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THE ROLE OF INTERVENTIONAL RADIOLOGY IN THE COMPLEX MANAGEMENT OF PORTAL HYPERTENSION COMPLICATIONS. LITERATURE REVIEW

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Abstract

Introduction. Portal hypertension in cirrhosis remains a cause of complications (variceal bleeding, ascites, hypersplenism, hepatic encephalopathy); minimally invasive interventional tactics are indicated in a significant proportion of patients.

Purpose of the study. To summarize data on the efficacy and safety of TIPS, BRTO/PARTO/CARTO, PTHVE and partial splenic artery embolization (PSE), as well as on portal pressure monitoring and postoperative management.

Search strategy. Review (2005–2025) in PubMed/MEDLINE, Scopus, Web of Science, eLIBRARY; RCTs, cohort/retrospective studies, meta-analyses were included; observational studies, abstracts and outdated reviews were excluded. A total of 315 studies were identified, 58 of which were included in the analysis.

Results. Endoscopic ligation provides primary hemostasis in 90–95% and, when combined with β-blockers, reduces recurrence by 40–50%; PTHVE – hemostasis 85–95%, 1-year recurrence ~15–20%, serious complications 3–5%; TIPS prevents recurrence in 80–90% of patients, PE 25–35%; the addition of embolization to TIPS reduces the risk of rebleeding (RR≈0.58), with post-TIPS PPG >12 mmHg – HR≈0.47; for gastric varices BRTO – success 90–95%, PE <5%, PARTO/CARTO are comparable; in refractory ascites TIPS reduces the recurrence rate by more than 70%; PSE increases platelet count by 40–60%: effect lasts ≥6–12 months. Optimization and monitoring: 8 mm stents reduce PE rate; success – HVPG reduction by ≥20–30% or <12 mmHg; Doppler signs of dysfunction – velocity <90 cm/s or >50% gradient; CT/MRI control at 4–6 weeks, ultrasound every 3 months.

Conclusions. Interventional radiology is central; novelty – PPG-guided stratification (>12 mmHg), monitoring, solutions for PE reduction (8 mm stents); questions of transhepatic pressure measurement standardization and optimal intervention sequence remain, requiring prospective studies.

Keywords: *portal hypertension, liver cirrhosis, interventional radiology, hypersplenism, esophageal varices, TIPS*

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Резюме

РОЛЬ ИНТЕРВЕНЦИОННОЙ РАДИОЛОГИИ В КОМПЛЕКСНОМ ВЕДЕНИИ ОСЛОЖНЕНИЙ ПОРТАЛЬНОЙ ГИПЕРТЕНЗИИ. ОБЗОР ЛИТЕРАТУРЫ

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Введение. Портальная гипертензия при циррозе остаётся причиной осложнений (варикозные кровотечения, асцит, гиперспленизм, печёночная энцефалопатия); у существенной доли пациентов показана минимально инвазивная интервенционная тактика.

Цель исследования. Обобщить данные об эффективности и безопасности TIPS, BRTO/PARTO/CARTO, PTHVE и частичной эмболизации селезёночной артерии (PSE), а также о мониторинге портального давления и послеоперационном ведении.

Стратегия поиска. Обзор (2005–2025) в PubMed/MEDLINE, Scopus, Web of Science, eLIBRARY; включались РКИ, когортные/ретроспективные исследования, мета-анализы; исключались наблюдения, тезисы и устаревшие обзоры. Идентифицировано 315 работ, в анализ вошли 58.

Результаты. Эндоскопическое лигирование обеспечивает первичный гемостаз в 90–95% и при сочетании с β-блокаторами снижает рецидивы на 40–50%; PTHVE – гемостаз 85–95%, годичный рецидив ~15–20%, серьёзные осложнения 3–5%; TIPS предотвращает рецидив у 80–90% пациентов, ПЭ 25–35%; добавление эмболизации к TIPS уменьшает риск повторного кровотечения (RR≈0,58), при пост-TIPS PPG >12 мм рт. ст. – HR≈0,47; для желудочных вариксов BRTO – успех 90–95%, ПЭ <5%, PARTO/CARTO сопоставимы; при рефрактерном асците TIPS снижает частоту рецидивов более чем на 70%; PSE повышает уровень тромбоцитов на 40–60%: эффект ≥6–12 мес. Оптимизация и мониторинг: стенты 8 мм уменьшают частоту ПЭ; успех – снижение HVPG на ≥20–30% или <12 мм рт. ст.; допплер-признаки дисфункции – скорость <90 см/с или >50% градиент; контроль КТ/МРТ на 4–6-й неделе, УЗИ каждые 3 месяца.

Выводы. Интервенционная радиология занимает центральное место; новизна – PPG-ориентированная стратификация (>12 мм рт. ст.), мониторинг, решения для снижения ПЭ (8-мм стенты); остаются вопросы стандартизации чреспечёночного измерения давления и оптимальной последовательности вмешательств, требующие проспективных исследований.

Ключевые слова: *портальная гипертензия, цирроз печени, интервенционная радиология, гипертспленизм, варикозное расширение вен пищевода, TIPS.*

Для цитирования:

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Түйіндеме

ПОРТАЛДЫ ГИПЕРТЕНЗИЯНЫҢ АСҚЫНУЛАРЫН КЕШЕНДІ БАСҚАРУДАҒЫ ИНТЕРВЕНЦИЯЛЫҚ РАДИОЛОГИЯНЫҢ РӨЛІ. ӘДЕБИЕТТІК ШОЛУ.

