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# Duodenal Ulcer and Its Complications: Bleeding, Perforation, Penetration

**Dmytro Maksymchuk** [a]

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***Corresponding Author*** [a]

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**Abstract**

The relevance of the research on this topic is conditioned by the fact that duodenal ulcer is a serious problem, which is addressed by the efforts of a huge number of gastroenterologists around the world, and therefore it is necessary to comprehensively study as much as possible modern theoretical information on this issue. In this regard, this study is aimed at the fullest possible disclosure of the theory accumulated to date regarding information about duodenal ulcer and their complications, namely: bleeding, perforation, penetration. The leading approach to the study of this issue is an empirical method that makes it possible, in combination with many theoretical methods, to conduct a comprehensive comparative analysis of the existing array of scientific literature, which, most importantly, is relevant to the present time, and, possibly, to identify certain new approaches regarding various aspects in issues related to duodenal ulcer and its complications. This paper presents the results of a theoretical review of information about duodenal ulcer and its complications that have appeared in the literature recently, and covers various aspects related to this disease, with much attention paid to the issues of complications.



**Contents**



[a] Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine

## 1 Introduction

Duodenal ulcer is a type of peptic ulcer that is a serious disease. Duodenal ulcers develop in the mucous membrane of the duodenum, which is the first part of the small bowel (Johnson, 2018). Peptic ulcer disease can be identified as a separate disease, or it can be considered from the position of symptomatic ulcers that occur in the case of various chronic diseases of internal organs, taking certain types of medications, endocrine disorders, as well as so-called "stress ulcers" (Ivashkin et al., 2020). Anatomically, the surface of the stomach and duodenum contains a protective system that includes preepithelial, epithelial, and subepithelial elements. Ulceration occurs as a result of damage to the surface of the mucous membrane, which extends beyond the surface layer. While most duodenal ulcers are manifested by dyspepsia as the main associated symptom, the manifestations can vary in severity (Quinones & Woolf, 2021).

A high risk of complications, primarily bleeding, perforation, and penetration is a considerable problem that occurs in this duodenal ulcer (Petrova et al., 2014). In the treatment of a large number of patients with peptic ulcer disease, H2-blockers as well as proton pump inhibitors (in another way, PPIs) are used. Some patients are treated using endoscopic methods, while an examination for the presence of H. pylori is conducted. It is important to note that the need for surgical intervention is reduced, which is due to advances in drug therapy, as well as advances in endoscopic treatment (Tazhbenova et al., 2019). Surgical intervention for peptic ulcer disease, which was once common, is now prescribed only for the treatment of PUD complications that are not amenable to other non-surgical methods of treatment (Hasadia et al., 2018). At the same time, the treatment of all acute complications of duodenal ulcer is an important task facing modern surgery. At the moment, the observed trend reflects the fact that the opportunities provided by surgery do not coincide with the practice available in the clinic (Babkin, 2017).

It is necessary to study this disease in detail from different sides, considering new approaches in terms of diagnosis, treatment, the definition of its general characteristics. According to numerous studies that estimated the prevalence of duodenal ulcers, they occur in about 5-15% of the population of Western countries. It is important to note that H. pylori infection makes a considerable contribution to the development of duodenal ulcers (Labenz et al., 1996). The main reason may also be the use of non-steroidal anti-inflammatory drugs. It is believed that colonization of mucosa with H. pylori and persistent inflammation leads to the weakening of its surface layer and it becomes vulnerable to hydrochloric acid. Another theory says that H. pylori can lead to increased production of hydrochloric acid, and this, in turn, further aggravates the initial damage. It is also known that certain prostaglandins play an important role in the production of protective mucus in both the stomach and small bowel. The cyclooxygenase enzyme catalyzes their biosynthesis (La Vonne & Zun, 2008; Simonetti et al., 2020). Taking nonsteroidal anti-inflammatory drugs leads to the inhibition of the catalytic pathways of both isoforms of this enzyme, which means that the number of prostaglandins decreases, which leads to negative consequences for the mucosa. Thus, taking this group of drugs is one of the pathophysiological factors in the occurrence of duodenal ulcers (Olbe et al., 1996). Other causes can also lead to peptic ulcer disease by various mechanisms, and the result, as a rule, is a recurrent lesion of the mucosa, which in turn predisposes the tissue to ulceration or an increase in the secretion of gastric acid, which also leads to damage (Quinones & Woolf, 2021).

