consisting of a second-generation cephalosporin alone or a combination regimen that includes broad-spectrum coverage of gram-negative aerobes (principally *E. coli*) and anaerobes (*Bacteroides* spp.). *It should be emphasized that ordinarily, the goal of antibiotic therapy is not to treat the appendicitis itself.* In uncomplicated cases antibiotics are used to reduce the incidence of wound and deep peritoneal infections that may occur after the operation and to protect against the consequences of bacteremia. In cases complicated by abscess formation or bacteremia, antibiotics are used to treat the complications. The literature regarding antibiotic prophylaxis is complicated, but there does seem to be consensus about the following: (1) in uncomplicated cases, a second-generation cephalosporin is as effective in reducing wound complications as multiple drug regimens; (2) antibiotics are most effective when given just before or at the time of surgery, to obtain good tissue levels as the incision is being made; and (3) in uncomplicated cases, one dose is enough and additional doses after the operation do not further reduce infection rates.

**OPERATIVE DECISIONS**

The first decision to be made is whether the procedure will be performed through a traditional “open” approach or with the assistance of laparoscopy. Numerous trials comparing open and laparoscopically assisted approaches have been performed since the technique was popularized in the early 1990s. A number of outcome–cost and meta-analyses have been published in the last few years as well. Based on the most recent information available, it seems clear that, in uncomplicated cases where the diagnosis is secure, the laparoscopic approaches may offer a small reduction in pain scores, a mild reduction in hospital stay, and possibly a reduction in wound infection rates. Return to work may also occur earlier. In these cases, however, the operating time and overall hospital costs of the laparoscopic approach are higher. Thus, in a cost analysis, the benefit of laparoscopically assisted appendectomy can only be realized if the patients routinely return to work and productive activity sooner than patients undergoing open procedures. This advantage has not yet been shown. Patients with complications of appendicitis have not yet been included in large enough numbers to reach conclusions about the relative advantages of either approach. In the meantime, the optimal choice for operative approach should be based on likelihood of diagnosis, complexity of the appendicitis, and severity of illness. The one circumstance in which laparoscopic approach may offer a definite advantage is when the diagnosis is in doubt. The diagnosis is particularly difficult to make in young women. In this group, as many as 25% to 50% of patients explored for the diagnosis of acute appendicitis will actually have another disorder. Although the rate of “negative exploration” is expected to decrease with increasing use of imaging modalities such as ultrasound and appendix-directed CT, it seems likely that this group of patients will continue to pose a challenge. Thus, it will probably turn out
that patients in this subgroup will benefit from a laparoscopic approach. At the time of the operation, the appendix is removed if it appears inflamed. A key point in the operation includes dissection of appendix to its true base at the confluence of the tenia on the cecal wall. Failure to fully dissect the appendix may lead to retention of an appendiceal stump that is sufficiently large to harbor recurring appendicitis. A number of such cases have been reported, occurring even many years later. Such cases should serve as a warning to the wary clinician: even when a patient reports a prior appendectomy and has a scar to prove it, there may yet be a recurrent appendicitis. Once identified, the appendix is amputated close to the base. When the operation is performed open, it is customary to invert the appendiceal stump into the cecal lumen. However, there is no evidence that this reduces postoperative leak or fistula formation, either being exceedingly rare events in uncomplicated cases. When surgery is performed laparoscopically, the appendix is usually amputated at its base using a stapling device, and no inversion is performed. When the base of the appendix cannot be identified because inflammation or abscess formation precludes safe dissection, a closed suction drain may be placed into the cavity. If the lumen of the appendix has not been obliterated, the drain allows fecal contents to drain to the outside, thereby preventing accumulation of pus and fecal material inside the peritoneal cavity. If the exploration or laparoscopy fails to reveal acute appendicitis, a search for the cause of the acute abdominal pain must be undertaken. If no other source of pain can be identified, it is reasonable to remove the appendix. There are three reasons for removing the appendix, even if it appears grossly normal: first, the presence of a scar and history of exploration for the diagnosis may lead future care providers to assume the appendix has been removed; second, if the pain recurs, removal of the appendix eliminates this diagnosis from the differential (with the caveat just noted); and third, even in grossly normal appendices, early intramural or serosal inflammatory changes (so-called periappendicitis) have been noted with regularity (25%–50%) in microscopic evaluation or with special stains for inflammatory cytokines.