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Кіріспе. Цирроз кезіндегі порталдық гипертензия асқынулардың себебі болып қалады (варикозды қан кету, асцит, гиперспленизм, бауыр энцефалопатиясы); аз инвазивті араласу тактикасы пациенттердің айтарлықтай бөлігінде көрсетілген.

Мақсаты. TIPS, BRTO/PARTO/CARTO, PTHVE және ішінара көкбауыр артериясының эмболизациясының (PSE), сондай-ақ портал қысымын бақылау және операциядан кейінгі басқарудың тиімділігі мен қауіпсіздігі туралы деректерді жинақтау.

Іздеу стратегиясы. Шолу (2005–2025) PubMed/MEDLINE, Scopus, Web of Science, eLIBRARY; RCT, когорттық/ретроспективті зерттеулер, мета-талдаулар қосылды; бақылау зерттеулері, тезистер мен ескірген шолулар алынып тасталды. Барлығы 315 зерттеу анықталды, оның 58-і талдауға қосылды.

Нәтижелер. Эндоскопиялық байлау 90–95% біріншілік гемостазды қамтамасыз етеді және β-блокаторлармен біріктірілгенде қайталануды 40–50% төмендетеді; PTHVE – гемостаз 85–95%, 1 жылдық қайталану ~15–20%, ауыр асқынулар 3–5%; TIPS пациенттердің 80–90%, PE 25–35% қайталануды болдырмайды; TIPS-ке эмболизацияны қосу қайта қан кету қаупін азайтады (RR≈0,58), TIPS кейінгі PPG >12 мм.сын.бағ. – HR≈0,47; асқазанның варикозды BRTO үшін – табыс 90–95%, PE <5%, PARTO/CARTO салыстырмалы; отқа төзімді асцитте TIPS қайталану жиілігін 70% -дан астамға төмендетеді; PSE тромбоциттер санын 40–60%-ға арттырады: әсері ≥6–12 айға созылады. Оңтайландыру және бақылау: 8 мм стенттер PE жылдамдығын төмендетеді; табыс – HVPG ≥20–30% немесе <12 мм рт.ст.-ға төмендеуі; Дисфункцияның доплерологиялық белгілері – жылдамдық <90 см/с немесе >50% градиент; 4-6 аптада КТ/МРТ бақылау, 3 ай сайын ультрадыбыстық.

Қорытынды. Интервенциялық радиология орталық болып табылады; жаңалық – PPG-басқаруымен стратификация (>12 мм.сын. бағ.), мониторинг, ПЭ азайту шешімдері (8 мм стенттер); Транс-бауыр қысымын өлшеуді стандарттау және оңтайлы араласу реттілігі мәселелері перспективалық зерттеулерді қажет етеді.

Түйін сөздер: *порталдық гипертензия, бауыр циррозы, интервенциялық рентгенология, гиперспленизм, өңештің варикоздары, TIPS.*

Дәйексөз үшін:

Аксултанов Н.А., Даутов Т.Б., Землянский В.В., Тен И.Э., Рахимжанова Р.И., Догалбаев Е.К., Тукинов Р.Я., Тулемисов А.К., Абдрахманова Ж.С., Темірбеков А.Ж. Порталды гипертензияның асқынуларын кешенді басқарудағы интервенциялық радиологияның рөлі. Әдебиеттік шолу // Ғылым және Денсаулық сақтау. 2025. Vol.27 (6), Б. 159-171. *doi 10.34689/SH.2025.27.5.018*

Relevance

Portal hypertension (PH) most often occurs in the context of liver cirrhosis and is a significant cause of morbidity and mortality [7, 15]. Its complications – esophageal and gastric varices, ascites, hypersplenism, and hepatic encephalopathy – determine the clinical course and prognosis of the disease [8, 23].

According to the World Health Organization, approximately 500 million people worldwide are infected with hepatitis B and C viruses – the main etiologic causes of cirrhosis and, consequently, portal hypertension. In 2019 alone, hepatitis-related diseases resulted in more than 1.1 million deaths [47], highlighting the scale of the global burden and the need for improved treatment approaches.

Despite advances in pharmacological and endoscopic treatments, their effectiveness remains limited in a significant proportion of patients. According to a systematic review and Bayesian network meta-analysis of 40 RCTs, TIPS (transjugular intrahepatic portosystemic shunt) and DSRS (distal selective splenorenal shunt) are better at preventing recurrent bleeding, but are associated with a risk of hepatic encephalopathy and do not demonstrate a convincing survival benefit compared with endoscopic or medical therapy [9, 58].

Interventional radiological techniques include TIPS, BRTO (balloon-occluded retrograde transvenous obliteration), PARTO/CARTO (vascular plug/coil-assisted retrograde transvenous obliteration), PTHVE (percutaneous transhepatic variceal embolization), and splenic artery embolization; they represent effective, minimally invasive approaches to the treatment of PH and its complications. Successful variceal and collateral obliteration, portal pressure reduction, and clinical stabilization of patients with a wide range of complications have been described [5, 42].

