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Anterior Abdominal Wall Pain

Anastasia I. Dolgushina[1,2], Maria I. Karpova[1,2], Igor A. Karpov[1], Nikita B. Nadtochiy[1,2], Anna A. Saenko[1]*

[1] *South Ural State Medical University, Chelyabinsk, Russian Federation*
[2] *Chelyabinsk Regional Clinical Hospital, Chelyabinsk, Russian Federation*

Aim: to present modern approaches to the differential diagnosis and treatment of anterior abdominal wall pain.
Key points. Pain in the anterior abdominal wall is a common reason for visiting a gastroenterologist and is often misinterpreted. Signs that distinguish it from visceral and parietal pain include local character, a positive Carnett sign and the effectiveness of local anesthetic injection. Among the main causes, it is necessary to highlight diseases that are not accompanied by a palpable mass in the anterior abdominal wall (anterior cutaneous nerve entrapment syndrome, ilioinguinal nerve syndrome, slipping rib syndrome, radiculopathy and myofascial pain syndrome). Another group of causes of pain in the anterior abdominal wall is represented by diseases in which areas of infiltration (tumors, endometriosis, infections) or hernial protrusions are determined, in which radiation methods play an important role in diagnosis.
Conclusion. Knowledge of pathognomonic clinical and instrumental signs is the basis for differential diagnosis and choice of treatment strategy for pathology of the anterior abdominal wall.
Keywords: anterior abdominal wall pain, abdominalgia, Carnett's sign, abdominal pain
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Боль в передней брюшной стенке

А.И. Долгушина[1,2], М.И. Карпова[1,2], И.А. Карпов[1], Н.Б. Надточий[1,2], А.А. Саенко[1]*

[1] *ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации, Челябинск, Российская Федерация*

[2] *ГБУЗ «Челябинская областная клиническая больница», Челябинск, Российская Федерация*

Цель: представить современные подходы к дифференциальному диагнозу и лечению боли в передней брюшной стенке.
Основные положения. Боль в передней брюшной стенке является распространенной причиной обращения к гастроэнтерологу и часто неверно интерпретируется. К признакам, позволяющим отличить ее от висцеральной и париетальной боли, относятся локальный характер, положительный симптом Карнетта и эффективность локальной инъекции анестетика. Среди основных причин следует выделить заболевания, которые не сопровождаются очаговыми изменениями передней брюшной стенки (синдромы ущемления переднего кожного нерва, илиоингвинального нерва, «скользящего ребра», радикулопатии и миофасциальный болевой синдром). Другая группа причин боли в передней брюшной стенке представлена заболеваниями, при которых определяются участки инфильтрации (опухоли, эндометриоз, инфекции) или грыжевые выпячивания, при этом важную роль в диагностике играют лучевые методы.
Заключение. Знание патогномоничных клинико-инструментальных признаков является основой дифференциального диагноза и выбора стратегии лечения патологии передней брюшной стенки.
Ключевые слова: боль в передней брюшной стенке, абдоминалгия, симптом Карнетта, абдоминальная боль
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Introduction

Abdominal pain is often a difficult diagnostic problem, requiring the involvement of physicians of various specialties. Traditionally, depending on the mechanism of development, the following types of abdominal pain are distinguished: visceral, parietal, reflected (irradiating) and psychogenic

[1]. An important practical significance is the determination of the nature of the course of abdominal pain. Thus, three months [2] or six months [1] are considered as a time interval characterizing chronic abdominal pain. Among the causes of both acute and chronic abdominal pain, pathology of the anterior abdominal wall is of significant importance [3]. The frequency of its detection depends significantly on the specialization of the physician and the type of medical institution [4]. In previously published studies, pain associated with anterior abdominal wall pathology was the reason for treatment in 2–10 % of cases [5–7] among patients admitted to gastroenterological or surgical hospitals. It is worth noting that the exclusion of organic pathology on the basis of standard diagnostic tests increases the probability of this origin of pain to 30 % [4]. R. Kawamura et al. published a detailed analysis of 12 case histories of patients who, due to ineffective treatment of functional gastrointestinal disorders, underwent additional laboratory and instrumental examinations to rule out the initial diagnosis, resulting in 66.7 % diagnosed with anterior abdominal wall pain [8]. Misinterpretation of the source of pain can warrant numerous expensive examinations, invasive tests, and lead to catastrophizing [9].

Differential diagnosis

The anterior abdominal wall pain can be associated with a wide range of diseases, and there are a number of characteristics that distinguish it from visceral and parietal pain. As a rule, the pain is clearly localized in a specific area of the anterior abdominal wall, increases with activities that cause abdominal muscle tension: standing and sitting, coughing, laughing, and may decrease in the supine position. Often there is a history of triggers such as physical activity, trauma, abdominal surgery — in this case, the pain may be localized near the scar. The most sensitive and specific physical test for the differential diagnosis of intra-abdominal pathology and pain caused by tension of the muscles of the anterior abdominal wall is the Carnett's sign. This sign is named after the surgeon John B. Carnett, who first proposed it in 1926 [10]. The technique involves palpation of the abdomen to determine the area of maximum soreness when the patient is in the supine position. The patient is then asked to raise both legs or lift the head and shoulders above the bed to tense the abdominal muscles while the physician palpates the abdomen (Figure 1). The Carnett's test is considered positive if palpation of the abdomen in the tense position causes the same or greater pain as in the resting position. Another diagnostic criterion may be the positive effect of local anesthetic injection [11].