Despite the differences observed in various studies regarding the role of H. pylori in the development of duodenal ulcers, the presence of a causal relationship between H. pylori infection and duodenal ulcer has been proven. Other factors are also responsible for the development of duodenal ulcers, they also affect differences in the prevalence of diseases (Ahmed & Belayneh, 2019). It was typically believed that hypersecretion of hydrochloric acid together with faulty diet and stress were the causes of peptic ulcer disease, but the discovery of H. pylori, as well as the widespread use of NSAIDs in therapeutic practice, led to this perception changing in the second half of the 20th century (Lanas & Chan, 2017). Given the prevalence of this disease, it is extremely important to comprehensively study all the available information concerning this issue, based on the most modern-day data from reliable sources.

## 2 Materials and Methods

In the course of the research, various empirical methods were used (the study of the information accumulated to date on a given topic, the description of the collected data, the comparison of the information obtained), as well as many theoretical methods (study and generalization; analysis; synthesis; systematization; concretization; classification; induction and deduction); to describe the results obtained, it was necessary to use empirical methods of mathematical statistics, as well as a graphical representation of the results. Individual provisions were derived from general ones when using the deductive method. On the contrary, general provisions were derived from individual ones using the induction method. In the case of synthesis, various related elements were combined into a common logical structure for them. In contrast, in the analysis, the general structure was divided into its constituent parts. When specifying the studied provisions, they were interpreted in such a way that it was possible to identify some important properties for them and their specific relations. Various signs of the studied phenomena were compared, and, at the same time, the differences between them or, on the contrary, similar factors were identified. In all cases, an important part of the research is the collection of information, as well as the subsequent systematization together with the generalization of the described phenomena. As a result, the investigated facts were subjected to subsequent processing, while the existing relations between them were evaluated. All this made it possible to describe the collected information using scientific terminology specific to this field of knowledge and classify them according to the patterns identified in this case. Subsequently, the analysis acquires a deeper character and reaches the deep essence of the studied provisions. After that, it becomes possible to formulate certain conclusions together with recommendations regarding the practical side of the area under study. It is important to note that an integrated approach to the use of all these methods determines the desired result, and the studied phenomena were subjected to a comprehensive review. In addition, it is necessary to understand that in this study, as in any other, the methods used were refracted especially to ensure that they could be used to solve the tasks initially set.

The study of the problem was conducted in several stages: firstly, a theoretical analysis of existing methodological approaches in the scientific literature, dissertations on the issue, as well as the theory and methodology of research was carried out; at the same time, the purpose, methods of the research were determined and the relevance of the work was substantiated. Further, the theoretical conclusions obtained during the study were analyzed, verified, and clarified. Lastly, the final theoretical and practical conclusions were made, the results obtained were summarised and systematized. To write this paper, literary sources that have been published over the past few years were selected and analyzed. Its results were described and summarized in the following sections of this paper.

## 3 Results and Discussions

Anatomically, the duodenum is a part of the gastrointestinal tract and is located between the stomach and the small bowel. It includes four segments: the proximal segment, which is known as the duodenal bulb and connects to the liver through the hepatoduodenal ligament containing the hepatic artery, portal vein, and common bile duct. The second or descending segment surrounds the head of the pancreas. The third segment is the horizontal part. The upper mesenteric vessels are located ventrally to this segment. The fourth segment follows before the jejunum (Amini & Lopez, 2021; Widana et al., 2021). Duodenal ulcers are associated with three main complications: bleeding, perforation, and obstruction. Most patients with bleeding undergo endoscopic intervention. However, for a smaller part of patients, a complete surgical intervention is required. A small percentage of patients (from 2% to 10%) may experience perforation (Lanas et al., 1997). These patients usually complain of very severe diffuse abdominal pain, which can begin as epigastric pain and become generalized. Surgical intervention needs consideration in patients with perforated ulcers. However, a small percentage of patients may experience spontaneous sealing of the perforation. Gastric outlet obstruction is the rarest complication associated with duodenal ulcer and studies concerning treatment and diagnosis are limited (Quinones & Woolf, 2021; Novoa, 2021).