Several meta-analyses, including a contemporary review of TIPS with variceal embolization, have shown that the combined strategy reduces the risk of rebleeding (RR ≈ 0.58) without affecting the incidence of shunt dysfunction, hepatic encephalopathy, and mortality [29]. In a large retrospective study in patients with post-TIPS portal hypertension (PPG > 12 mmHg, the addition of variceal embolization reduced the likelihood of rebleeding (HR = 0.47) [11].

However, the following tasks remain open: determining the optimal sequence of interventions, unifying methods for monitoring portal pressure, and developing highly accurate transhepatic methods for measuring PPG, which will allow for the establishment of stricter criteria for indications and contraindications for interventional procedures [22].

Therefore, conducting a review analysis of the role of interventional radiology in the treatment of portal hypertension complications – with an emphasis on efficacy, safety, and monitoring methods, including new transhepatic pressure measurement techniques – seems highly relevant. Systematization of current data facilitates the refinement of diagnostic and treatment algorithms and improves the clinical prognosis in patients with liver cirrhosis and portal hypertension.

Purpose of the study. To study and systematize current data on the role of interventional radiology in the diagnosis and treatment of complications of portal hypertension in patients with cirrhosis, with an emphasis on the effectiveness, safety and prospects for the clinical use of minimally invasive interventions.

Search strategy

The literature search was aimed at identifying and analyzing publications on the use of interventional radiological methods in the diagnosis and treatment of complications of portal hypertension in liver cirrhosis. The search period of 2005–2025 was chosen because it was during this period that major technological and methodological advances occurred in interventional radiology for portal hypertension: the introduction of covered stents for TIPS, standardization of HVPG measurement, the development and widespread use of BRTO and its modifications (PARTO, CARTO), clarification of indications for PSE, as well as the revision and updating of international consensuses (Baveno VI–VII) and clinical guidelines for the management of patients with cirrhosis. Studies from the last twenty years include large RCTs, meta-analyses, and national/international guidelines based on modern pharmacotherapy regimens (including the use of direct antiviral agents for viral hepatitis), ensuring their consistency with current clinical practice. The choice of this time interval, on the one hand, eliminates the use of outdated data based on early, technically imperfect interventions, and on the other, allows for the monitoring of long-term outcomes and assessment of the safety profile of interventional techniques in a real-world patient population. The search was performed in Russian and English using the following databases and resources: PubMed (MEDLINE), Scopus, Web of Science, Google Scholar, eLIBRARY, and CyberLeninka. In some cases, references to earlier publications of historical significance to the issue under study are provided.

The search strategy used keywords and their logical combinations:

- in Russian: «портальная гипертензия», «цирроз печени», «интервенционная радиология», «эмболизация варикозных вен», «селезёночная артерия», «TIPS», «чреспечёночная эмболизация варикозно-расширенных вен»;
- in English:portal hypertension, cirrhosis, interventional radiology, transjugular intrahepatic portosystemic shunt (TIPS), splenic artery embolization, esophageal varices, portal pressure measurement, BRTO, PARTO, PTHVE, CARTO, embolization.

Inclusion criteria:

- randomized controlled trials (RCTs);
- cohort and retrospective studies;
- systematic reviews and meta-analyses;
- clinical guidelines and consensus documents;
- original papers with clinical and/or experimental data on the topic.

Exclusion criteria:

- isolated clinical cases without generalization;
- conference abstracts;
- unverified sources (newspaper publications, advertisements);
- duplicate or outdated reviews without new data.

The initial search yielded 315 sources. After removing duplicates and applying inclusion/exclusion criteria, 58 publications with the most relevant and representative data were retained for the final analysis (Figure 1).

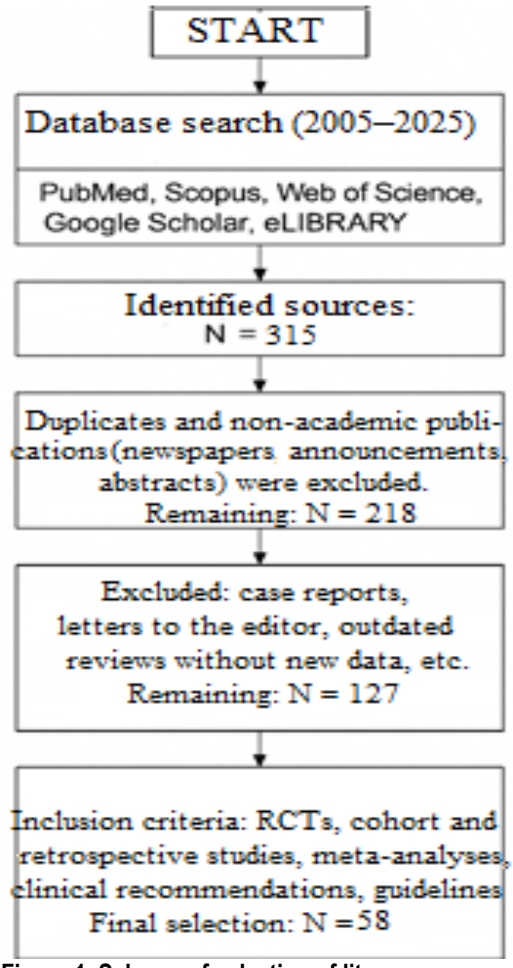

Figure 1. Scheme of selection of literary sources.