In terms of physical and instrumental examination capabilities, the causes of anterior abdominal wall pain can be divided into two groups. The first includes clinical situations when palpation does not reveal focal changes of the anterior abdominal wall. The second group is represented by diseases in which infiltration areas (tumors, endometriosis,

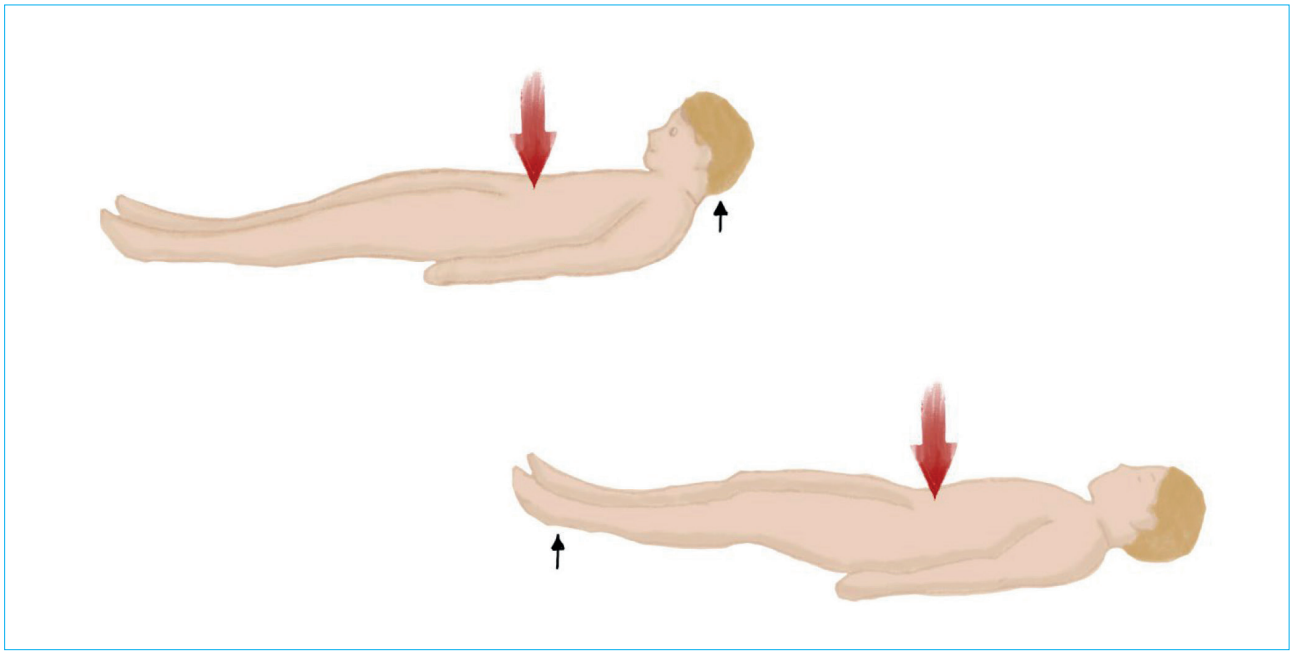

Figure 1. Method for determining Carnett's sign

Рисунок 1. Методика определения симптома Карнетта

Table. Pathology of the anterior abdominal wall
Таблица. Патология передней брюшной стенки

Condition ***Состояние***	**Clinical characteristics** ***Клиническая характеристика***
Diseases not accompanied by a palpable mass in the anterior abdominal wall *Заболевания, не сопровождающиеся пальпируемым образованием в передней брюшной стенке*	
Anterior cutaneous nerve entrapment syndrome *Синдром ущемления переднего кожного нерва*	Localized unilateral sharp pain along the edge of the rectus abdominis muscle. It may radiate to the upper half of the body and worsen with bending forward, shaking, coughing and laughing. Often has a connection with previous physical activity. There is an effect from local injection of anesthetic *Локализованная односторонняя резкая боль по краю прямой мышцы живота. Может иррадиировать в верхнюю половину тела, усиливаться при наклоне вперед, тряске, кашле и смехе. Часто имеет связь с предшествующей физической нагрузкой. Есть эффект от локального введения анестетика*
Ilioinguinal nerve syndrome *Синдром илиоингвинального нерва*	The patient has a history of operations with a Pfannenstiel incision, inguinal hernioplasty, and appendectomy. Pain in the iliac region radiating to the groin, upper inner thigh and back, has a piercing character *В анамнезе — операции с разрезом по Пфанненштилю, паховая герниопластика, аппендэктомия. Боль в подвздошной области с иррадиацией в пах, верхнюю внутреннюю поверхность бедра и спину, имеет пронизывающий характер*
Slipping rib syndrome *Синдром «скользящего ребра»*	Increased mobility of the anterior ends of the VIII–X ribs. Pain occurs when coughing, sharply turning the body and decreases when lying on the affected side. Diagnostics — "hook" technique (pulling upward the anterior edge of the X rib) and dynamic ultrasound examination *Увеличение подвижности передних концов VIII–X ребер. Боль возникает при кашле, резком повороте туловища и уменьшается в положении лежа на пораженной стороне. Диагностика — прием «крючка» (оттягивание вверх переднего края X ребра) и динамическое ультразвуковое исследование*
Herpes zoster	Pain and other sensory disturbances, vesicular rash spreading to one or more adjacent dermatomes. In some cases — weakness of the abdominal wall muscles with a myotome distribution *Боль и другие сенсорные нарушения, везикулярная сыпь с распространением по одному или нескольким смежным дерматомам. В некоторых случаях — слабость мышц брюшной стенки с миотомным распределением*
Radiculopathy in the thoracic spine *Радикулопатия в грудном отделе позвоночника*	Back pain, paravertebral muscle tension. The pain intensifies with movement. Radicular symptoms in dermatomal or myotomal distribution *Боль в спине, напряжение паравертебральных мышц. Боль усиливается при движении. Корешковые симптомы в дерматомном или миотомном распределении*
Diabetic thoracic radiculopathy *Диабетическая торакальная радикулопатия*	Severe pain with dysesthesia spreading along the dermatome in a patient with diabetes mellitus. In some cases, weakness of the abdominal wall muscles with a myotome distribution. May be combined with sensory and motor impairments and other complications of diabetes mellitus *Выраженная боль с дизестезией с распространением по дерматому у пациента с сахарным диабетом. В некоторых случаях — слабость мышц брюшной стенки с миотомным распределением. Может сочетаться с сенсорными и двигательными нарушениями, с другими осложнениями сахарного диабета*
Transient abdominal pain associated with exercise *Преходящая боль в животе, связанная с физической нагрузкой*	Pain during sports activities with repetitive movements, localized in the lateral parts of the mid-abdomen along the costal border *Боль во время спортивных нагрузок с повторяющимися движениями, локализованная в боковых отделах средней части живота вдоль реберной границы*