Statistics regarding the occurrence of uncomplicated peptic ulcer disease have decreased in recent years. At the same time, complications of peptic ulcer disease are an important problem. There may be a connection with the widespread practical use of non-steroidal anti-inflammatory drugs in therapeutic practice, in addition, therapy with non-steroidal anti-inflammatory drugs (NSAIDs) may increase the risk of relapse of complications. Mortality after complications of peptic ulcer disease increases with age (van der Ende et al., 1996). Timely diagnosis and treatment of complicated ulcers can reduce mortality. The use of proton pump inhibitors may help reduce the risk of complications of peptic ulcer disease, and also reduce the risk of recurrent bleeding in patients with a history of ulcerative bleeding. These conclusions were made in the analysis of 93 studies (Lau et al., 2011). Duodenal perforation is a rare complication but it poses a mortal threat. The mortality rate ranges from 8% to 25% in the literature. In 1688, a perforated duodenal ulcer was described by Muralto and reported by Lenepno. Subsequently, in 1894, Dean reported the first case of successful surgical closure of a perforated duodenal ulcer. In 1929, Cellan-Jones described a technique for healing perforations using omentum, and later, in 1937, Graham modified this technique. The perforation of the duodenal ulcer can be free or covered. Free perforation occurs when the contents of the intestine freely permeate into the abdominal cavity and cause general peritonitis. Covered perforation occurs when an ulcer forms a hole for the entire thickness, but adjacent organs, such as, for example, the wall of the pancreas, outside this area, prevent free flow (Kurtieva et al., 2021; Susilo et al., 2021).

A peptic ulcer is a common cause of duodenal perforation. As a rule, patients with duodenal ulcers experience abdominal pain or hunger at night. A perforation can usually cause sudden severe pain in the upper abdomen. However, in patients with weakened immunity or elderly patients, clinical signs may be undetectable and delay the diagnosis (Amini & Lopez, 2021).

Regarding the etiology of perforated duodenal ulcers, it is believed that the leading cause of their occurrence is peptic ulcer disease (Huang et al., 2002). Acute duodenal perforation is estimated to occur in 2–10% of patients with ulcers. And the two main causes of peptic ulcer disease and, accordingly, the resulting perforation are H. pylori infection and taking NSAIDs. In patients with recurrent ulcers, despite active treatment, it is necessary to take into account hypersecretory conditions, such as Zollinger-Ellison syndrome. Duodenal perforation can also occur in people with diverticula and ischemia of the duodenum, infectious and autoimmune diseases, including Crohn's disease, scleroderma, and vasculitis (for example, polyarteritis nodosa). In addition, tumors can directly penetrate the wall of the duodenum or cause obstruction. The perforation may also be associated with chemotherapy. Retinated gallstones in the duodenum may also be associated with perforation (Yeung et al., 2004). Endoscopy of the upper digestive tract can lead to iatrogenic perforations in the duodenum. The frequency of endoscopic perforations is higher for medical procedures. The rate of duodenal perforation after retrograde cholangiopancreatography (ERCP) ranges from 0.09 to 1.67%. Stapfer Scale was developed to classify perforations associated with ERCP. Type I perforations – large lateral or medial perforation of the duodenal wall – are usually caused by an endoscope. Type II perforations, also known as perivaterial lesions, are associated with sphincterotomy. Type III perforation is damage to the distal bile duct, while type IV perforation is only air in the retroperitoneal space, which can be observed in images, and often proceeds asymptomatically. Risk factors for perforations associated with ERCP are old age, dysfunction of the Oddi sphincter, the presence of a preliminary incision, intramural injection of a contrast agent, and anatomical anomalies such as after gastrectomy according to Billroth II.

Surgical intervention can also lead to perforation of the duodenum. The damage caused may go unnoticed during the initial surgery and appear a few days later in the form of delayed perforation due to coagulation necrosis of the duodenal wall (Carchi et al., 2021). Laparoscopic cholecystectomy is one of the most common surgical procedures in general surgery. In a group of 77,604 patients who underwent laparoscopic cholecystectomy, 12 duodenal injuries were registered (0.015%). In the world literature, 74 cases of duodenal damage after laparoscopic cholecystectomy have been identified. The mechanisms of injury are mainly associated with thermal burns, electrocoagulation, or sharp or blunt dissection.

Duodenal injuries are rare and account for less than 2% of all abdominal injuries. Most injuries of this kind occur due to penetrating injuries. Isolated injuries of the duodenum are rare, they often occur together with injuries to other organs and damage to large vessels. Ingested foreign bodies usually pass through the gastrointestinal tract without complications. Less than 1% cause perforation. Ingestion of sharp and thin foreign bodies is associated with a higher risk of perforation. Implanted foreign bodies, such as an endoprosthesis or an artificial vessel, can cause erosion of the duodenum, leading to the formation of fistulas

and abscesses. Spontaneous perforations can occur in newborns. The reason underlying this phenomenon remains unknown (Ansari et al., 2019). One study has identified that duodenal ulcer perforation was more common in the age group from forty to forty-nine years (sixty cases were studied in which this complication occurred). The highest incidence rate was found at the age of forty – forty-nine years (25%), then twenty – twenty-nine years (21.67%), then thirty – thirty-nine years (20%), and then fifty – fifty-five years (15%) (Noola & Shivakumar, 2016).