Results and discussions

Evolution of interventional methods in portal hypertension

In 1951, R. Myers and D. Taylor were the first to propose indirectly assessing portal pressure: by measuring the gradient between the weighted and free hepatic venous pressure (WHVP), they obtained an approximation to the pressure in the portal vein and thus laid the basis for stratification prognosis in portal hypertension [43].

The first attempts to create an intrahepatic portosystemic shunt without open surgery date back to the early 1980s. In 1983, R. Colapinto (University of Toronto) performed balloon dilation in a human patient to create a connection between the hepatic and portal veins; however, without a metal stent, the shunt quickly collapsed [20]. Clinically stable results were only achieved with the introduction of metal stents.

A turning point was the use of the covered Palmaz stent in TIPS in January 1990, performed by the group of G. M. Richter, Nöldge G., J. Palmaz and M. Rössle at the University of Freiburg (Germany). The use of a metal stent finally eliminated the problem of bypass tract obstruction and ensured the widespread clinical use of the method [48].

In parallel, selective embolization methods for the treatment of complications of portal hypertension were improved. In 1973, F.E. Maddison first described complete embolization of the splenic artery to control bleeding from varicose veins, which became the basis for the subsequent development of partial splenic embolization (PSE) [38]. Within the Soviet/Russian tradition, a significant step in the development of endovascular techniques was made by A. Granov, P.G. Tarazov and V.K. Ryzhkov, who showed that tumor-related arterioportal fistulas may cause hyperkinetic variants of portal hypertension with variceal hemorrhage and demonstrated options for their endovascular treatment [25]. In the same line, a structured account of angiographic diagnostics and endovascular management of portal-hypertensive complications (variceal bleeding, hypersplenism and others) was provided in the monograph by A.M. Granov and A.E. Borisov “Endovascular Surgery of the Liver” (1986), which for many years remained a key reference for surgical and radiological strategies in the treatment of portal hypertension [2].

At the turn of the 1990s, the BRTO (balloon-occluded retrograde transvenous obliteration) method was developed based on the idea of retrograde variceal obliteration. The first series of clinical BRTO interventions were performed in December 1999 by D. Sze and M. D. Dake at Stanford University, using a balloon and a sclerosant (Gelfoam + ethanolamine oleate) [53].

In the early 2010s, modifications of BRTO were proposed that eliminate the need for prolonged balloon retention:

- PARTO (plug-assisted RTO) – Gwon et al., 2013: bypass obliteration using vascular plugs [27];
- CARTO (coil-assisted RTO) – Lee et al., 2012: embolization coils are used instead of a balloon, simplifying the technique and reducing the risk of complications [34].

The evolution of interventional technologies demonstrates a shift from experimental approaches to standardized and highly effective procedures that now form the basis for treating complications of portal hypertension. However, choosing the optimal approach is impossible without understanding the pathogenesis and clinical and hemodynamic typology of the disease. Therefore, it is appropriate to further review the generally accepted classification of portal hypertension, based on the location of portal blood flow blockage and the degree of pressure increase. This serves as the basis for diagnosis, prognosis, and selection of interventional strategies (Table 1).

The table shows that portal hypertension has both etiopathogenetic and hemodynamic classifications, forming the basis for comprehensive diagnosis and treatment. Based on the location of the block, presinusoidal, sinusoidal, postsinusoidal, and suprahepatic variants are distinguished, each with its own causes and clinical features [4]. Sinusoidal portal hypertension is of the greatest clinical significance in liver cirrhosis, as it most often leads to decompensation and complications.

However, presinusoidal forms can be accompanied by severe portal hypertension with normal HVPG, requiring additional diagnostic methods. Classification by HVPG allows for risk stratification: values ≥ 10 mmHg are associated with a high risk of variceal development, while values ≥ 12 mmHg are associated with the likelihood of life-threatening bleeding. Thus, the presented systematization has practical value, facilitating the choice of optimal treatment tactics, prediction of complications and substantiation of indications for interventional procedures.

Table 1.

Classification groups of portal hypertension.

Criteria	Type / Gradation	Characteristics / Main Causes
By block localization	Presinusoidal	Obstruction of the portal or splenic vein (thrombosis, congenital anomalies, schistosomiasis).
	Sinusoidal	The most common cause in liver cirrhosis; increased resistance develops at the level of the hepatic sinusoids.
	Post Sinusoidal	Obstruction at the level of the hepatic veins/small venules (veno-occlusive disease, alcoholic hepatitis).
	Suprahepatic	Obstruction of the hepatic veins or inferior vena cava (Budd-Chiari syndrome, membranous occlusion).
By severity (HVPG)	Norm	≤ 5 mmHg
	Portal hypertension	> 5 mmHg
	Clinically significant portal hypertension (CSPH)	≥ 10 mmHg; high risk of variceal development.
	Critical portal hypertension	≥ 12 mmHg; high risk of variceal bleeding.

Consequently, the transition from early experimental interventions to standardized modern techniques (TIPS, PSE, BRTO, and their modifications) reflects a focus on improving treatment safety and effectiveness. Current classifications, taking into account both the block location and the HVPG level, allow for complication risk stratification and justification for optimal treatment decisions. Combining pathogen-targeted diagnostics with interventional approaches ensures personalized therapy for portal hypertension, increasing survival and improving patient quality of life.

Diagnosis of portal hypertension

Methods for diagnosing portal hypertension can be invasive and non-invasive.