Continuation of Table. Pathology of the anterior abdominal wall
Продолжение таблицы. Патология передней брюшной стенки

"Sports hernia", "core muscle damage", sports pubalgia *«Спортивная грыжа», «повреждение основных мышц», спортивная пубалгия*	Pain in the groin area in athletes caused by various muscle-tendon injuries in the peripubic area *Боли в паховой области у спортсменов, обусловленные различными мышечно-сухожильными повреждениями в окололобковой области*
Myofascial pain syndrome *Миофасциальный болевой синдром*	Trigger points in the muscle upon palpation *Триггерные точки в мышце при пальпации*
Diseases accompanied by a palpable mass in the anterior abdominal wall *Заболевания, сопровождающиеся пальпируемым образованием в передней брюшной стенке*	
Hernia *Грыжа*	Pain in the area of hernial protrusion (epigastric, hypogastric, umbilical, Spigelian line, inguinal, postoperative) *Боль в области грыжевого выпячивания (эпигастрий, гипогастрий, пупочная, спигелиевой линии, паховая, послеоперационная)*
Damage/hematoma of the muscles of the anterior abdominal wall *Повреждение/гематома мышц передней брюшной стенки*	Taking anticoagulants, severe cough, history of trauma. A palpable, painful formation that increases with tension in the abdominal muscles. There may be signs of acute blood loss (hypotension, anemia) *Прием антикоагулянтов, сильный кашель, травма в анамнезе. Пальпируемое болезненное образование, увеличивающееся при напряжении мышц живота. Возможны признаки острой кровопотери (гипотония, анемия)*
Endometriosis of the anterior abdominal wall *Эндометриоз передней брюшной стенки*	Cyclic abdominal pain, history of laparotomy, palpable tender masses *Циклическая абдоминальная боль, лапаротомия в анамнезе, пальпируемые болезненные образования*
Benign and malignant neoplasms *Доброкачественные и злокачественные новообразования*	Painful mass, often deeply located, increasing in size over time, the possible presence of a proven malignant tumor of another location *Болезненные образования, часто глубоко расположенные, увеличивающиеся в размерах в динамике, возможно наличие доказанной злокачественной опухоли другой локализации*
Dercum's disease (neurolipomatosis) *Болезнь Деркума (нейролипоматоз)*	Obesity with multiple painful lipomatosis *Ожирение с множественным болезненным липоматозом*
Infections of the anterior abdominal wall *Инфекции передней брюшной стенки*	Possible fever, weakness, weight loss. History of injuries, surgeries. If the causative agent is actinomycosis, it can be detected by histological examination. *Возможно повышение температуры, слабость, снижение массы тела. Травмы, операции в анамнезе. В случае если возбудителем являются актиномицеты, диагноз может быть подтвержден при гистологическом исследовании*

infections) or hernias are detected (Table) [12]. In the second case, radiation methods play the most important role in diagnosis [13–15].

Etiology of pain in the anterior abdominal wall

The most common cause of abdominal wall pain is ***anterior cutaneous nerve entrapment syndrome (ACNES)***. The first description of this syndrome was made in 1792 by J.P. Frank, who defined the condition as "muscular peritonitis" [16]. John B. Carnett at the beginning of the 20th century called the syndrome "intercostal neuralgia" and stated its high prevalence among patients presenting with complaints of abdominal pain [10]. The modern English-language term "abdominal cutaneous nerve entrapment syndrome" was introduced in 1972 by W.V. Applegate [16]. T. van Assen et al. analyzed a database of patients presenting with acute abdominal pain to the emergency department during the period 2011–2012. The frequency of ACNES as a cause of referrals was 2 %, which allowed them to calculate the prevalence of ACNES as 1:1800 patients in the general population [6].

The mechanism of nerve injury in this syndrome is not fully known. It is thought that branches of the lower thoraco-abdominal intercostal nerves Th7–Th12 may be pinched at the lateral edge of the rectus abdominis, where they run from the inner part of the abdominal wall to the outer part at right angles. At this location (about three-quarters of the length of the rectus muscle), there is a fibrous ring that provides a smooth surface for the bundle, consisting of the nerve and its vessels surrounded by fatty and connective tissue, to pass through. After passing through the aponeurosis of the rectus abdominis muscle the cutaneous nerves make another right angle to continue along the abdominal wall. The complex course of the nerve creates prerequisites for its local compression at the level of the fibrous ring, including bundle herniation in case of increased intra-abdominal pressure, tension of the muscles of the anterior abdominal wall [12].

