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POSTOPERATIVE COMPLICATIONS OF LIVER RESECTION FOR HEPATOCELLULAR CARCINOMA

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Abstract

Background:
Postoperative complications continue to be a major challenge following liver resection for hepatocellular carcinoma despite advances in surgical techniques and perioperative care. These complications adversely affect patient recovery, increase morbidity, prolong hospital stay, and may compromise long-term outcomes. Bile leakage is one of the most common and clinically important complications after liver resection, with reported incidence ranging from 3.3% to 8.7%. Understanding the frequency and risk factors of postoperative complications is essential to improve perioperative management and patient outcomes.

Objective(s):
To evaluate the postoperative complications of liver resection for hepatocellular carcinoma.

Methodology:
A descriptive cross-sectional study was conducted among 47 patients who underwent liver resection for hepatocellular carcinoma at Shaikh Zayed Hospital Lahore. Data were collected from a prospectively maintained database documenting demographic characteristics, clinical variables, comorbidities, tumor characteristics, operative parameters, and postoperative complications. All patients underwent open liver resection performed by experienced hepatobiliary surgeons. Data were entered and analyzed using SPSS version 27. Descriptive statistics were applied to calculate frequencies and percentages.

Results:
Among the 47 patients, the majority were in the 41-50 years age group (19, 40.4%), with a slight female predominance (27, 57.4%). Most patients had normal BMI (21, 44.7%). Regarding comorbidities, hypertension was present in 18 patients (38.3%), diabetes in 12 patients (25.5%), and coronary disease in 11 patients (23.4%). Smoking history was reported in 17 patients (36.2%) and alcohol consumption in 9 patients (19.1%). Tumor characteristics revealed that the majority of tumors were located in the right hepatic lobe (37, 78.7%), with tumor diameter less than 5 cm in 26 patients (55.3%). Preoperative plasma

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albumin levels were above 5 g/L in 36 patients (76.6%), and ASA score 1-2 was observed in 32 patients (68.1%). Hemi hepatectomy was the most frequently performed procedure (31, 66.0%), with operation time less than 5 hours in 29 patients (61.7%) and blood loss less than 500 mL in 28 patients (59.6%). Postoperatively, biliary fistula was observed in 6 patients (12.8%), and drainage time exceeded 72 hours in 35 patients (74.5%).

Conclusion(s):

The findings of this study indicate that liver resection for hepatocellular carcinoma is associated with a number of postoperative complications, with biliary fistula being the most frequently observed complication. The majority of patients had preserved liver function, which may have contributed to the absence of more severe complications such as post-hepatectomy liver failure. These findings highlight the need for careful patient selection, meticulous surgical technique, and close postoperative monitoring to improve outcomes.

1 Introduction

The field of hepatic surgery began in 1887, when Langenbuch in Germany successfully performed the first left lateral liver lobectomy.[1]

Liver cancer is the third most common cause of cancer-related death worldwide. Hepatocellular carcinoma (HCC) is the most common primary liver carcinoma, accounting for 75% of all primary liver malignancies.[2]

The Global Burden of Disease (GBD) Study 2021 said that more than 529,000 people were diagnosed with new liver cancer, and the disease caused 483,800 deaths worldwide in 2021.[3]

The epidemiology of liver cancer has undergone significant changes in recent years. These changes are primarily driven by the increasing prevalence of obesity and metabolic dysfunction-associated steatotic liver disease (MASLD), as well as significant advancements in the treatment of hepatitis B virus (HBV) and hepatitis C virus (HCV) infections. Although the incidence of HBV- and HCV-related liver cancer has decreased with the widespread use of antiviral therapies, the global burden of liver cancer remains high. In fact, liver cancer deaths increased by approximately 25% between 2010 and 2019, mainly due to the rising prevalence of alcohol-related liver disease and non-alcoholic steatohepatitis (NASH).[4]

Hepatocellular carcinoma (HCC) is the leading cause of cancer-related deaths among people with chronic liver disease and remains one of the most serious complications of cirrhosis. Its rising incidence and high mortality make it a major global health issue. The main causes of chronic liver injury that often lead to cirrhosis include hepatitis B virus (HBV), hepatitis C virus (HCV), alcohol-related liver disease (ALD), and metabolic dysfunction-associated steatotic liver disease (MASLD). HCC is more common in men than in women, and its prevalence increases with age. Despite advances in surveillance and treatment, only a small percentage of patients are diagnosed early enough for curative options. As a result, the five-year survival rate remains below 30%, highlighting the urgent need for earlier detection and more effective therapies.[5]