Invasive methods. HVPG is recognized as the "gold standard" for assessing the severity of portal hypertension. The method is based on catheterization of the hepatic vein: first, free venous pressure is measured, then, after balloon occlusion of the ostium, the weighted pressure is measured; their difference is the portal system gradient. Indications include decompensation risk stratification in cirrhosis and an objective assessment of the effectiveness of interventions (TIPS, selective variceal embolization). Limitations: an experienced interventional radiologist, specialized equipment, and an angiographic unit are required; invasive complications (bleeding, infection) are possible. Furthermore, in presinusoidal forms and portal vein thrombosis, HVPG may be incorrect, since it does not reflect extrahepatic pressure [36].

Non-invasive methods. Transient elastography (FibroScan) measures the velocity of ultrasound (shear) waves in the liver, which is directly related to tissue stiffness. Increased stiffness indicates fibrosis and increased intrahepatic resistance, indirectly indicating portal hypertension. This method is suitable for mass screening of patients at risk of cirrhosis decompensation and for monitoring progression during therapy. Results may be affected by venous congestion in the liver (e.g., in heart failure), cholestasis, as well as obesity and severe ascites, which make measurements difficult [32].

Contrast-enhanced ultrasound (CEUS) supplements standard ultrasound by incorporating microbubble contrast, allowing for qualitative and quantitative assessment of liver vascularization and portal blood flow characteristics. Portal hypertension is characterized by delayed portal vein emptying and changes in hepatic sinusoid and collateral filling. CEUS is used to clarify the severity of portal hypertension, predict decompensation, and select optimal candidates for interventional procedures. Limitations include the need for contrast (contraindicated in severe heart failure and allergies) and significant operator-dependent interpretation [39].

Portal vein Doppler ultrasonography allows for the assessment of blood flow velocity and direction, vein diameter, and splenic artery resistive index. These parameters reflect the degree of portal hypertension and are used for initial diagnosis, as well as for follow-up after TIPS or selective embolization. The method depends on the quality of the equipment and the experience of the specialist: with significant ascites, significant obesity, or an unfavorable acoustic window, accuracy is reduced, so the results should be interpreted with caution and, if in doubt, confirmed by other methods [40].

CT and MRI play an important role in the diagnosis of portal hypertension. Multiphase contrast-enhanced CT allows for a detailed assessment of the anatomy of the portal and hepatic veins, identifying thromboses, collaterals, and varicose veins of the stomach and esophagus, as well as associated complications (ascites, hepatocellular carcinoma). MRI, including MR angiography, provides high information content in the study of the vascular bed without radiation exposure and allows for dynamic assessment of portal blood flow. Modern MR elastography quantitatively measures the stiffness of the liver and spleen, which correlates with the severity of portal hypertension and the risk of variceal development. Limiting factors include high cost, limited availability, and contraindications to MRI (implanted devices, claustrophobia) [55].

General treatment tactics

Treatment of portal hypertension is carried out in a stepwise manner, moving from minimally to maximally invasive interventions. Initially, drug therapy is prescribed, followed by endoscopic methods if necessary. If conservative and endoscopic approaches are ineffective, TIPS or surgical bypass procedures are performed [24].

A generalized algorithm for treatment tactics for complicated portal hypertension, reflecting the sequence of interventions and their clinical outcomes, is shown in Figure 2.

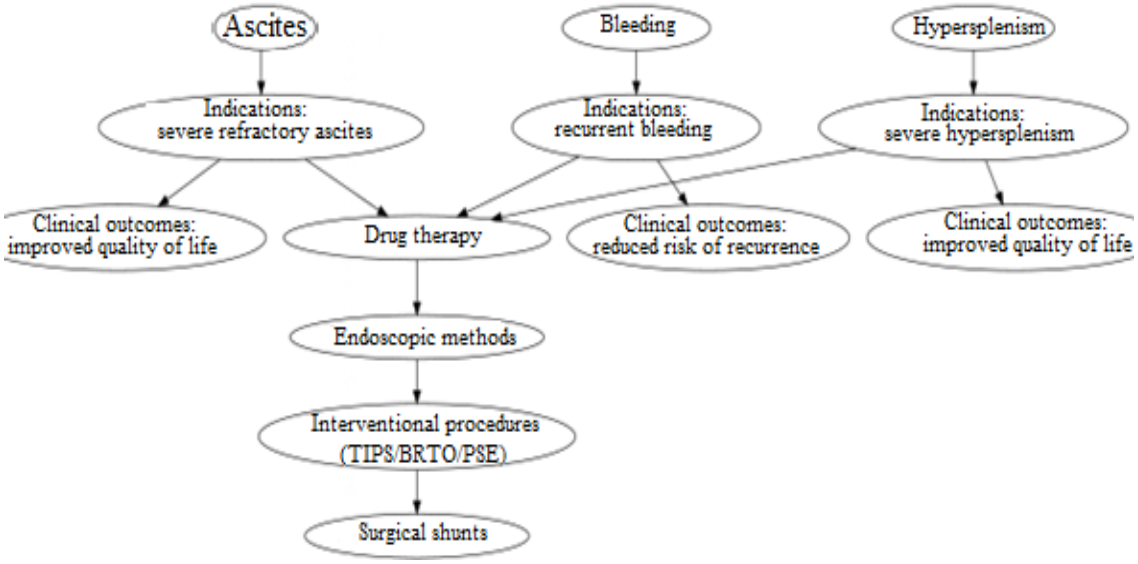

Figure 2. Generalized algorithm for choosing treatment tactics for complicated portal hypertension.