Treatment of duodenal perforation depends on the type of perforation. With a covered type of perforation, conservative treatment is possible. Before starting conservative treatment, it is important to examine patients using diatrizoate to confirm the absence of gastrointestinal tract contents' permeation. Conservative treatment consists of intravenous infusion therapy, abstinence from eating and drinking (nil per os), intravenous administration of proton pump inhibitors (PPIs), broad-spectrum antibiotics, H. pylori eradication, and repeated clinical assessment of the condition. The data show that somatostatin may be useful for closing the enterocutaneous fistula. Studies have shown that in patients with covered perforations, the mortality rate for conservative treatment was 3% compared to 6.2% for surgical treatment. The most important components of conservative treatment of duodenal perforation include repeated clinical examination; radiologically confirmed absence of gastrointestinal tract contents' permeation; repeated blood tests; support of the urinary and respiratory systems.

Small and large perforations are two subtypes of the group of free perforations of duodenum ulcers. For small perforations, there are two main treatment strategies – endoscopic or simple surgical intervention. Large-sized free perforations usually require reconstructive surgery, which includes duodenoduodenostomy (the first option), duodenoejunoanastomy (the second option), and Billroth II surgery. Perforation in the first or proximal second part requires treatment with Billroth II surgery. Sepsis is a frequent complication in the perforation of a duodenal ulcer, which leads to a fatal outcome in about 40-50% of cases. Upon arrival in the surgery room, from 30% to 35% of patients with duodenal ulcer perforation already have sepsis. More than 25% of patients have septic shock within the first month after surgery, the mortality rate from which ranges from 50% to 60%. Postsurgical complications were reported in 30% of patients. Age over 40 years, a history of shock, and a larger perforation size are considered risk factors that cause an increase in the frequency of postsurgical complications. Common surgical complications include pneumonia, wound breakdown, peritonitis, the occurrence of postoperative hernia and enterocutaneous fistula, intraabdominal abscess, infection in the surgical area, and intestinal obstruction. Out of these, an infection of the surgical intervention area (32%) is considered the most frequent complication after the surgery (Amini & Lopez, 2021).

Figure 1. A case from clinical practice

Figure 1 (Francavilla & Pollock, 2017), demonstrates the results of computed tomography (CT) of the abdominal cavity of a patient with a perforation of the duodenal ulcer obtained in the axial direction, with contrast enhancement (after oral and intravenous contrast). Attention is drawn to the free extravasation of oral contrast from a discrete defect of the anterior edge of the first part of the duodenum (arrow) into the abdominal cavity (asterisks). Oral contrast spreads from below (not shown) along the right paracolic gutter into the pelvis and collects in the recto-uterine pouch. Over the past decade, there have been considerable changes in the approach to abdominal surgery – from laparotomy to minimally invasive operations. Currently, laparoscopy has become the gold standard in most planned abdominal procedures. However, there is still a debate about the use of a laparoscopic approach in emergency cases, such as peritonitis. On the one hand, previously published studies warn, for example, about possible pneumoperitoneum-induced pneumonia, while, on the other hand, there are advantages with less need for postsurgical analgesia and shorter hospitalization.

One of the conditions in which laparoscopic access can be considered is a perforated duodenal ulcer. Clearly, due to the success of drug therapy, the frequency of conditions associated with duodenal ulcers and requiring urgent medical care has sharply decreased and planned surgical intervention for duodenal ulcers has been practically abandoned. But duodenal ulcer perforation is one of the complications which is still common in emergency departments. The discussion on the comparison of laparoscopic access with laparotomy in the treatment of perforated duodenal ulcers is not yet complete even after a decade. Thanks to recent advances in minimally invasive surgery, laparoscopy is giving more and more promising results, and this should be taken into account for patients with duodenal ulcer perforation, so it is possible that performing laparoscopy instead of laparotomy in this situation may be the best solution (Murad et al., 2020).