In addition to the major causes of cirrhosis, several less common conditions also increase the risk of developing hepatocellular carcinoma (HCC). These include primary biliary cirrhosis, hereditary hemochromatosis, α1-antitrypsin deficiency, chronic exposure to aflatoxin B1, and cigarette smoking. The global burden of HCC continues to grow, with both its incidence and prevalence increasing steadily across many regions of the world. According to projections from the World Health Organization (WHO), liver cancer is expected to claim more than one million lives annually by 2030, highlighting the urgent need for effective prevention, early detection, and improved treatment strategies.[6]

The development of hepatocellular carcinoma (HCC) is a gradual process driven by long-standing liver damage caused by chronic liver diseases. Persistent injury to the liver triggers ongoing inflammation, leading to repeated cycles of

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hepatocyte destruction and regeneration. Over time, this continuous repair process promotes the progression of fibrosis and eventually cirrhosis, while genetic and epigenetic abnormalities accumulate within liver cells. These alterations create a favorable environment for tumor formation by stimulating abnormal cell growth, suppressing programmed cell death, promoting the formation of new blood vessels, and allowing cancer cells to escape immune surveillance. Although the sequence of molecular events may differ depending on the underlying cause of liver disease, the biological processes that ultimately result in the development of HCC are largely shared across different etiologies.[7]

Timely detection of hepatocellular carcinoma (HCC) plays an essential role in improving patient outcomes, as curative therapies are most successful when the tumor is identified at an early stage. Unfortunately, HCC usually develops silently, and its early symptoms are often absent or nonspecific, resulting in delayed diagnosis for many patients. For this reason, regular surveillance is strongly recommended for individuals at increased risk, especially those with cirrhosis or chronic hepatitis B or C virus infection. Among the available surveillance methods, abdominal ultrasonography, either alone or in combination with serum alpha-fetoprotein (AFP) measurement, continues to be the most widely adopted approach for the early identification of HCC.[8]

In individuals at high risk of developing hepatocellular carcinoma (HCC), particularly those with chronic hepatitis B (HBV) infection or cirrhosis regardless of its underlying cause, the diagnosis is primarily established using characteristic findings on imaging studies or by histopathological examination. Unlike many other malignancies, HCC can often be diagnosed confidently without a tissue biopsy when typical radiological features are identified on non-invasive imaging in patients who are at increased risk. This imaging-based approach enables an accurate diagnosis while avoiding the need for routine histological confirmation in most cases.[9]

The diagnosis and staging of hepatocellular carcinoma (HCC) rely primarily on advanced imaging techniques, including dynamic contrast-enhanced computed tomography (CT), magnetic resonance imaging (MRI), and contrast-enhanced ultrasound (CEUS). To ensure a consistent and reliable evaluation of liver lesions, the Liver Imaging Reporting and Data System (LI-RADS) provides standardized criteria for image capture, interpretation, and reporting, thereby improving diagnostic confidence. However, when imaging findings are inconclusive or fail to demonstrate the typical radiological features of HCC, a liver biopsy is required to confirm the diagnosis. Histopathological assessment not only verifies the presence of malignancy but also offers important prognostic information regarding tumour characteristics and biological behaviour, which can influence treatment planning. Therefore, establishing an accurate diagnosis and determining the extent of disease are essential steps in selecting the most appropriate management approach for patients with HCC.[10]

The treatment of hepatocellular carcinoma (HCC) has advanced significantly in recent years, with improvements in both diagnostic techniques and therapeutic strategies leading to more personalized patient care. Effective management requires close collaboration among specialists from multiple disciplines to ensure the most appropriate treatment plan. The choice of therapy is determined after careful evaluation of several factors, including tumour stage, underlying liver function, the patient's performance status, coexisting medical conditions, and individual treatment preferences. Based on these considerations, patients may be offered surgical resection, liver transplantation, local ablative procedures, locoregional interventions, or systemic therapies, either alone or in selected combinations to achieve the best possible clinical outcome.[11]

Liver resection is considered one of the most effective curative treatment options for patients with hepatocellular carcinoma (HCC) who are carefully selected for surgery. Over the years, advances in assessing liver function before surgery, improvements in imaging technology, a better understanding of liver anatomy, and ongoing refinements in surgical techniques have made liver resection safer and more successful. These

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developments have contributed to improved long-term survival, with reported five-year survival rates ranging from 38% to 61%, depending on the stage of the disease. However, surgical resection is suitable for only a small proportion of patients, and recurrence of HCC after surgery continues to be a major obstacle to achieving favorable long-term outcomes.[12]