The last intraoperative decision is whether the wounds should be left open, with the risk of wound infection, or whether they can be closed primarily. Although most authors recommend leaving the incisions open when there is gross contamination by pus and fecal material, there is increasing evidence that this may be no more unsafe and less costeffective than closing all wounds (where it is feasible) and later treating any wound infections that result. This decision should be individualized to each patient.

POSTOPERATIVE CARE

In uncomplicated cases, patients may take liquids and then solid food as soon as they feel able, and discharge should be anticipated within 24 to 48 h. Postoperative antibiotics and nasogastric decompression are not indicated routinely in such patients. Patients with perforation, abscess, or other complications have a variable course. With established peritonitis or abscess formation, a longer course of antibiotics may be needed, from 5 to 7 days after surgery.
SPECIAL CONSIDERATIONS

CHILDREN

Incomplete formation of the immune system and the underdevelopment of greater omentum that does not reach the right iliac area, promote the rapid spread of destructive changes in the appendix, reduce the possibility of separating the inflammatory process and create conditions for increased frequency of complications of disease or generalization of infection. The peculiarity of the disease is the predominance of local over general symptoms. Clinical equivalent of pain in young children is to change behavior and refusal of food. The first objective clinical symptom is often fever (39-39.5°C), and repeated vomiting (in 40-45%). Examination when the child is asleep can detect pain that provokes bending leg in the hip joint and attempt to push the surgeon's hand, you can also differentiate protective tension of muscles of anterior abdominal wall and active muscular protection.

ADVANCED AGE

It is widely recognized that elderly patients with appendicitis present with less acute symptoms, less impressive clinical signs, and leukocytosis. Up to 30% of elderly patients present more than 48 h into the illness, and between 50% and 70% have a perforation at the time of surgery. In addition, the elderly are susceptible to malignancy and other processes that are in the differential diagnosis, making correct preoperative diagnosis of acute appendicitis more difficult. Perioperative complications and mortality of delayed intervention increase with age as well. However, timely intervention can result in very acceptable complication rates, even in the most elderly patients. Therefore, in this age group, it is reasonable to be diagnostically aggressive (i.e., use CT scan) to establish the diagnosis or to identify other pathology and to move as quickly as possible to the appropriate intervention.

PREGNANCY

The diagnosis of acute appendicitis during pregnancy is one of the most challenging of all clinical problems. Pregnancy itself, especially in the early stages, is associated with nausea, vomiting, abdominal pain and physiological leucocytosis. In the first and early second trimester, the evolution of symptoms and signs is not different from that in nonpregnant women. After the fifth month, the cecum and appendix are shifted upward by the expanding uterus. In the last trimester, localized tenderness from the appendix may be found in the upper flank and right upper quadrant of the abdomen. Ultrasound is very helpful in this setting, as it may provide images of the appendix, gallbladder, uterus, and other pelvic organs. X-rays should be avoided if at all possible. When the diagnosis of appendicitis is considered likely, the patient should be explored. The following considerations should be borne in mind if the diagnosis is not certain: (1) appendicitis is not more common in any of the three trimesters; (2) progression to perforation seems to be more common in the last trimester, presumably because of delays in seeking treatment and delays in recognition of the need for surgery; (3) fetal mortality is probably less than 5% if the appendix is removed before rupture and as high as 20% if the appendix is removed after rupture; and (4) maternal mortality is small (less than 1%) but has been reported almost exclusively in patients who had a ruptured appendix. On the other hand,
patients and relatives need to be counseled about the risks of negative laparotomy to the fetus. Overall, however, it would seem that, while the risk of preterm labor in increased, the actual harm to the fetus is not associated with increased perinatal mortality. These considerations strongly argue for a proactive approach to exploration in doubtful cases and probably justify the higher negative laparotomy rates of 25% to 40% that have been reported. One additional consideration is whether it is safe and appropriate to submit the pregnant patient to laparoscopic exploration and appendectomy. In the last trimester of pregnancy, it is technically too difficult for laparoscopic instruments to reach the appendix, which lies above or behind the uterus, and the procedure is most expeditiously performed using an open incision. In the first and early second trimester, however, it is feasible to perform laparoscopy and, if needed, appendectomy with laparoscopic assistance. The safety of laparoscopic surgery in pregnancy remains a controversial subject, with some groups reporting no adverse events and some groups reporting higher than expected incidents of adverse fetal outcomes. When the diagnosis of appendicitis seems likely, an open procedure is probably the most expeditious approach.