One of the studies evaluated the effectiveness and safety of laparoscopy as an initial approach to the treatment of duodenal perforations. It was noted that for patients undergoing laparoscopic treatment, the number of hospitalizations to the intensive care unit, the occurrence of acute kidney damage, and acute respiratory distress syndrome is smaller. The study reflected how duodenal perforation in a total of one hundred patients was treated. In patients who underwent laparoscopic surgery, the chances of recovery without complications were 4.3 times higher than in patients who underwent open surgery. It is generally noted that laparoscopy in the treatment of a perforated duodenal ulcer is considered safe and can be used as a routine method of treating this pathology (Jamal et al., 2019).

Another study examined the results obtained from the accelerated rehabilitation program for patients with perforated duodenal ulcers. Data were collected on two hundred and six patients. The main group consisted of seventy-seven patients with a perforation diameter of up to one centimeter, where the ulcer was sutured laparoscopically and a protocol for accelerated rehabilitation was performed. The control group consisted of one hundred twenty-nine patients for whom open ulcer suturing was performed, and the postsurgical period remained conventional. In the main group, postsurgical complications were observed in one case (1.3%), there were no fatal outcomes, and the average duration of stay in the hospital was 4.8 days. In the control group, there were no complications, the mortality rate was 2.3%, and the duration of stay in the hospital was on average 8.1 days. Laparoscopic methods in the treatment of perforated ulcers provide an opportunity to use the program of accelerated rehabilitation of patients in emergency surgery. Conditions are created for the early discharge of the patient, and, accordingly, it is better both from the economic and clinical points of view. Relapses may occur in cases where there is no controlled anti-ulcer therapy (Khripun et al., 2018).

Another study also notes that surgical treatment of a perforated ulcer is safe to carry out using the laparoscopic method and this method has no disadvantages. Seventy-one patients were examined in a retrospective study. Patients who underwent laparoscopic surgery stayed in the hospital for less time. At the same time, it was noted that the frequency of complications and mortality in the groups did not differ. Seven prognostic factors for the occurrence of septic complications were found: age over seventy years, a history of diseases of the cardiovascular and respiratory systems, class 3 and higher on the ASA scale of assessment of the patient's status, the concentration of C-reactive protein is more than 100 mg/l, the Mannheim peritonitis index is more than 21, the time from the onset of symptoms is more than a day, and general peritonitis. Therefore, factors suggesting imminent septic complications can be evaluated before surgery (Muller et al., 2016). Gastrointestinal bleeding is still a common cause of hospitalization (Raju et al., 2007). Although endoscopy is the gold standard of treatment, to ensure the optimal choice of therapy, it is necessary to apply an interdisciplinary approach. In 85% of cases, the bleeding site is localised proximal to the Treitz's ligament

and, therefore, is classified as bleeding from the upper gastrointestinal tract. Acute bleeding from the upper gastrointestinal tract remains an important clinical problem with a frequency of 37–172 per 100,000 people. Despite the success of pharmacology and endoscopy, mortality remains high, that is, up to 14% in recent decades; this may be the result of demographic changes when older patients suffer from concomitant diseases.

Non-varicose bleeding is the most common cause of bleeding from the upper gastrointestinal tract, with 31-67% of cases caused by peptic ulcer disease. It was noted that duodenal ulcers bleed 1.3-2.3 times more often than gastric ulcers. Due to anatomical aspects, endoscopic therapy of bleeding from duodenal ulcers can be very difficult, especially if the bleeding site is located on the posterior wall of the duodenal bulb. In addition, the gastroduodenal artery is located directly behind the posterior wall of the duodenum, and erosion of this artery or its branches can lead to massive bleeding and is associated with an increased risk of repeated bleeding. Therefore, it is not surprising that duodenal ulcer complicated by bleeding is associated with higher rates of mortality, the need for surgery, and re-hospitalization compared to gastric ulcers. Therefore, it is especially important to know the current recommendations for the management of patients with upper gastrointestinal tract bleeding and recent studies to adhere to a systematic therapeutic approach. In addition, with duodenal ulcers associated with a high risk, it is very important to control bleeding when endoscopic treatment has not given the necessary effect and the bleeding persists or recurs.