Liver resection continues to be a key treatment for hepatocellular carcinoma (HCC) and remains one of the few options that can provide a potential cure. It is usually recommended for patients with early-stage disease who have well-preserved liver function and are fit for surgery. Over the years, advances in surgical techniques, improved perioperative care, and more careful patient selection have made the procedure safer and have resulted in better recovery, higher survival rates, and improved long-term outcomes.[13]

Over the past two decades, minimally invasive surgery has significantly reshaped the surgical management of hepatocellular carcinoma (HCC). For carefully selected patients with early-stage disease, laparoscopic liver resection has become an accepted standard treatment. Studies have shown that it achieves oncological outcomes comparable to those of conventional open liver resection while providing several perioperative benefits, including less tissue injury, faster postoperative recovery, shorter hospital stays, and a lower incidence of postoperative complications. More recently, robotic liver resection has expanded the role of minimally invasive liver surgery by enabling surgeons to perform increasingly complex hepatic procedures without compromising oncological outcomes. However, despite its potential advantages, the routine use of robotic liver resection remains limited because of the substantial costs involved, restricted access to robotic systems, and the extensive training and technical expertise required for its safe and effective use.[14]

Despite continuous improvements in surgical techniques and perioperative care, postoperative complications remain a frequent and important concern after liver resection for hepatocellular carcinoma (HCC), affecting approximately 20–50% of patients. These complications may arise from the surgical procedure itself or from medical conditions that develop during the postoperative recovery period, and together they continue to influence patient recovery and clinical outcomes.[15]

Surgical site infection (SSI) is among the most frequently reported complications after liver resection and remains a major concern during the postoperative period. The incidence of SSI after hepatectomy is estimated to range between 2% and 15%, with differences largely influenced by the extent of liver resection and the patient's overall clinical condition. Patients who develop SSI often experience delayed recovery, longer hospital stays, increased treatment costs, and a greater risk of further postoperative complications, which may negatively affect survival. Several factors have been shown to increase the risk of SSI, including hypoalbuminaemia, hyperbilirubinaemia, prolonged operative time, the need for dialysis, and the presence of pre-existing wounds. Careful preoperative evaluation, correction of modifiable risk factors, and strict perioperative infection control measures are therefore essential to reduce the occurrence of SSI and improve patient outcomes after liver resection.[16]

Bile leakage is one of the most common and clinically important complications after liver resection. Although advances in surgical techniques and perioperative care have reduced its occurrence, it remains a major postoperative problem, with a reported incidence of 3.3% to 8.7%. The International Study Group of Liver Surgery (ISGLS) defines postoperative bile leakage as a drain fluid bilirubin concentration that is at least three times the serum bilirubin concentration on or after postoperative day 3, or any biliary collection or biliary peritonitis requiring radiological or surgical intervention. The development of bile leakage can delay recovery and is associated with a greater risk of post-hepatectomy liver failure, postoperative infection, prolonged hospital stay, and mortality. Prompt diagnosis and appropriate treatment are therefore essential to reduce complications and improve patient outcomes after liver resection.[17]

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Post-hepatectomy liver failure (PHLF) is one of the most severe complications following liver resection and is a major cause of postoperative mortality. It occurs when the remaining liver cannot adequately recover after surgery and fails to perform its normal functions, including protein synthesis, bile excretion, and detoxification. The condition is usually identified by a progressive rise in serum bilirubin levels and prolongation of the international normalized ratio (INR), which typically becomes evident from the fifth postoperative day. Patients who develop PHLF often require longer hospitalization and are at greater risk of multiple organ dysfunction and postoperative death. Because of these serious consequences, careful patient selection, comprehensive preoperative assessment of liver function, and appropriate perioperative management are essential to reduce the risk of developing PHLF.[18]

Post-hepatectomy hemorrhage (PHH) is an uncommon complication of liver resection, but it can have serious consequences for postoperative recovery and may become life-threatening if not managed promptly. To establish a uniform approach for its diagnosis and reporting, the International Study Group of Liver Surgery (ISGLS) developed standardized diagnostic criteria and a grading system. According to the ISGLS definition, PHH is diagnosed when the postoperative hemoglobin level decreases by more than 3 g/dL from the baseline postoperative value, when blood transfusion is required because of postoperative bleeding, or when radiological or surgical intervention is needed to achieve hemostasis. Based on the severity of bleeding and the treatment required, PHH is classified into three grades: A, B, and C. This classification has been widely adopted in clinical practice and research because it provides a common framework for reporting PHH, comparing surgical outcomes across studies, and guiding the management of patients after liver resection.[19]