The treatment algorithm for complicated portal hypertension presented in Fig. 2 is based on a stepwise approach: from drug and endoscopic therapy to interventional and, if necessary, surgical procedures. For each complication (ascites, variceal bleeding, hypersplenism), indications and expected outcomes are outlined, emphasizing the individualization of the approach. Interventional techniques (TIPS, BRTO/PARTO/CARTO, PTHVE, PSE) occupy a central place as a link between the conservative and surgical stages. Assessment of clinical outcomes – reduced risk of recurrence and improved quality of life – allows the effectiveness of interventions to be balanced against their invasiveness and potential risks.

Drug therapy is based on the administration of non-selective β-blockers (propranolol, nadolol), antispasmodic nitrates, and vasopressin/terlipressin to reduce portal blood flow and pressure. The main indications are the prevention of primary and secondary bleeding from varicose veins; contraindications are severe bronchial asthma, severe bradycardia, and unstable heart failure [24].

For acute or refractory bleeding from esophageal and gastric varices, endoscopic ligation (EVL) or sclerotherapy are used. Endoscopy provides direct control of the bleeding source and is the first-line therapy in acute episodes, and is also used in combination with β-blockers as an alternative or adjunctive method [24].

If bleeding persists despite optimal medical and endoscopic therapy, the next step is transhepatic variceal vein embolization (PTHVE). This method allows for targeted obliteration of the esophagogastric varices and collaterals. If PTHVE is ineffective or recurrent, TIPS is indicated for the following indications:

- refractory variceal bleeding not controlled by medical and endoscopic therapy;
- secondary bleeding prevention in high-risk patients (Child–Pugh C < 14 points);
- refractory ascites or hydrothorax requiring frequent paracentesis;
- hepatorenal syndrome and pulmonary complications of portal hypertension in selected cases.

TIPS is a key element of interventional tactics: it allows for the control of bleeding and refractory ascites. The choice of technique is based on the liver's functional reserve and the risk of hepatic encephalopathy [41, 46].

To reduce the risk of recurrent bleeding, TIPS is often supplemented with variceal embolization. According to a meta-analysis, this combination almost halves the relative risk of recurrent bleeding without significantly increasing the incidence of shunt dysfunction or encephalopathy [56].

If TIPS is impossible or contraindicated (e.g., severe liver failure, unfavorable venous access anatomy), surgical shunting procedures are performed – distal splenorenal shunt (DSRS) or paraportal portocaval shunt. They provide long-term decompression of the portal system, but require open surgery and are associated with higher periprocedural risk; therefore, they are primarily indicated for young patients with good general condition and an expected survival of more than 5 years [45].

Complications of portal hypertension and their management

Varicose veins of the esophagus and stomach

Endoscopic variceal ligation (EVL) is a first-line treatment for acute bleeding from esophageal and gastric varices. In RCTs, the method provided primary bleeding control in 90–95% of cases and, when combined with non-selective β-blockers, reduced the risk of recurrence by 40–50% [4]. Limitations include the need for repeat sessions (an average of 3–4) and the risk of local complications, such as post-ligation ulcers and esophageal stenosis [1, 3].

The first successful series of transhepatic interventions were described in 1974, after which the method became firmly established in clinical practice as an effective way to stop and prevent recurrent bleeding in portal hypertension. PTHVE is performed by percutaneous catheterization of the portal or splenic vein through the liver parenchyma, followed by the passage of microinstruments into the left gastric vein. Microcoils, adhesive compositions (Histoacryl), sclerosing agents (ethanolamine, polidocanol), or combinations thereof are used to obliterate varices.

According to large retrospective series [23, 28], primary hemostasis in acute bleeding is achieved in 85–95% of cases, and the risk of recurrence within the first year is approximately 15–20%. An additional advantage is the possibility of combined

intervention – simultaneous embolization of collaterals and thrombectomy in portal vein thrombosis.

Limitations of this method include invasive access, the risk of intra-abdominal bleeding, and bile duct damage; however, with modern ultrasound and fluoroscopic guidance, the incidence of serious complications typically does not exceed 3–5%. In Asian and Eastern European countries, transhepatic embolization is often used as a first-line intervention for recurrent variceal bleeding, while BRTO is primarily used for types II–III gastric varices.

If endoscopic treatment is ineffective or bleeding recurrs, TIPS is indicated. Multicenter data confirm that TIPS without embolization prevents recurrent bleeding in 80–90% of cases; however, the risk of hepatic encephalopathy is 25–35% [2, 46]. The addition of variceal embolization to TIPS further reduces the relative risk of recurrence by almost half (RR ≈ 0.58) without a statistically significant increase in the incidence of shunt dysfunction or encephalopathy [12].

Retrograde obliteration techniques are increasingly being used for patients with type II–III gastric varices, particularly in cases of failed endoscopy or in the presence of large gastrorenal bypass grafts:

- BRTO provides a 90–95% clinical success rate in stopping bleeding and almost completely prevents recurrence; the risk of encephalopathy is <5% [44];
- PARTO and CARTO simplify the BRTO technique, eliminating the need for prolonged balloon retention. PARTO has been shown to have comparable efficacy to BRTO and a favorable safety profile (recurrence <10%, encephalopathy <3%) [27], while CARTO demonstrates similar results with a shorter procedure time and a lower sclerosant dose [35].