The main clinical manifestation of ACNES is acute or chronic pain, with localization along the edge of the rectus abdominis, usually unilateral. The pain may irradiate to the upper half of the body, increase with forward bending, shaking, coughing and laughing, occur spontaneously or be associated with previous physical activity. Some patients are characterized by a decrease in symptoms in the horizontal position. Wearing a bandage (tight belt, corset) does not reduce the pain, on the contrary, it may increase it. As a diagnostic tool, a questionnaire including 18 questions detailing symptoms is proposed, but it has not been validated in Russia [6].

An objective examination reveals an area of clearly localized pain on palpation along the edge of the rectus abdominis muscle and a positive Carnett's sign [17]. A disproportionately strong sensation of pain when squeezing the skin area in the zone of maximum pain (positive "pinch test") is characteristic [18]. Analysis of data from 1,116 patients allowed us to identify four main characteristics of ACNES: sensory disturbances in the area of pain sensation (78 %), positive pinch (78 %) and Carnett's sign (87 %), and response to local injection therapy (81 % of patients noted a twofold reduction in pain) [19].

Over the years, various physical ACNES therapies have been studied, especially deep tissue massage and percutaneous electrical nerve stimulation [20]. Currently, a common treatment algorithm includes the use of antidepressants and/or anticonvulsants, and, if they are ineffective, the sequential use of a minimally invasive method — local injection therapy and, if ineffective, neurectomy [19]. Local anesthetic injections (5 mL of 1 % lidocaine, possibly in combination with glucocorticosteroids) into the trigger point on the abdominal wall are performed under or without ultrasound control, result in rapid symptom relief within 2–3 minutes, and are not only a therapeutic method, but also a diagnostic test. In general, in 50–86 % of patients after this manipulation there is a regression of symptoms, and the duration of the effect was different [21]. During neurectomy, the terminal nerve branches of the *n. intercostales* are removed at the point of maximal pain above the rectus abdominis muscle; performing the operation results in a positive outcome in 73 % of patients [22].

Another common cause of abdominal pain is ***damage to the ilioinguinal and iliohypogastric nerves***. As a rule, this syndrome develops in patients who have undergone surgical interventions in the lower abdominal cavity: inguinal hernioplasty, appendectomy and gynecological interventions with Pfannenstiel incision. The ilioinguinal and iliohypogastric nerves are branches mainly of the L_1 root, contain some fibers from L_2 (ilioinguinal) and Th_{12} (iliohypogastric), envelop the transverse and internal oblique muscles, pass through the internal and external oblique muscles of the abdomen below and medial to the anterior superior iliac ostium. They then pass through the inguinal canal and exit through the external inguinal ring. The ilioinguinal nerve is thought to be slightly more likely to be injured because it is located directly under the external oblique fascia. The mechanisms of damage to both nerves include mechanical trauma with a suture or surgical mesh [23].

Clinical symptoms may appear immediately or some time after the traumatic impact. Pain has a burning, piercing character, often accompanied by hyperalgesia, allodynia and other manifestations of neuropathic pain. Pain may have a postural character, often intensifies with abdominal distension. Sensory disturbance in the zone of innervation of the affected nerve is possible. Localization of symptoms — in the lower abdomen, typically spreading to the thigh, leg and genital area. Diagnosis is made on the basis of physical examination: pain on palpation over the nerve exit site near the iliac spinous process and positive Carnett's sign. One of the techniques that increase pain sensations is the maneuver "bending and twisting", in which the patient stands, overextends and turns the torso from and to the painful side. An additional diagnostic test is the effect of local anesthetic injection, which is injected

into the suspected site of compression or into the area of maximum pain [23]. Some studies have recommended the use of paravertebral blockade of the L_1 and L_2 roots to differentiate the affected nerves — pain relief with paravertebral blockade indicates in favor of the diagnosis of ilioinguinal nerve involvement. If oral analgesics and local injection therapy have no effect, nerve ablation or surgical treatment is sometimes used [24].

The ***sliding rib syndrome*** is associated with irritation of the intercostal nerve when false ribs (VIII–X) are hypermobile. The anterior ribs, due to weakness or rupture of the intercartilaginous joints, "slip" out of their normal anatomical position and may overlap the ribs above [25]. The first description was made in 1919 by the British orthopedist E.F. Cyriax, and later in the literature this syndrome was referred to as "Cyriax syndrome" and "snapping rib syndrome" [26]. The sliding rib syndrome can be associated with congenital anomaly, connective tissue dysplasia and occur due to trauma, either sports or domestic. The clinical picture is usually presented by sudden pain that can progress to dull, aching and spilling pain. Provoking factors are various movements, including bending, turning, coughing, relief is brought by lying on the affected side. Often patients can feel sliding, clicking in the lower part of the chest at certain movements [25]. Radiation diagnostic methods are usually uninformative, various variants of dynamic ultrasound have been proposed [27]. The "hook" symptom is the most important for diagnosis, when the doctor initially places his fingers under the lower edge of the rib arch, then moves them forward and upward, which is accompanied by displacement of the "sliding" rib and sharp pain [27]. The treatment includes the administration of nonsteroidal anti-inflammatory drugs, local injection therapy with exposure to the corresponding intercostal nerve, which relieves pain and is an additional criterion for diagnosis. In patients refractory to conservative treatment, surgical resection of the anterior rib and various modifications of rib fixation are possible [28].