Postoperative pulmonary complications (PPCs) are a common cause of morbidity after liver resection and can negatively affect the patient's recovery. They frequently prolong hospital stay, increase the need for additional treatment, and are associated with worse postoperative outcomes. The most common pulmonary complications include pneumonia, pleural effusion, pulmonary edema, acute respiratory distress syndrome (ARDS), respiratory insufficiency, and pulmonary embolism. Their occurrence is influenced by both patient- and procedure-related factors. Advanced age, smoking, chronic respiratory disease, and poor preoperative health increase the risk, while extensive liver resection, prolonged hepatic ischemia, intraoperative blood transfusion, and hemodynamic instability during surgery further contribute to their development. Careful perioperative respiratory care and prompt recognition of these complications are important for reducing their impact, promoting recovery, and improving clinical outcomes after liver resection.[20]

Acute kidney injury (AKI) is a major medical complication that can occur after hepatectomy and is associated with increased postoperative morbidity and mortality. The physiological changes and alterations in blood flow that occur during liver resection make patients more susceptible to postoperative renal dysfunction. A large multicenter study found that almost one in six patients developed AKI after hepatectomy. Older age, obesity, diabetes mellitus, hypertension, anemia, prolonged operative time, planned open liver resection, and the use of the Pringle manoeuvre were identified as independent risk factors for its development. Recognizing these factors before surgery can help identify patients at greater risk, allowing appropriate perioperative measures to be taken to reduce the incidence of AKI and improve postoperative outcomes.[21]

Postoperative intra-abdominal infection (IAI) is a common and serious complication following liver resection for hepatocellular carcinoma (HCC). Although advances in surgical techniques and perioperative care have lowered the rate of postoperative complications, IAI continues to be an important cause of morbidity and reduced survival. Patients who develop postoperative IAI tend to have shorter overall survival than those without infection. Studies have identified preoperative weight loss, liver cirrhosis, and

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prolonged operative time as independent risk factors for the development of IAI. Careful preoperative assessment, appropriate patient optimization, and meticulous perioperative management are therefore essential to reduce the risk of postoperative infection and improve long-term outcomes after hepatectomy.[22]

Postoperative complications remain an important concern after curative liver resection for hepatocellular carcinoma because they can influence both short-term and long-term outcomes. Although these complications are known to delay recovery after surgery, they are also associated with an increased risk of tumor recurrence and lower overall survival. Patients who experience postoperative complications are more likely to develop early tumor recurrence, particularly within the first two years after hepatectomy, than those with an uncomplicated postoperative course. Moreover, postoperative complications have been shown to independently predict early recurrence and reduced long-term survival. Therefore, reducing the occurrence of postoperative complications and ensuring their timely management are essential for improving postoperative recovery and achieving better long-term oncological outcomes.[23]

Hepatocellular carcinoma (HCC) is an important and growing health concern in Pakistan because the number of people affected by liver cancer continues to increase. However, there is still a shortage of comprehensive national data, and most of the existing evidence is based on studies from individual hospitals. In Pakistan, chronic hepatitis C virus (HCV) infection is the main cause of HCC, accounting for approximately 60–70% of cases, whereas hepatitis B virus (HBV) is the predominant cause in many other Asia-Pacific countries. The treatment of HCC is often complicated by delayed diagnosis, limited availability of specialized hepatobiliary services, and constraints within the healthcare system, which can negatively affect patient outcomes. Furthermore, the lack of nationally accepted guidelines for HCC management emphasizes the need for locally generated evidence to support clinical practice and improve the management of patients undergoing liver resection for hepatocellular carcinoma.[24]

Laparoscopic liver resection is now considered a well-established treatment for patients with liver lesions and has shown favorable surgical outcomes. However, postoperative complications continue to be a significant concern because they can prolong hospital stay, delay recovery, and negatively affect patient outcomes. Although advances in surgical techniques and perioperative care have improved the safety of this procedure, the available evidence on the factors associated with postoperative complications and their effect on postoperative outcomes remains limited. Therefore, further studies are needed to better understand these complications, identify patients at increased risk, and improve perioperative management to achieve better surgical outcomes.[25]

1.1 RATIONALE

Postoperative complications remain a major challenge following liver resection for hepatocellular carcinoma despite advances in surgical techniques and perioperative care. These complications adversely affect patient recovery, increase morbidity, prolong hospital stay, and may compromise long-term outcomes. Therefore, this study is undertaken to evaluate postoperative complications after liver resection for hepatocellular carcinoma to generate evidence that may improve perioperative management, enhance patient outcomes, and support evidence-based clinical practice.