Table 2 provides a comparative analysis of the main interventional techniques for PG according to key clinical criteria.

Table 2.

Interventional treatment methods for PG.

Method	Main indications	Brief Description of the Technique	Clinical efficacy level	Main risks	Special Notes
TIPS	Prevention of recurrent bleeding	Creation of an intrahepatic portosystemic shunt	70–80%	Encephalopathy, shunt dysfunction	Not used in severe liver failure
BRTO	Gastric varices types II–III	Injection of sclerosant into gastrorenal collaterals with temporary balloon occlusion	80–100%	Ascites, increased portal pressure	Preferred for large gastrorenal bypasses
PARTO	Recurrent bleeding	Sclerotherapy using a vascular plug instead of a balloon	75–95%	Ascites	Simplifies the BRTO technique, reduces procedure time
CARTO	Recurrent bleeding	Sclerotherapy using embolization coils	75–85%	Ascites	Less sclerosant required, shorter procedure
PTHVE	Bleeding from varices after unsuccessful endoscopy; bridge to TIPS	Transhepatic approach; selective obliteration of varices/collaterals	85–95%	Invasiveness, bleeding, bile duct injury	Targeted obliteration; ± thrombectomy; bridge or alternative to TIPS
PSE	Hypersplenism, thrombocytopenia	Partial embolization of the splenic parenchyma	Increase in platelet count by 40–60%	Post-embolization syndrome, pleural effusion	Improves preparation for invasive procedures

The comparative table shows that each interventional technique for portal hypertension has clear indications and its own risk-benefit balance. TIPS remains a universal solution for controlling bleeding and refractory ascites, but is associated with an increased risk of encephalopathy. BRTO and its modifications (PARTO, CARTO) are particularly effective for gastric varices, providing a high rate of recurrence prevention; simplified PARTO/CARTO techniques offer advantages in terms of convenience and safety. PTHVE is appropriate when endoscopy is unsuccessful or unavailable as a bridge/alternative to TIPS, providing targeted obliteration of collaterals and, if necessary, combination with thrombectomy. PSE does not directly reduce portal pressure, but it reliably corrects hypersplenism and can serve as a preparatory step for other interventions. The choice of strategy should be individualized based on the anatomy, functional state of the liver, and clinical priorities.

Ascites

The first step in treating ascites in cirrhosis is drug therapy with diuretics and albumin. A combination of spironolactone (100–400 mg/day) and furosemide (40–160 mg/day) is typically used, which ensures a negative sodium balance and effective removal of excess fluid. In large paracenteses, simultaneous albumin infusion at a rate of 6–8 g/L of removed fluid reduces the risk of paracentesis-related circulatory dysfunction, maintains circulating volume, improves renal parameters, and reduces post-puncture complications [6, 13, 49].

In refractory ascites – when adequate doses of diuretics are ineffective or relapse occurs less than 4 weeks after large-volume paracentesis – regular therapeutic paracentesis with albumin replacement is indicated. Removal of up to 8–10 liters of ascitic fluid is performed under ultrasound guidance, which reduces the risk of bleeding and infectious complications [49].

In patients with refractory ascites, despite optimal diuretic regimens and repeated paracenteses, TIPS significantly improves outcomes. Multicenter RCTs have shown that, compared with paracentesis, TIPS reduces the rate of ascites recurrence by more than 70% and improves quality of life due to a smaller ascites volume, reduced hospitalizations, and better exercise tolerance [10, 18]. The main limitations of the method are the risk of hepatic encephalopathy (20–30%) and

the need for strict patient selection taking into account liver function and risk profile [17].

Hypersplenism

In portal hypertension, PSE is performed to correct hypersplenism accompanied by thrombocytopenia, leukopenia and anemia.

Indications for PSE:

- Thrombocytopenia (< 50 × 109 L) preventing safe endoscopic or surgical interventions;
- Severe hypersplenism with frequent bleeding or refractory ascites;
- Preparation for TIPS or liver transplantation with a risk of bleeding.

The technique involves percutaneous catheterization of the splenic artery under X-ray control, followed by embolization of 50–70% of the parenchyma with polyvinyl alcohol particles or microspheres. Selective or segmental embolization preserves the arterial buffer response and reduces the risk of necrosis of large areas of tissue [31].

Short-term results include a 40–60% increase in platelet counts within 1–2 weeks after the procedure, a reduction in the severity of ascites, and a decrease in the incidence of variceal bleeding. Typical adverse events include post-embolization syndrome (fever, pain in the left hypochondrium), which is usually relieved by analgesics and NSAIDs [31].

Long-term effects: a sustained increase in platelets by 30–50% persists for 6–12 months or longer, allowing for planned endoscopic and surgical interventions without a high risk of bleeding. The procedure also reduces the load on the portal system and is sometimes accompanied by a reduction in ascites volume [31].

Clinical experience in Kazakhstan confirms the high efficacy of PSE. In a series of more than 170 procedures performed in clinics in Almaty and Astana, regional interventional radiologists recorded an average increase in platelet count from 45 × 10^9L to 95 × 10^9L and a 35% reduction in the incidence of recurrent ascites in the first six months after the procedure. These data indicate the safety of the method and its suitability for inclusion in standard care for patients with complicated portal hypertension in domestic practice [54].