Radiculopathy in thoracic spine. The area of pain in lesions of Th_7–Th_{12} extends to the abdominal wall, with the Th_7 dermatome corresponding to the subcostal region and the level of the ureter, Th_{10} — to the level of the umbilicus, and Th_{12} — to the iliac region. The causes of radiculopathies can be vertebrogenic compression, trauma, *Herpes zoster*, diabetes mellitus, less often other pathologic processes.

Discogenic radiculopathy. Root injury is usually associated with disc extrusion (herniation). It should be noted that herniated discs at the level of the thoracic spine are relatively rare — less than 1 % of all herniated discs, and much less often compared to the cervical and lumbar spine lead to compression of nerve structures due to a sufficiently large reserve of space in the spinal canal at this level. Usually, but not always, there is back pain, tension of paravertebral muscles. The pain spreads over the dermatome, is often shooting in nature, but can be constant and burning. Radiculopathies are characterized by a "mechanical type of pain" with an increase in its severity with movement and a decrease at rest, increased with coughing, sneezing and pushing, increased with flexion of the neck. In some cases, a zone of altered sensitivity with distribution over a specific dermatome is identified. In 20 % of patients with thoracic radiculopathy, motor symptoms develop in the form of paresis of the muscles of the anterior abdominal wall, which is noticeable by asymmetry in the contraction of the abdominal muscles, bulging of the abdominal wall on the affected side in the upright position. This may be accompanied by a decrease in the corresponding abdominal reflex. When Th_9–Th_{10} roots are affected, the Beevor's sign is described — displacement of the umbilical ring upward when the head is tilted. Paresis of the anterior abdominal wall muscles can mimic the picture of flatulence, which significantly complicates differential diagnosis with abdominal gastrointestinal diseases, especially when accompanied by complaints of abdominal discomfort and bloating [29]. Some patients with disc herniations at the thoracic level have clinical symptoms beyond radiculopathy. Leg weakness, increased knee and Achilles reflexes, abnormal foot signs, conductive sensory disturbances, and pelvic disorders are indicative of myelopathy, which significantly changes the management of the patient and makes it necessary to consider surgical intervention first [30].

In the diagnosis of radiculopathies, magnetic resonance imaging (MRI) of the spine is of leading importance, which makes it possible to visualize the nature and severity of structural abnormalities. As a rule, the reason for the examination is the need for a differential diagnosis, first of all, in case of suspicion of oncological or inflammatory process, or the lack of effect of standard analgesic treatment within 4–6 weeks and the planning of local injection therapy or surgical treatment.

The approach to therapy of thoracic radiculopathies depends on the severity of pain, its duration (acute, chronic), and the presence of comorbidities. Given the lack of specific recommendations for this lesion localization, treatment methods

similar to those for discogenic lumbosacral radiculopathy are usually used [31, 32]. Transforaminal epidural corticosteroid injections performed under the control of various imaging techniques have gained particular importance in the therapy of patients with radicular lesions at the thoracic level in recent years [33]. However, some investigators caution against topical diagnostic errors in selecting the target of therapy, given the large variability in dermatome maps [34].

Herpes zoster is another possible cause of anterior abdominal wall pain. *Herpes zoster* reactivation, which occurs in 30–50 % of people during their lifetime, causes lesions of the sensitive ganglia, including the posterior roots at the thoracic level. This leads to the development of vesicular rashes localized in the area of one or more adjacent dermatomes, which in the acute phase of the disease is accompanied by pain, burning, itching. In 10–34 % of patients, neuropathic pain syndrome persists for more than 6 months, in which case postherpetic neuralgia is diagnosed. Herpes zoster presents a serious diagnostic problem usually at an early stage before the manifestation of characteristic rashes within 1–7 days. As in radiculopathy of other genesis, some cases of herpetic ganglioneuritis develop motor symptoms with weakness of the muscles of the anterior abdominal wall.

Diagnosis of *Herpes zoster* when typical rashes appear is usually not very difficult. However, in difficult cases, it should be taken into account that the most accurate test for the diagnosis of Herpes zoster is PCR for varicella zoster DNA in vesicle samples with sensitivity and specificity of 95 and 100 %, respectively [35].

Early and proper administration of antiviral agents is of key importance in the treatment of *Herpes zoster*. Therapy in the acute phase of the disease usually includes non-steroidal anti-inflammatory drugs or acetaminophen, in case of intense resistant pain opioids may be prescribed, additionally antidepressants and/or anticonvulsants may be used. Therapy of postherpetic neuralgia follows the principles of neuropathic pain treatment, the first choice drugs are usually transdermal systems with lidocaine and gabapentinoids (gabapentin, pregabalin) [36].

Asymmetric diabetic neuropathy. Diabetic thoracic radiculopathy is a rare lesion both in terms of the causes of radiculopathy and among neurologic complications of diabetes mellitus. In the development of this pathology, a significant role is played by diabetic microangiopathy. Pain syndrome develops acutely or subacutely, is usually intense, often accompanied by excruciating dysesthesias. The distribution of pain has a radicular pattern with distribution around the trunk. However, the involvement of branches of the spinal nerve can be selective, which is manifested by pain localized to a certain area of the abdominal wall. Sometimes the lesion affects several thoracic dermatomes on one or both sides [37]. In some cases, weakness of the muscles of the anterior abdominal wall — "pseudohernia" — develops. There is evidence that needle electromyography can detect abnormalities in paraspinal or abdominal wall muscles in patients without obvious motor deficits [38]. Diagnosis of diabetic thoracic radiculopathy usually requires exclusion of discogenic pathology. The pain syndrome usually gradually regresses over weeks/months with treatment. Therapy is aimed at effective pain control; no specific recommendations have been developed.