2 LITERATURE REVIEW

Yang et al. (2025) conducted a multicenter observational study involving 420 patients with hepatocellular carcinoma who underwent curative laparoscopic liver resection to evaluate the impact of postoperative morbidity on long-term prognosis. The study identified risk factors for postoperative morbidity using logistic regression analysis and assessed overall survival, recurrence, and time to recurrence. Postoperative morbidity occurred in 147 patients (35%) and was significantly associated with higher early and late tumor recurrence rates, reduced overall survival,

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and shorter time to recurrence. Multivariable analysis showed that postoperative morbidity increased the risk of long-term mortality by 43% and tumor recurrence by 92%. Diabetes mellitus, cirrhosis, portal hypertension, Child–Pugh grade B, multiple tumors, poor tumor differentiation, and intraoperative blood transfusion were identified as independent risk factors for postoperative morbidity. The authors concluded that postoperative morbidity adversely affects long-term oncological outcomes after laparoscopic liver resection for hepatocellular carcinoma, highlighting the importance of optimizing perioperative management to minimize postoperative complications.[26]

Yang et al. (2024) conducted a multicenter retrospective study involving 226 patients who underwent laparoscopic liver resection for hepatocellular carcinoma to investigate the association between preoperative body mass index (BMI) and postoperative morbidity. Patients were categorized into low-BMI, normal-BMI, and high-BMI groups, and postoperative morbidity, surgical site infection (SSI), and 30-day mortality were compared among the groups. The study found that patients with both low and high BMI had significantly higher postoperative morbidity rates than those with normal BMI (40% and 32.1% vs. 17.2%, respectively). Multivariate analysis identified both low BMI and high BMI as independent risk factors for postoperative morbidity as well as surgical site infection. However, no significant difference in 30-day postoperative mortality was observed among the groups. The authors concluded that abnormal preoperative BMI is associated with an increased risk of postoperative complications following laparoscopic liver resection for hepatocellular carcinoma, highlighting the importance of preoperative nutritional assessment and optimization to improve surgical outcomes.[27]

Vaghiri et al. (2024) conducted a retrospective cohort study involving 188 patients who underwent curative liver resection for hepatocellular carcinoma between 2004 and 2021 to identify factors predicting disease-free survival (DFS) and overall survival (OS). The study evaluated clinicopathological characteristics and postoperative complications using univariate and multivariate Cox regression analyses. The postoperative 1-, 3-, and 5-year disease-free survival rates were 77.9%, 49.7%, and 41.0%, while the overall survival rates were 72.7%, 54.7%, and 38.8%, respectively. Tumor diameter ≥45 mm, chronic alcohol abuse, and postoperative intra-abdominal abscess were identified as independent predictors of poorer disease-free survival. Furthermore, sepsis and post-hepatectomy liver failure (ISGLS grade B/C) were significant independent predictors of reduced overall survival. The authors concluded that both oncological characteristics and postoperative complications have a substantial impact on long-term outcomes after curative liver resection for hepatocellular carcinoma, emphasizing the importance of preventing postoperative complications to improve patient prognosis.[28]

Pu et al. (2023) conducted a multicenter retrospective study involving 3,876 patients with hepatocellular carcinoma who underwent either laparoscopic hepatectomy or open hepatectomy to compare the incidence of postoperative infectious complications. The study used propensity score matching, inverse probability of treatment weighting, and multivariable logistic regression to evaluate postoperative infections, including surgical site infection (SSI), organ/space SSI, and remote infection. The results showed that laparoscopic hepatectomy was associated with a significantly lower overall rate of postoperative infectious complications than open hepatectomy (6.9% vs. 14.6%, $P < 0.001$). Patients in the laparoscopic group also had significantly lower incidences of incisional SSI, organ/space SSI, and remote infections. After adjustment for potential confounding factors, laparoscopic hepatectomy remained an independent predictor of reduced postoperative infectious complications. The authors concluded that laparoscopic liver resection is associated with fewer postoperative infectious complications than open hepatectomy in patients undergoing liver resection for hepatocellular carcinoma, supporting its use when clinically appropriate.[29]

Tian et al. (2023) conducted a single-center retrospective study involving 1,773 patients with

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hepatocellular carcinoma who underwent either laparoscopic liver resection (LLR) or open liver resection (OLR) over a 10-year period to compare short- and long-term surgical outcomes. After propensity score matching, 567 patients were included in each group for analysis. The study evaluated intraoperative blood loss, postoperative complications, length of hospital stay, overall survival, and disease-free survival. The results demonstrated that patients undergoing laparoscopic liver resection experienced significantly less intraoperative blood loss, shorter postoperative hospital stay, and a lower incidence of postoperative complications than those undergoing open liver resection (23.8% vs. 32.8%, P = 0.001). However, no significant differences were observed in overall survival or disease-free survival between the two groups. The authors concluded that laparoscopic liver resection provides better short-term postoperative outcomes with fewer complications while maintaining comparable long-term oncological outcomes to open liver resection for patients with hepatocellular carcinoma.[30]