The initial stabilization of hemodynamics is the first step to the treatment of duodenal ulcers complicated by bleeding. In addition to fluid replacement, the possibility of transfusion of red blood cells should be considered to stabilize the condition of patients. Bleeding can have a wide range of clinical manifestations from minor bleeding up to hemorrhaging shock with a fatal outcome. Therefore, early risk assessment is extremely important for classification into high and low-risk categories to develop further therapeutic strategies for patient management. Several prognostic estimates have been developed for pre-and post-endoscopic calculations. The Glasgow-Blatchford and *Rockall scores* are the most popular and frequently used. The use of proton pump inhibitors (PPIs) has been evaluated in several studies and is recommended in the guidelines for drug treatment before and after endoscopy. An analysis involving 2223 patients showed that pre-endoscopic administration of PPIs considerably reduces the possibility of high-risk bleeding and the need for endoscopic intervention, however, interestingly, this did not affect the likelihood of repeated bleeding, mortality, or the need for surgical intervention. In addition, it has been shown that prokinetics, having a positive effect on gastric emptying, when administered before endoscopy (usually 30-120 minutes before), improve endoscopic visualization. However, the use of PPIs and prokinetics should not delay emergency endoscopy in patients with active bleeding from an ulcer.

Endoscopy is the absolute gold standard for the diagnostics and treatment of bleeding duodenal ulcers. Localization of the exact site of bleeding allows for further risk stratification and endoscopic therapy in one step. However, the timing of endoscopy in patients with upper gastrointestinal bleeding is still often discussed (Kjeldsen & Kjeldsen, 2000). The latest recommendations suggest performing an endoscopy within 24 hours after the encounter. However, it is necessary to further differentiate patients according to their risk profile and hemodynamic situation. In patients with hemorrhaging shock, endoscopy should be performed urgently after hemodynamic stabilization in 12 hours.

Immediately after the endoscopy, it is very important to re-evaluate the individual risk for each patient to identify "high-risk" patients with an increased risk of repeated bleeding and mortality. It should be noted here that there is no precise standardized definition of "high risk", especially in the case of duodenal ulcers. Repeated bleeding occurs in 8-25% of patients, and this is still a serious problem in the treatment of this condition. Alternative treatment strategies should be chosen when endoscopy does not give results and the bleeding persists or recurs. In general, 2 treatment options are currently available: surgical intervention and transcatheter arterial embolization (TAE). Historically, surgical treatment was considered the first treatment option after a failed endoscopy. As for bleeding ulcers, there are still the following two indications for surgical intervention: firstly, when endoscopic therapy is ineffective and the bleeding persists, and secondly when the bleeding recurs after a successfully repeated endoscopy. About 2.3–10% of patients require surgery due to unsuccessful endoscopic treatment.

TAE is a serious alternative to surgical intervention. Initially, TAE was used only for unsuitable candidates for surgery, while surgery was the main treatment option in patients with ongoing bleeding. However, TAE has become widespread and is currently used in clinical practice. In several studies, it has been demonstrated

that this is a safe alternative even for patients who are unsuitable for surgical intervention. However, when analyzing the frequency of repeated bleeding, it was shown that TAE may be associated with an increase in the frequency of repeated bleeding compared to surgery. It is important to understand that further decisions regarding the treatment of patients after unsuccessful endoscopy should be made in a multidisciplinary manner (collectively by an endoscopist, surgeon, and radiologist), taking into account the individual condition of the patient (age and concomitant pathologies) and the features of bleeding (Mille et al., 2021). It was identified that the presence of a history of gastroduodenal ulcer is an independent risk factor when assessing the need for endoscopic intervention among patients with bleeding in the upper gastrointestinal tract (in addition to the assessment according to the Glasgow-Blatchford prognostic criteria for bleeding risk and the urea-creatinine nitrogen scale) (Takatori et al., 2018).

In one study, the concentrations of various cytokines were studied in patients with duodenal ulcers complicated by bleeding Figure 2 (Mille et al., 2021). It is known that the presence *of H. pylori* triggers local and systemic cytokine signaling, which, in turn, can affect healing and carcinogenesis processes, as well as possible perforation. It was shown that in patients infected *with H. pylori*, the concentrations of pro-inflammatory interleukin 6 and tumor necrosis factor in the blood serum are significantly higher. The protective role of interleukin 17A in *H. pylori* eradication in infected patients is also emphasized (Milic et al., 2019).