**INCIDENTAL APPENDECTOMY**

This term refers to the removal of the appendix when the laparotomy or laparoscopy is being performed to address an unrelated clinical problem. The stated goal of this practice is to prevent an episode of acute appendicitis later on. It may be reasonable to perform incidental appendectomy in children and young adults, but it is difficult to justify the practice in patients over the age of 30 years. Incidental appendectomy should not be performed if, in the surgeon’s judgment, there is a possibility that it would incur any additional morbidity.

**COMPLICATIONS**

*Appendicular infiltrate* – is an inflammatory conglomerate formed by greater omentum, small bowel loops, cecum and ascending colon, which adhere each other to separate the inflamed destructed appendix and exudate from the free abdominal cavity. Infiltrate formed in case of high protection ability of macroorganism and low virulence of microorganisms that caused acute appendicitis. The frequency of different authors ranges from 0.2% to 5%. Infiltrate is being formed on 3-5 days from the disease beginning. During questioning the patient can establish that the disease began typically for acute appendicitis, but gradually abdominal pain decreased, became dull, and at the time of addressing in the hospital more often pain occurs during movement and does not bother the patient at rest. Decreased patient's body temperature to normal or low-grade. On the background of deceasing clinical symptoms of acute appendicitis in the right iliac area is palpated dense, initially painful mass. Infiltratemay dissolve or suppurate. If infiltration resolves, then the patient has normal body temperature, pain persists in the area of infiltration, which decreases in size, normal complete blood count. Resorption lasts approximately 8-16 days. If a patient diagnosed with appendicular infiltrate, he must be hospitalized and assign anti-inflammatory drugs and antibiotics to prevent suppuration of infiltrate.
After resolution of infiltrates should perform routine appendectomy at least 3 months from the onset of the disease.

**Appendicular abscess.** The most common reason for the formation of appendicular abscess is suppuration of appendicular infiltrate, sometimes it is caused by the formation of purulent exudate due to perforation of the appendix. Early sign of suppuration of infiltrate are the appearance of pain in the region of abdominal mass. In addition there are clinical signs of intoxication (fatigue, headache, hectic fever, tachycardia). In CBC, increases the blood leukocytosis and leukocyte shift to the left. CT is excellent at delineating such lesions. In cases of abscess the use of CT directs a percutaneous approach to drainage. In this situation, the base of the cecum and appendix are not recognizable in the inflammatory mass. A secure operative closure is not feasible and operative intervention is not likely to accomplish much more than percutaneous drainage of the abscess. CT-directed drainage avoids laparotomy until definitive (so-called interval) appendectomy is performed 3 month later. This approach is particularly suited to the elderly, infirm patient who is at risk for more morbidity in the acutely ill and debilitated state. It should be emphasized that a nonoperative approach is employed most successfully when the acute illness is passed or when the abscess is circumscribed. Most patients are better served by early operation once the diagnosis is made.