Hepatic encephalopathy

Hepatic encephalopathy (HE) is one of the most serious complications of decompensated cirrhosis, especially after TIPS. Lactulose and L-ornithine-L-aspartate (LOLA) are recommended for the prevention and treatment of minimal and mild HE in the pre- and post-procedural periods. A multicenter RCT demonstrated that lactulose improves cognitive function, reduces the frequency of minimal HE episodes, and modulates the intestinal microbiota, which is of key importance before TIPS and during follow-up [51].

The selection of technical parameters of TIPS, primarily the stent diameter, determines the balance between portal pressure reduction and the risk of PE. *Van K. et al.* showed that 8 mm covered stents are comparable to 10 mm in preventing recurrent variceal bleeding, but are significantly less likely to cause encephalopathy [37]. Similar data were presented by *Lo K. et al.,* confirming the feasibility of a smaller diameter for reducing neurological complications without losing the effectiveness of decompression [30].

In spontaneous portosystemic shunts leading to recurrent PE, interventional obliteration is used – PTO (percutaneous transhepatic obliteration) and PTS (percutaneous transhepatic sclerotherapy). According to Ishikawa T. et al., targeted elimination of the pathological shunt significantly reduces the frequency of PE episodes and improves the general neurological status of patients [50].

Other complications

Portosystemic shunt syndrome (PSS) occurs when excessive blood flow through TIPS or spontaneous portosystemic collaterals leads to recurrent PE, decreased liver perfusion, and cognitive impairment. For correction, embolization of pathological shunts is performed via a percutaneous transjugular or transhepatic approach using microcoils or vascular plugs. In a series of 28 patients by Saad V.E., complete obliteration of the shunts resulted in the resolution of encephalopathy in 85% of cases and improvement in liver function tests without a significant increase in portal pressure [50].

Rare but clinically important complications include splenorenal aneurysms, shunt thrombosis, and prosthetic infection.

Splenorenal aneurysms are often detected incidentally during follow-up examinations after selective splenic artery embolization. For most aneurysms <2 cm, dynamic observation is preferred, whereas aneurysms >2 cm or symptomatic ones are subject to endovascular occlusion with microcoils or vascular plugs [19, 21].

TIPS graft thrombosis occurs in 5–10% of cases and is manifested by increased portal pressure, recurrent ascites, or bleeding. Patency is restored by thrombolysis followed by angioplasty or implantation of an additional stent [52].

Prosthetic stent infection is rare (<1%) and is usually associated with bacteremia or hematogenous spread of microorganisms. Treatment involves a long course of broad-spectrum antibiotics and, if necessary, removal or replacement of the infected stent segment [15].

Algorithm for postoperative monitoring and criteria for early detection of obstruction

After TIPS, PSE, BRTO/PARTO, and PTHVE, a uniform follow-up protocol combining imaging and clinical assessment is required. At 4–6 weeks after the procedure, multiphase abdominal CT or MRI is performed to confirm graft patency, exclude bleeding, and monitor stent position [57]. Doppler ultrasound is performed every 3 months during the first year and then every 6 months. Blood flow velocity in the TIPS tract < 90 cm/s or a difference of > 50 cm/s between two adjacent segments indicates a stricture and requires angioplasty or stenting [33].

Indications for repeat interventions:

- An increase in portal gradient of more than 5 mmHg compared to baseline after TIPS;
- An increase in varicose vein sac volume on follow-up ultrasound/CT by more than 20% of the previous value;
- Recurrence of bleeding or ascites in the absence of signs of infection or non-compliance with therapy [58].

Success criteria: reduction of portal pressure by 20–30% or more (achieving HVPG < 12 mmHg), absence of recurrent variceal bleeding, and cessation or significant reduction of ascites without frequent paracentesis. Warning signs: appearance of new collaterals, slow or turbulent blood flow in the TIPS tract, as well as clinical decompensation (increased encephalopathy, increased ascites) with preserved shunt anatomy [16].

Conclusion

Interventional radiology plays a key role in the modern management of portal hypertension complications. Minimally invasive procedures – PTHVE, TIPS, BRTO/PARTO/CARTO, and selective splenic artery embolization – effectively reduce portal pressure, control recurrent variceal bleeding, reduce the incidence of refractory ascites, and correct hypersplenism, often providing faster clinical results and improved quality of life compared to traditional approaches.

The safety of interventions has significantly improved thanks to technological advances – the use of covered stents, precise optimization of bypass graft diameter, and the use of microcoils and vascular occluders. This has reduced the risk of encephalopathy and bypass dysfunction. Standardized imaging and clinical monitoring protocols allow for the timely detection of warning signs – such as bypass obstruction, variceal sac enlargement, and cognitive deterioration – and targeted repeat interventions.

Promising milestones include the development of transhepatic methods for direct portal pressure measurement, equipping stents with integrated flow/pressure sensors, and the implementation of AI models for individualized treatment. These approaches will enable more precise risk stratification, continuous hemodynamic monitoring, and informed selection of optimal interventional strategies for each patient.

Therefore, the combination of evidence-based interventional techniques, technological improvements, and digital predictive tools forms the basis for multidisciplinary management algorithms aimed at improving survival and quality of life in patients with liver cirrhosis and portal hypertension.

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