Shehta et al. (2022) conducted a retrospective study involving 293 patients who underwent hepatic resection for hepatocellular carcinoma between June 2010 and June 2019 to determine the incidence, predictive factors, and impact of postoperative bile leakage on surgical outcomes. The study found that postoperative bile leakage occurred in 17 patients (5.8%). Patients with bile leakage had a longer hospital stay, a higher incidence of post-hepatectomy liver failure, and more postoperative abdominal collections than those without bile leakage. Multivariate analysis identified Child–Pugh class B, macroscopic portal vein invasion, major liver resection, and use of the Pringle maneuver as independent predictors of postoperative bile leakage. However, postoperative bile leakage did not significantly affect overall survival or disease-free survival. The authors concluded that bile leakage remains an important postoperative complication after liver resection for hepatocellular carcinoma and that identifying patients at high risk may help improve perioperative management and reduce postoperative morbidity.[31]

Li et al. (2021) conducted a retrospective study involving 885 patients with hepatocellular carcinoma who underwent hepatectomy to investigate the association between postoperative serum procalcitonin (PCT) levels and post-hepatectomy liver failure (PHLF). Logistic regression analysis was performed to identify risk factors for PHLF, while Kaplan–Meier analysis was used to evaluate postoperative outcomes. The study found that 311 patients had elevated postoperative PCT levels (≥1 ng/mL), which were significantly associated with an increased risk of PHLF (HR = 3.801, $p < 0.001$). Elevated PCT levels were also associated with a higher incidence of postoperative sepsis, increased intensive care unit admission, and higher 30-day and 3-month mortality rates. In addition, portal hypertension, portal occlusion time greater than 30 minutes, and blood transfusion exceeding 200 mL were identified as independent risk factors for PHLF. The authors concluded that elevated postoperative serum procalcitonin is a useful biomarker for predicting post-hepatectomy liver failure and poor short-term postoperative outcomes following liver resection for hepatocellular carcinoma.[32]

Kobayashi et al. (2021) conducted a retrospective study involving 437 patients who underwent open or laparoscopic liver resection between 2010 and 2020 to evaluate the probability of postoperative complications according to patient characteristics, operative complexity, and the use of an Enhanced Recovery After Surgery (ERAS) protocol. The study assessed operative outcomes, postoperative complications, and the Comprehensive Complication Index. The results demonstrated that increasing operative complexity was associated with longer operative time, greater blood loss, prolonged hospital stay, and a higher rate of postoperative complications. Multivariable analysis identified advanced age, higher operative complexity, biliary reconstruction, and non-use of the ERAS protocol as independent predictors of postoperative complications. In contrast, implementation of the ERAS protocol was associated with a significantly lower risk of postoperative complications across all levels of surgical complexity. The authors concluded that perioperative management using an ERAS

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protocol can reduce postoperative complications after liver resection and improve postoperative recovery.[33]

Chen et al. (2021) conducted a multicenter retrospective study involving 144 patients with hepatocellular carcinoma to develop and validate a preoperative model for predicting post-hepatectomy liver failure (PHLF) using Gd-EOB-DTPA-enhanced magnetic resonance imaging (MRI) radiomics combined with clinical variables. The study included 111 patients in the training cohort and 33 patients in the validation cohort. Radiomics features and clinical risk factors were incorporated to construct a liver failure (LF) prediction model, and its diagnostic performance was compared with radiomics-only and clinical-only models. The combined LF model demonstrated the highest predictive accuracy for PHLF, with an area under the receiver operating characteristic curve (AUC) of 0.956 in the training cohort and 0.844 in the validation cohort, outperforming both the radiomics and clinical models. The authors concluded that the radiomics-based clinical model provides an accurate preoperative method for predicting post-hepatectomy liver failure in patients undergoing liver resection for hepatocellular carcinoma and may assist clinicians in identifying high-risk patients and optimizing perioperative management.[34]

Nakano et al. (2018) conducted a retrospective cohort study involving 556 patients who underwent curative liver resection for hepatocellular carcinoma between January 2011 and December 2016 to identify the risk factors for postoperative bile leakage. The study evaluated the incidence of postoperative bile leakage and analyzed potential predictive factors using univariate and multivariate analyses. Postoperative bile leakage occurred in 28 patients (5.0%) and was associated with increased postoperative morbidity and operative mortality. Multivariate analysis identified a history of stereotactic body radiotherapy, body mass index <20 kg/m², Child–Pugh class B cirrhosis, central hepatectomy, and operative time ≥375 minutes as independent risk factors for postoperative bile leakage. Furthermore, the incidence of bile leakage increased progressively with the number of risk factors present, reaching 45.0% among patients with three or more risk factors. The authors concluded that identifying these predictive factors can help stratify high-risk patients and facilitate perioperative management to reduce postoperative bile leakage following liver resection for hepatocellular carcinoma.[35]