**Abscesses of the abdominal cavity.** *Abscess in the Douglas space* - is the accumulation of pus in the recto-cystic pouch in men and recto-uterine pouch in women. Occurs in 0.2 % of all cases of acute appendicitis. Formed on 4-5 day and clinically is characterized by fever, pain in the abdomen, sometimes with dysuria, discomfort in the rectum, tenesmus. During digital rectal examination in men is revealed as painful anterior wall of rectum. In women during digital pelvic examination is reveal as painful posterior vaginal vault. Pelvic ultrasonography detect accumulation of fluid in pelvis. Treatment: open surgery drainage or draining the abscess through the rectum in men or through the vagina in women.

**Subdiaphragmatic abscess** - a pus accumulation in the subdiaphragmatic space above the liver. Clinically can be characterized by a rapid clinical course with severe intoxication. Signs are fever, pain in the right side of the chest, wheezing, dry cough. During physical examination: slightly increased liver, which is painful at palpation, decreased breathing sounds at the lower right lung at auscultation. Ultrasonography and CT of the abdominal cavity should be conducted to confirm the diagnosis and select optimal treatment strategy. Treatment: minimally invasive puncture of abscess under ultrasound or CT guidance, or open surgery drainage.

**Interloop abscesses** - limited accumulation of pus between the loops of the small intestine. In patients with acute appendicitis occurs in 0.02% of cases. Clinical signs: in the area of the abscess is defined muscle rigidity of the anterior abdominal wall, pain, positive Blumberg sign, painful palpable mass; fever, leukocytosis. Treatment: percutaneous drainage under ultrasound guidance or open surgery drainage.

**Pylephlebitis** – a suppurative and inflamed thrombosis of the portal vein, which is a rare but potentially lethal complication of an intraabdominal infection with a mortality rate of 25%. The most commonly reported etiology of pylephlebitis is
diverticulitis, followed by appendicitis, cholecystitis, pancreatitis, and other intra-abdominal infections. Pylephlebitis occurs as a result of an abdominal infection draining into the portal venous system. The infection is usually polymicrobial. The symptoms of pylephlebitis are non-specific and the condition is potentially lethal. There should be a high clinical suspicion in patients who present with abdominal pain, fever, and other signs of sepsis, as well as leukocytosis and elevated liver enzymes. Patients may also have hepatomegaly and jaundice. Pylephlebitis can be diagnosed via abdominal ultrasonography or CT showing a thrombus in the portal vein. If pylephlebitis is suspected, broad-spectrum antibiotics that cover Gram-negative bacilli, anaerobes, and aerobes should be administered immediately and subsequently modified pending culture results.

VI. Plan and structure of class

<table>
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<th>Main stages of the class, their function and meaning</th>
<th>Learning objective in the levels of mastering</th>
<th>Methods of teaching and control</th>
<th>Guidelines</th>
<th>Time distribution</th>
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<td>Preliminary stage Arrangements Determining the relevance, educational objectives and motivation Control of the input level of knowledge, skills and abilities: 1. Etiology and pathogenesis 2. Clinical signs 3. Diagnosis 4. Treatment</td>
<td>I 2 2 2</td>
<td>Survey Survey, tests Clinical cases, MCQs Clinical cases, MCQs</td>
<td>Questions Questions, II level MCQs Typical clinical cases, II level MCQ Typical clinical cases, II level MCQ</td>
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<td>4.</td>
<td>Main stage</td>
<td>III</td>
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<td>Master the skills of the physical examination</td>
<td>Practical training</td>
<td>Patients with acute appendicitis</td>
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<td>2</td>
<td>Perform physical examination of the patient with acute appendicitis</td>
<td>Practical training</td>
<td>Patients with acute appendicitis, patients cards</td>
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<td>Plan the patients laboratory and instrumental examinations</td>
<td>Practical training</td>
<td>Clinical cases, III level MCQs</td>
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<td>Differential diagnosis</td>
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<td>Treatment schemes</td>
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<td>Typical and atypical clinical cases</td>
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### Final stage

