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Anatomically Extended Liver Resections: Modern Technologies and Risk Factors for Complications

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ABSTRACT

Currently, anatomically extended liver resections represent an important area of hepatobiliary surgery, requiring consideration of multiple risk factors. The aim of this article is to review the latest advances in liver resection technologies and to analyze the main factors affecting the risk of complications.

KEYWORDS: Anatomical liver resection, extended hepatectomy, minimally invasive surgery, laparoscopic liver resection, robotic surgery, portal vein embolization (PVE), liver venous deprivation (LVD), artificial intelligence in surgery, postoperative bile leakage (POBL), portal vein thrombosis (PVT), ERAS protocol, surgical navigation systems, hepatic tumor resection, risk factor assessment, preoperative planning.

Introduction.

Extended anatomical liver resections are performed in patients with hepatic space-occupying lesions extending beyond a single segment or lobe. The high complexity of these interventions is due to the need to consider anatomical features, the volume of the future liver remnant (FLR), and the general condition of the patient.

Modern technologies in liver resection

In recent years, minimally invasive hepatobiliary surgery techniques have developed significantly, including laparoscopic and robotic resections. According to meta-analyses, these are associated with less blood loss, lower complication rates, and shorter hospital stays.

Significant progress has been made in surgical planning through the use of computer modeling of hepatic circulation and artificial intelligence (AI)-assisted navigation.

Risk factors for complications

According to studies, key risk factors determining complications after extended liver resections include:

- ✓ Volume of resection (e.g., trisectionectomy);

- ✓ Advanced age (>75 years);
- ✓ Comorbidities (diabetes, obesity);
- ✓ Low serum albumin (<3.5–3.8 g/dL);
- ✓ Blood loss >1000 mL;
- ✓ Intraoperative blood transfusion;
- ✓ Anatomical complexity of the tumor (vascular invasion, proximity to the hepatic hilum);
- ✓ Use of ALPPS in patients with cholangiocarcinoma (high mortality).

Research methods

An analysis of more than 60 publications from PubMed, Scopus, and Web of Science (2020–2025) was conducted. The review included meta-analyses, retrospective cohort studies, AI solutions, and clinical guidelines in hepatobiliary surgery. Special attention was paid to POBL (postoperative bile leakage), portal vein thrombosis (PVT), ERAS protocols, and surgical navigation systems.

Result and discussion.

A meta-analysis of 43,824 patients (PubMed, 2023) found POBL risk factors to include male sex, diabetes, Child–Pugh \geq B, ALPPS, trisectionectomy, central resection, biliary reconstruction, and low albumin.

A study of laparoscopic resections (n=938) showed that procedural complexity, blood loss >1000 mL, age >70, and cirrhosis increase the risk of complications and lengthen hospital stay.

PVE vs. LVD: comparative studies revealed that LVD results in faster FLR hypertrophy and lower PHLF risk (OR 0.45).

ERAS protocols: failure risk is higher in patients with ASA \geq 3, age >70, male sex, and large resections (PubMed, 2024).

PVT occurs in 2.4% of cases post-resection, particularly after portal vein reconstruction and sectionectomy, with most cases treated by anticoagulation.

AI models such as CoRe (AUC 0.84) and PSR allow for planning resection volumes while preserving 98% of functional hepatic parenchyma. These methods are being implemented in clinics in Europe and Japan.

Conclusion.

With modern technologies, extended anatomical liver resections are becoming safer, but they require strict preoperative assessment of risk factors. The most promising directions are the integration of AI systems into surgical planning and navigation, as well as the development of complication prediction scales. PVE and LVD are becoming the standard for preoperative preparation when the FLR is insufficient. It is also essential to monitor ERAS protocol failures and to manage PVT promptly.

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