Azar et al. (2018) conducted a systematic review to summarize the definitions, risk factors, prediction models, and preventive strategies for post-hepatectomy liver failure (PHLF) following liver resection. The review reported that the incidence of PHLF ranges from 1% to 34%, depending on the definition used, the extent of liver resection, and patient characteristics. The authors highlighted that PHLF remains one of the leading causes of postoperative morbidity and mortality despite advances in surgical techniques and perioperative care. They discussed the commonly used definitions of PHLF, including the 50–50 criteria, peak bilirubin >7 mg/dL, and the International Study Group of Liver Surgery (ISGLS) definition. The review also identified several important risk factors, including inadequate future liver remnant, poor preoperative liver function, cirrhosis, diabetes mellitus, major hepatectomy, and advanced age. Furthermore, the authors emphasized the importance of careful patient selection, preoperative liver function assessment, portal vein embolization when indicated, and optimization of perioperative management to reduce the risk of PHLF. They concluded that early identification of high-risk patients and implementation of preventive strategies are essential to improve postoperative outcomes after liver resection.[36]

Zhao et al. (2016) conducted a retrospective study involving 166 patients who underwent liver resection for hepatocellular carcinoma to evaluate the incidence and risk factors of postoperative infectious complications. Among the study population, 42 patients (25.3%) developed postoperative infectious complications, while 124 patients had an uncomplicated postoperative course. Clinical characteristics and operative variables were compared between the two groups, and logistic regression analysis was performed to

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identify independent predictors of infection. The study found that plasma albumin <35 g/L, intraoperative blood loss >500 mL, and biliary fistula were independent risk factors for postoperative infectious complications. In addition, patients with postoperative infection had significantly longer operative time and drainage duration than those without infection. The authors concluded that poor nutritional status, excessive intraoperative blood loss, and biliary fistula increase the risk of postoperative infectious complications after liver resection for hepatocellular carcinoma, emphasizing the importance of careful perioperative management to improve surgical outcomes.[37]

Ishii et al. (2014) conducted a comprehensive review of postoperative complications following liver resection, with particular emphasis on hepatocellular carcinoma and other liver tumors. The review summarized the incidence, definitions, classification, and grading of major postoperative complications, including post-hepatectomy liver failure, bile leakage, ascites, renal failure, coagulation disorders, and surgical site infections. The authors reported that the overall morbidity rate after liver resection ranged from 4.1% to 47.7%, reflecting considerable variation among published studies. They also highlighted the limitations of existing classification systems and proposed a unified grading system to standardize the reporting of postoperative complications. The authors concluded that a universal classification system would improve consistency in reporting, facilitate comparison among studies, and enhance the evaluation of surgical outcomes after liver resection.[38]

OBJECTIVE

To investigate postoperative complications after liver resection for hepatocellular carcinoma.

HYPOTHESIS

1. **Null Hypothesis (H0):**
   There is no significant association between patient and surgery related factors and postoperative complications after liver resection for hepatocellular carcinoma.
2. **Alternative Hypothesis (H1):**
   There is a significant association between patient and surgery related factors and postoperative complications after liver resection for hepatocellular carcinoma.

3 OPERATIONAL DEFINITIONS

I. **Hepatocellular Carcinoma (HCC):** The most common primary malignant tumor of the liver..
II. **Liver Resection (Hepatectomy):** Surgical removal of part of the liver to treat HCC.
III. **Postoperative Complications:** Any adverse event occurring after liver resection.
IV. **Post-hepatectomy Liver Failure (PHLF):** Impaired liver function following liver resection.
V. **Bile Leakage:** Escape of bile from the liver or bile ducts after surgery.
VI. **Surgical Site Infection (SSI):** Infection occurring at the surgical incision after liver resection.
VII. **A Pulmonary Complications:** Respiratory problems developing after liver surgery.
VIII. **Postoperative Morbidity:** Any complication occurring within 30 days after surgery..

4 MATERIAL AND METHODS

4.1: Study Design: It was an Retrospective study.
4.2: Settings: Data is collected from Shaikh Zayed Hospital Lahore.
4.3: Study Duration: The duration of study was 4 months.
4.4: Sample Size: A total sample size of 47 Patients.
4.5: Sampling Technique: A non-probability convenience sampling technique was used to enroll eligible participants for the study.