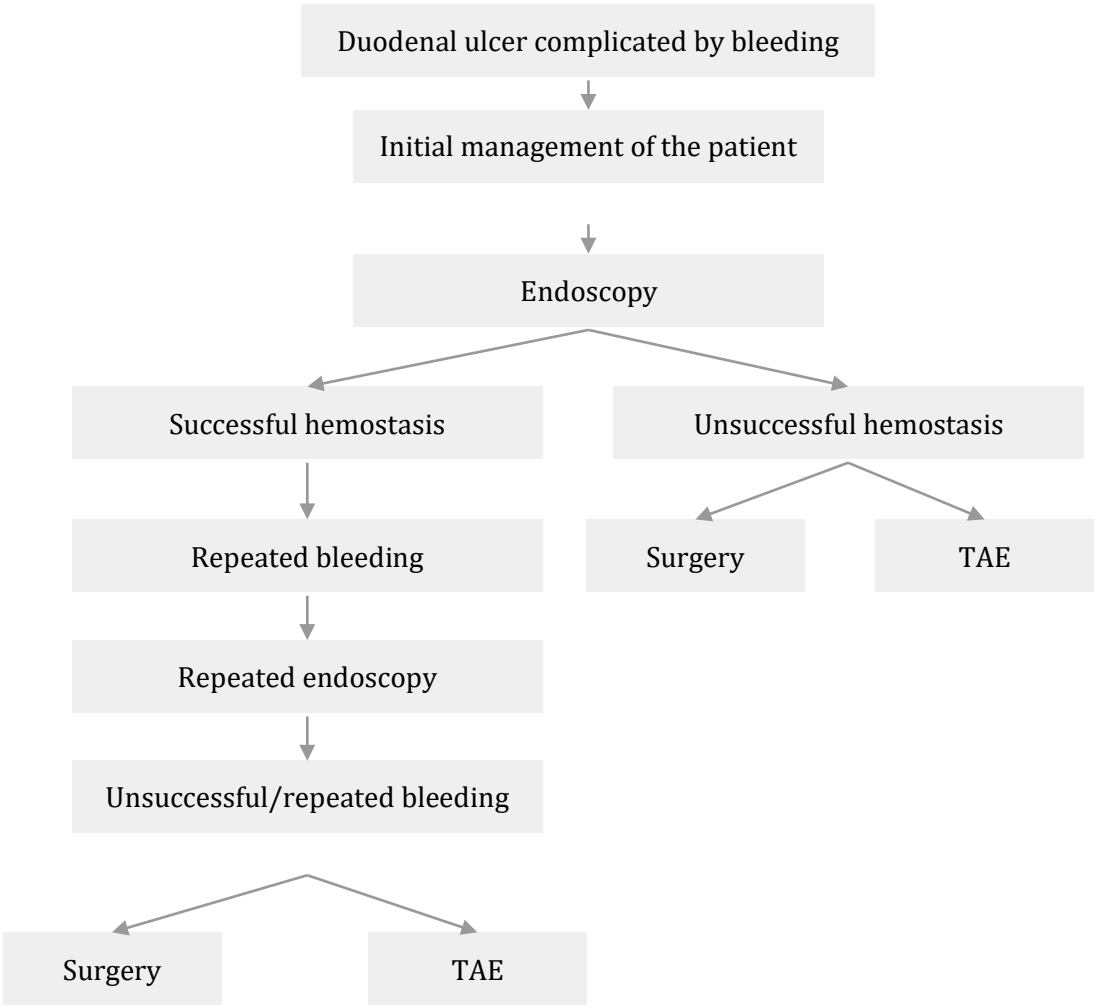


Figure 2. The scheme reflects the algorithm of actions when working with a patient with a duodenal ulcer complicated by bleeding

When the ulcer crater breaks through the stomach or intestinal tract wall into the surrounding tissues but there is no free perforation or permeation of the contents into the abdominal cavity, this is called penetration. The pancreas is the most frequent site of penetration (Banks et al., 1994). Other sites of penetration include the omentum, bile ducts, liver, colon, mesocolon, and blood vessels. Patients may notice a change like abdominal pain, that is, pain that is not relieved by food or medication. The diagnosis is confirmed by intravenous contrast computed tomography. The treatment is surgical intervention (Qi & Koruth, 2020).

The penetration of a duodenal ulcer is characterized by the symptoms that indicate damage to other organs associated with this condition (in particular, symptoms that can give cholecystocholangitis, pancreatitis, etc.). Usually, penetration occurs in the pancreas (head, body) and the small omentum (Mens et al., 1983). It is less common for the liver, transverse colon, and gallbladder. It is important to note that in the blood test, in this case, an acceleration of the erythrocyte sedimentation rate will be observed; as well as leukocytosis (Kutyavina et al., 2020). Penetrating duodenal ulcer is a rare cause of acute necrotic pancreatitis. In this case, transmural endoscopic drainage can completely remove the necrotic contents through a stoma formed between the lumen of the gastrointestinal tract and the cavity of the necrotic cluster (Jagielski et al., 2015).