5. Correction of the professional skills and abilities

| III | Personal skills control, analysis and evaluation of the results of clinical work, clinical cases, level III MCQs | Clinical cases and III level MCQs |

6. Summarizing class

7. Homework
   (recommendation of basic and additional literature)

   Results of patients examination, MCQs and clinical cases solutions
   Oriented card for independent work with literature

|   |   |   | 30 min. |
VII. Materials for classes

Questions (α =І, α =ІІ)
1. Etiology and pathogenesis of acute appendicitis.
2. Classification of acute appendicitis.
3. Clinical signs of acute appendicitis.
4. Laboratory diagnosis of acute appendicitis.
5. Features of the clinical course of acute appendicitis in children, pregnant women, elderly people.
6. Role of localization procedures in diagnosing of acute appendicitis.
8. Treatment of acute appendicitis.

MCQs (α =ІІ)
1. Overall mortality rate in case of acute appendicitis is:
   A. 10-20%;
   B. 5-10%;
   C. 0.2-0.8%;
   D. 1-5%;
   E. 25%.
Correct answer: C.

2. Name the destructive form of appendicitis.
   A. Appendicular colic;
   B. Superficial;
   C. Hydrops of appendix;
   D. Phlegmonous;
   E. Catarrhal appendicitis.
Correct answer: D.

3. Koher sign is:
   A. Migration of the pain from the epigastrium to the right lower quadrant;
   B. Pain in the right lower quadrant;
   C. One time vomiting;
   D. Pain in the right upper quadrant;
   E. Pain in the epigastrium.
Correct answer: A

4. Appendicular artery is the branch of:
   A. a. ileocolica
   B. a. mesenterica inferior
   C. a. hepatica communis
   D. Celiac trunk
   E. a. iliaca interna
Correct answer: A
5. Which examination is considered to be a gold standard for acute appendicitis?
   A. Plain abdominal film;
   B. Abdominal ultrasound;
   C. Barium enema;
   D. Colonoscopy;
   E. Computed tomography.
   Correct answer: E.

Typical clinical cases (α =II)
1. A 34-year-old female patient suffered from abdominal pain for a week; no other gastrointestinal problems were noted. On clinical examination, a mass of about 6 cm was palpable in the right lower quadrant, appeared hard, not reducible and fixed to the parietal muscle. CBC: leukocytes – 7.5*10^9/l, ESR – 24 mm/hr. Temperature 37.4°C. Triple antibiotic therapy with cefotaxime, amikacin and tinidazole was very effective. After 10 days no mass in abdominal cavity was palpated. What time term is optimal to perform appendectomy?
   Answer: 3 month.

2. A 20-years-old man complains of pain in the lower abdomen (mainly on the right side). Symptoms commenced 12 hours before admission. He had noted anorexia during this period. Examination revealed tenderness in the right iliac fossa, which was maximal 1 cm below McBurney’s point. In appendicitis, where does the pain frequently commence?
   Answer: in the umbilical region and then moves to the right iliac fossa.

3. A 68-year old man, 14 hours ago appeared continuous pain in the RLQ, 2 hours ago pain decreased significantly. The diagnosis of acute appendicitis was made. What morphological form of acute appendicitis we must suspect?
   Answer: gangrenous appendicitis.

Atypical clinical cases (α =III)
1. At open operation a normal appendix is found, no other pathology in abdominal cavity. What is the most common procedure a surgeon should do if he finds a normal appendix?
   Answer: removal of appendix.

2. A 79-year-old man has had abdominal pain for 6 hours. An operation is performed, and a gangrenous appendix is removed. The stump is inverted. Why does acute appendicitis in elderly patients and in children have a worse prognosis?
   Answer: The omentum and peritoneal cavity appear to be less efficient in localizing the disease in these age groups.

VIII. Literature