Transient abdominal pain related to physical activity is considered as an independent syndrome in some literature [39]. As a rule, it concerns young people with abdominal pain, occurring during sport activities with repetitive movements (running, horseback riding). Localization in the lateral parts of the middle abdomen along the rib arch is characteristic, although it may occur in any parts and be accompanied by shoulder pain. The character of pain varies from sharp, stabbing to aching or pulling. The syndrome occurs in people of any gender and stature and can be observed even in well trained athletes. A provoking factor may be the ingestion of hypertonic drinks before exertion. Several theories have been proposed to explain the mechanism of pain onset, including diaphragmatic ischemia, compression of the phrenic artery by the medial arch ligament, and irritation of the parietal peritoneum. Commonly accepted recommendations for prevention include abstaining from large amounts of food and drink 2–4 hours before exercise, improving posture, and wearing a wide belt [40].

So-called ***"sports hernia"*** or ***athletic pubalgia*** has also been associated with physical activity. This syndrome also appears in the literature under the name "*core muscle injury*" and, despite the name, is not a true hernia. Currently, this syndrome combines various musculotendinous injuries in the peripubic region in athletes: tendinopathy of the rectus abdominis, contracture of the adductor muscle, inguinal hernia, femoroacetabular impingement and pubic ostitis [41].

Myofascial syndrome is one of the most common causes of musculoskeletal pain, in which trigger points are formed in muscles — areas of hyperexcitability, mechanical impact on which

leads to localized and reflected pain. Myofascial syndrome can develop in various muscles/muscle groups, including abdominal wall muscles. Causes of myofascial pain development are local overload and microdamage of muscle fibers, or reflex effects due to the phenomenon of viscero-motor convergence secondary to various pathological processes. In particular, myofascial syndrome sometimes occurs in patients with organic gastrointestinal diseases and persists after resolution of the visceral cause of pain [42]. A positive Carnett's sign is helpful in diagnosis. Treatment is aimed at eliminating the cause and pain relief. Local injections of local anesthetics and glucocorticosteroids into trigger points and methods of postisometric relaxation are highly effective [12].

Hernias of the anterior abdominal wall. Hernias of the anterior abdominal wall, even without impingement, can be one of the causes of abdominal pain [43]. Acquired hernias include postoperative hernias, which can occur wherever there has been an incision. The "weak" areas of the abdominal wall where hernias form in the presence of risk factors initially include the epigastric and inguinal regions, the umbilical ring, the white line of the abdomen, and the semilunar (Spigelian) line [44]. Spigelian hernias, given their rarity (0.1–2.4 % of all abdominal wall hernias), may be the cause of unrecognized abdominal pain [45]. One study demonstrated that up to 15 % of hernias are occult (not visible on examination, detected incidentally during radiation examination) [46]. Although the significance of such hernias is not completely clear, they could potentially be the cause of localized pain or discomfort. Radiologic diagnostic methods are the most informative for the diagnosis of abdominal wall hernias, especially when planning treatment [47].

Hematoma of the rectus sheath a rare and potentially dangerous clinical situation [48]. Hematomas most often occur in patients after abdominal trauma and surgical interventions. Elderly patients receiving anticoagulant therapy are at risk, especially after episodes of severe coughing [49]. Cases of anterior abdominal wall hematomas after COVID-19 infection have been described [50]. In addition to abdominal pain, the most frequent symptom is the presence of a palpable mass that does not cross the midline and may enlarge with contraction of the anterior abdominal wall muscles (Fothergill's sign). Physical examination in some patients may reveal ecchymoses on the anterior abdominal wall. Ultrasound and/or computed tomography (CT) of the anterior abdominal wall is necessary to confirm the diagnosis (Fig. 2).

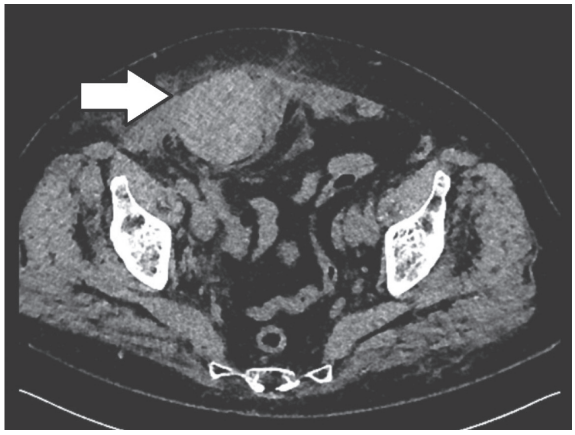

Figure 2. Abdominal computed tomography without contrast enhancement in a 62-year-old patient taking warfarin who presented with acute pain and swelling of the anterior abdominal wall. There is a hematoma — hyperdence (+73HU) homogeneous well-circumscribed round mass in the anterior abdominal wall (data obtained by the authors of the article)

Рисунок 2. Компьютерная томограмма брюшной полости без контрастирования пациента 62 лет, принимающего варфарин, который поступил с острой болью и отеком передней брюшной стенки. В структуре передней брюшной стенки определяется гематома — гиперплотное (+73 HU) однородное округлое образование с четкими границами (собственные данные)

A third of patients have signs of acute blood loss: decreased blood pressure and anemia. Such bleeding can be profuse and life-threatening, especially if it occurs in the region of the lower rectus muscle and spreads into the antecubital space (Retzius space) [51]. In most cases, conservative tactics are effective; less often, emergency intervention is necessary, consisting in surgical evacuation of the hematoma and ligation of the bleeding vessel [52].