Obstruction of the gastric outlet occurs in less than 5% of peptic ulcer disease cases. Duodenal ulcers and pyloric canal ulcers are usually associated with this condition. Pathophysiologically reversible causes (such as inflammation, oedema, spasm, and impaired pyloric motility), as well as irreversible causes (such as fibrosis), can lead to obstruction. Patients complain of nausea, vomiting, early satiety, epigastric pain, and weight loss. Patients may develop severe dehydration, azotemia, hyponatremia, hypochloremic and hypokalemic metabolic alkalosis with paradoxical aciduria due to prolonged vomiting. First of all, it is necessary to correct the lack of fluid and electrolytes. The gastric contents should be removed using a large-diameter Ewald tube, and then periodic suction through a nasogastric tube should be continued for several days. In many cases of obstruction, there are reversible components that can be treated conservatively. Patients who do not respond to conservative treatment require endoscopic dilation or surgery (Qi & Koruth, 2020).

Russian scientists have shown that with the help of combination therapy, it is possible to control lipid peroxidation and changes in the antioxidant blood status in patients with duodenal ulcer disease. At the same time, an endoscopic assessment of the condition of the duodenum was performed together with biochemical blood tests. At the same time, combination therapy implies laser, antioxidant, as well as conventional therapy. It was observed that this kind of therapy led to the more effective restoration of the duodenal mucosa in comparison with standard therapy (triple), which is used with the conventional scheme (Polozova, 2017).

One study evaluated the effect of therapy directed against *H. pylori* on the intestinal microbiota among patients with duodenal ulcers together with and without a probiotic complex. Patients were randomly distributed so that someone received only proton pump inhibitors together with clarithromycin and amoxicillin, and someone also received Bacillus subtilis and Enterococcus faecium together with these drugs. It is also important to note that it was identified: in patients with duodenal ulcers, the diversity and number of intestinal bacteria are less compared to the control group. At the same time, there was also a decrease in the number and diversity of intestinal bacteria and fungi for patients undergoing therapy without taking a probiotic complex, while no such changes were observed in the other group (Zhanabayeva et al., 2021). The results show that treatment of *H. pylori* caused a considerable decrease in the diversity of the intestinal microbiota, while combination therapy allowed protecting and restoring the intestinal microbiota (Wu et al., 2019).

## 4 Conclusion

Duodenal ulcer is a common clinical problem. The two most important risk factors are the infection with H. pylori and taking non-steroidal anti-inflammatory drugs. Patients may have dyspepsia, and the course of the disease may be asymptomatic at the initial stages. Endoscopy is the gold standard for the diagnostics of peptic ulcer disease, although there are also non-endoscopic methods. Duodenal ulcers can be complicated by bleeding, perforation, penetration, and obstruction of the gastric outlet. Patients with bleeding should be examined and treated according to the methods. To achieve hemostasis, it is recommended to perform diagnostic and therapeutic endoscopy. If endoscopic therapy does not give results, the next step is TAE or

surgery. The mortality rate caused by bleeding from peptic ulcer disease remains high. Perforation of a duodenal ulcer is also a lethal complication. The therapy depends on the type of perforation and may include both conservative methods and surgical intervention. Penetration is less common and is often associated with the pancreas.

The prognosis for patients with duodenal ulcers varies according to the severity of the initial condition. If the main reason was the use of non-steroidal anti-inflammatory drugs, then it is often possible to solve the problem by canceling this therapy together with symptomatic therapy of peptic ulcer disease. Patients infected with H. pylori need, first of all, to eliminate the infection, which in turn will affect the speed of recovery. Patients with complicated cases will be exposed to a higher mortality rate and the risk of complications with a potentially possible surgical intervention. To prevent possible complications of duodenal ulcers, timely diagnosis is extremely important. The doctor must collect a complete medical history, including detailed information about the symptoms present and the medications taken. In more complex cases, an interdisciplinary approach to diagnostics and treatment is extremely important, namely, a comprehensive professional approach. It should be noted that prevention is better than treatment. Therefore, it is recommended to avoid risk factors that can lead to peptic ulcer disease. Monitor nutrition and personal hygiene, avoid contaminated water and food, as well as avoid everything that leads to increased secretion of gastric acid – alcohol, cigarettes. Thus, it can be concluded that the problem of duodenal ulcer and its complications remains relevant to this day, therefore, it is actively considered in the scientific literature of recent years and continues to be studied, while new methods of diagnostics and treatment are being gradually introduced.

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## Biography of Author

**Dmytro Maksymchuk**
He is PhD Student, Department of Surgery and Proctology, Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine.
*Email: maksymchuk5896@murdoch.in*