Endometriosis of the anterior abdominal wall. Endometriosis of the anterior abdominal wall is a rare condition with an incidence of about 0.03–0.45 % and represents the appearance of endometrioid foci in the rectus abdominis or dermis, which occurs following various obstetric and gynecologic surgeries [53]. Endometriosis is most often localized in the area of the postoperative scar after cesarean section (about 85 % of all cases), but it can also occur after other interventions, including laparoscopic procedures [54]. The possible time from surgery

to diagnosis can vary from three months to two decades [53]. According to S.I. Elgina et al. when analyzing the localization of extragenital endometriosis, it was found that in 76.6 % of cases the lesion of the anterior abdominal wall is localized in the postoperative s car and in 23.3 % of patients — in soft tissues [55].

The main clinical manifestation is localized pain at the scar site during menstruation; in rare cases, the patient has skin changes, local nodules, ecchymoses on the abdominal wall during menstruation, or hyperpigmentation of the scar [56]. Transabdominal ultrasound remains the main screening tool, with subsequent clarification of the diagnosis and lesion volume by MRI or CT. Surgical treatment in the situation of endometriosis of the anterior abdominal wall is the main method of treatment.

Benign and malignant masses of the anterior abdominal wall. Tumors of the anterior abdominal wall can originate from skin, muscle, fat, bone, vessels, or be metastatic [14]. Metastatic lesion (Fig. 3) and desmoid tumor (Fig. 4) are the most common [15].

Desmoid tumor is a rare monoclonal tumor of deep soft tissues (musculoaponeurotic structures, fascia and ligaments) that is characterized by infiltrative growth, frequent recurrence and no tendency to metastasize. Tumors may occur sporadically or be associated with Gardner's syndrome. Clinical manifestations depend on the size and localization of the tumor: most often patients complain of painful nodular masses or dense infiltrates without clear boundaries [57, 58]. In general, the signs suspicious for malignancy are the presence of pain on palpation, size greater than 5 cm, location under the deep fascia, dynamic growth, recurrence after resection, and the presence of a proven malignant tumor of other localization [59, 60]. Since in most situations the clinical picture is nonspecific, radiation diagnostic methods (ultrasound, contrast-enhanced CT or MRI) are of paramount importance [13].

Infections of the anterior abdominal wall can develop after surgical interventions (Fig. 5) or be caused by specific pathogens such as actinomycosis [61]. Biopsy and morphologic

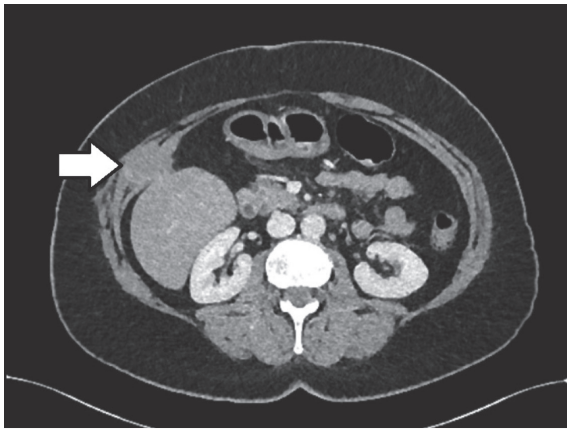

Figure 3. Abdominal contrast-enchanced computed tomograhpy (venous phase) of a 59-year-old patient with a history of lung carcinoma. There is solid lobulated mass with homogeneous diffuse contrast enhancement in the anterior abdominal wall muscles. According to the results of fine needle biopsy, metastasis of lung carcinoma (data obtained by the authors of the article)

Рисунок 3. Компьютерная томограмма брюшной полости с контрастированием (венозная фаза) пациента 59 лет с карциномой легкого в анамнезе. В структуре мышц передней брюшной стенки солидное образование дольчатой формы, однородной структуры с диффузным контрастированием. По результатам пункционной биопсии — метастаз карциномы легкого (собственные данные)

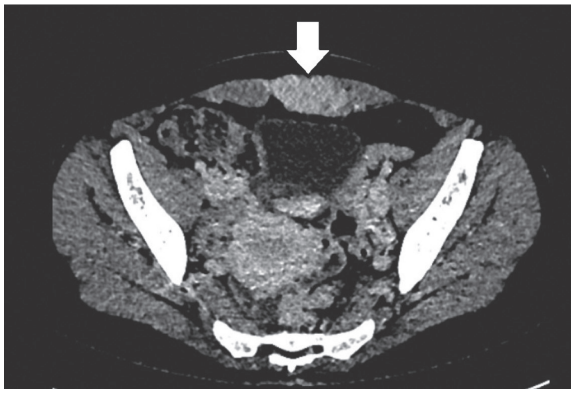

Figure 4. Abdominal contrast-enchanced computed tomograhpy (delayed phase) of a 38-year-old patient with complaints of minor pain and discomfort in the periumbilical region on the left. There is solid rounded well-circumscribed mass with homogeneous diffuse contrast enhancement in the left rectus muscle. According to the results of fine needle biopsy, a desmoid tumor (data obtained by the authors of the article)

Рисунок 4. Компьютерная томограмма брюшной полости с контрастированием (отсроченная фаза) пациента 38 лет с жалобами на незначительную болезненность и дискомфорт в околопупочной области слева. В структуре левой прямой мышцы определяется солидное округлое образование с четкими границами, однородной структуры, с равномерным диффузным контрастированием. По результатам пункционной биопсии — десмоидная опухоль (собственные данные)

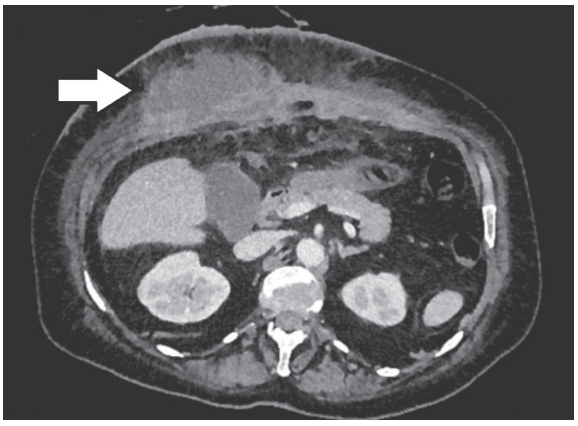

Figure 5. Abdominal contrast-enchanced computed tomograhpy (venous phase) of a 57-year-old patient with diabetes mellitus and complaints of fever, swelling and pain in the anterior abdominal wall. A circumscribed liquid round formation with a thin capsule and perifocal infiltration is determined; during surgery, an abscess of the anterior abdominal wall is confirmed (data obtained by the authors of the article)

Рисунок 5. Компьютерная томограмма брюшной полости с контрастированием (венозная фаза) пациента 57 лет, с сахарным диабетом, жалобами на лихорадку, отек и боль в передней брюшной стенке. Определяется отграниченное жидкостное округлое образование с тонкой капсулой, перифокальной инфильтрацией, при оперативном вмешательстве подтвержден абсцесс передней брюшной стенки (собственные данные)

examination of the mass are necessary to verify the diagnosis [62].

Rare causes of abdominal pain include ***Dercum's disease (neurolipomatosis)***, formerly called "adiposis dolorosa", which is an orphan disease. It is characterized by the appearance of multiple lipomas, accompanied by chronic pain, in obese individuals. Symptoms are resistant to conventional analgesics, can be provoked by mild irritation (rubbing against clothing), accompanied by ecchymoses and neuropsychiatric disorders [63, 64]. No specific therapy has been developed.

Conclusion

Pathology of the abdominal wall is a common cause of abdominal pain and is represented by a wide range of diseases. An interdisciplinary approach, knowledge of pathognomonic signs and the use of radiation examination methods are the basis of the differential diagnosis.

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Information about the authors

Anastasia I. Dolgushina – Dr. Sci. (Med.), Docent, Head of the Department of Hospital Therapy, South Ural State Medical University.
Contact information: dolgushinaai@yandex.ru;
454092, Chelyabinsk, Vorovskogo str., 64.
ORCID: https://orcid.org/0000-0003-2569-1699

Maria I. Karpova – Dr. Sci. (Med.), Docent, Head of the Department of Nervous Diseases, South Ural State Medical University.
Contact information: kmi_2008@mail.ru;
454092, Chelyabinsk, Vorovskogo str., 64.
ORCID: https://orcid.org/0000-0001-5848-7235

Сведения об авторах

Долгушина Анастасия Ильинична – доктор медицинских наук, доцент, заведующая кафедрой госпитальной терапии ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации
Контактная информация: dolgushinaai@yandex.ru;
454092, г. Челябинск, ул. Воровского, 64.
ORCID: https://orcid.org/0000-0003-2569-1699

Карпова Мария Ильинична – доктор медицинских наук, доцент, заведующая кафедрой нервных болезней ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации.
Контактная информация: kmi_2008@mail.ru;
454092, г. Челябинск, ул. Воровского, 64.
ORCID: https://orcid.org/0000-0001-5848-7235

Igor A. Karpov — Dr. Sci. (Med.), Docent, Professor of the Department of Plastic Surgery and Cosmetology of the Institute of Additional Professional Education, South Ural State Medical University.
Contact information: ikarpov174@gmail.com;
454092, Chelyabinsk, Vorovskogo str., 64.
ORCID: https://orcid.org/0009-0004-5432-2133

Карпов Игорь Александрович — доктор медицинских наук, доцент, профессор кафедры пластической хирургии и косметологии Института дополнительного профессионального образования ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации.
Контактная информация: ikarpov174@gmail.com;
454092, г. Челябинск, ул. Воровского, 64.
ORCID: https://orcid.org/0009-0004-5432-2133

Nikita B. Nadtochiy — Teaching Assistant, Department of Oncology, Radiation Diagnostics and Radiation Therapy, South Ural State Medical University; Radiologist, Chelyabinsk Regional Clinical Hospital.
Contact information: nnb77@bk.ru;
454092, Chelyabinsk, Vorovskogo str., 70.
ORCID: https://orcid.org/0000-0001-7123-120X

Надточий Никита Борисович — ассистент кафедры онкологии, лучевой диагностики и лучевой терапии ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации; врач-рентгенолог ГБУЗ «Челябинская областная клиническая больница».
Контактная информация: nnb77@bk.ru;
454092, г. Челябинск, ул. Воровского, 70.
ORCID: https://orcid.org/0000-0001-7123-120X

Anna A. Saenko* — Teaching Assistant, Department of Hospital Therapy, South Ural State Medical University.
Contact information: anna-selyanina@mail.ru;
454092, Chelyabinsk, Vorovskogo str., 64.
ORCID: https://orcid.org/0000-0002-3481-8092

Саенко Анна Алексеевна* — ассистент кафедры госпитальной терапии ФГБОУ ВО «Южно-Уральский государственный медицинский университет» Министерства здравоохранения Российской Федерации.
Контактная информация: anna-selyanina@mail.ru;
454092, г. Челябинск, ул. Воровского, 64.
ORCID: https://orcid.org/0000-0002-3481-8092

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* Автор, ответственный за переписку / Corresponding author