4.6: Sample Selection:
4.6.1: Inclusion Criteria:

- Underwent open liver resection
- Had surgery for benign or malignant liver tumors.
- Patients were grouped by surgical complexity grade I-III.

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4.6.2: Exclusion Criteria:

- Did not undergo liver resection.
- Had incomplete clinical surgical data.

4.7: Equipment(s):

Questionnaire.

4.8: ETHICAL CONSIDERATIONS

The rules and regulations set by the ethical committee of university of Lahore were followed while conducting the research and the rights of the research participants were respected.

- Written informed consent attached was taken from all the participants.
- All information and data collection was kept confidential.
- Participants were remained anonymous throughout the study.
- The subjects were informed that there are no disadvantages or risk on the procedure of the study.
- They were also be informed that they will be free to withdraw at any time during the process of the study.
- Data was kept in under key and lock while keeping keys in hand. In laptop it was kept under password.

4.9: DATA COLLECTION PROCEDURE

Data of this study was collected from operating theatres of Shaikh Zayed Hospital Lahore. The researcher employed a structured questionnaire to examine the postoperative complications of liver resection. The information gathered was recorded, contrasted, and subsequently examined.

4.10: DATA ANALYSIS PROCEDURE

- Data was analyzed using SPSS version 27.
- Data was analyzed using statically techniques and the required results were obtained in the form of table.
- Each question along with demographic information was analyzed.

5 RESULTS

Table 5.1: Hospital Distribution(n=47)

Table 5.1 *shows that the total number of patients was 47, and all of them were from a Shaikh Zayed Hospital Lahore*

Table 5.2: Frequency Distribution of Age (n=47)

Hospital Name	Frequency	Percentage(%)
Patient Age	Frequency	Percentage(%)
21-30	5	10.6
31-40	12	25.5
41-50	19	40.4
51-60	11	23.4
Total	47	100.0

Table 5.2 *shows that there were 21-30 years of participants which were 5 (10.6%), 31-40 years of participants which were 12 (25.5%), 41-50 years of participants which were 19 (40.4%), and 51-60 years of participants which were 11 (23.4%).*

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Table 5.3: Gender Distribution (n=47)

Table 5.3 *shows that there were 20 males which were 42.6% of the total population and 27 female participants which were 57.4% of the population.*

Gender	Frequency	Percentage(%)
Male	20	42.6
Female	27	57.4
Total	47	100.0

Table 5.4: Frequency Distribution of BMI (n=47)

Table 5.4 *shows that there were under weight participants which were 7 (14.9%), obese participants which were 10 (21.3%), over weight participants which were 9 (19.1%), and normal weight participants which were 21 (44.7%).*

BMI	Frequency	Percentage(%)
Under weight	7	14.9
Obese	10	21.3
Over weight	9	19.1
Normal	21	44.7
Total	47	100.0

Table 5.5: Hypertension Frequency Distribution (n=47)

Table 5.5 *shows that participants who had hypertension were 18 (38.3%), while participants with no hypertension were 29 (61.7%).*

Hypertension	Frequency	Percentage(%)
Yes	18	38.3
No	29	61.7
Total	47	100.0

Table 5.6: Coronary Disease Frequency Distribution (n=47)

Table 5.6 *shows that participants who had coronary disease were 11 (23.4%), while participants with no coronary disease were 36 (76.6%).*

Coronary Disease	Frequency	Percentage(%)
Yes	11	23.4
No	36	76.6
Total	47	100.0

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Table 5.7: Frequency Distribution of Diabetes (n=47)

Table 5.7 shows that participants who had diabetes were 12 (25.5%), while participants with no diabetes were 35 (74.5%).

Diabetes	Frequency	Percentage(%)
Yes	12	25.5
No	35	74.5
Total	47	100.0

Table 5.8: Frequency Distribution of Drinking (n=47)

Table 5.8 shows that participants who reported alcohol intake were 9 (19.1%), while participants who reported no alcohol intake were 38 (80.9%).

Drinking	Frequency	Percentage(%)
Yes	9	19.1
No	38	80.9
Total	47	100.0

Table 5.9: Frequency Distribution of Smoking (n=47)

Table 5.9 shows that participants who were smokers were 17 (36.2%), while participants who were non-smokers were 30 (63.8%).

Smocking	Frequency	Percentage
Yes	17	36.2
No	30	63.8
Total	47	100.0

Table 5.10: Frequency Distribution of Tumor Location (n=47)

Table 5.10 shows that tumors were located in the left hepatic lobe in 10 participants (21.3%), while the right hepatic lobe was involved in 37 participants (78.7%).

Tumor Location	Frequency	Percentage(%)
Left	10	21.3
Right	37	78.7
Total	47	100.0

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Table 5.11: Frequency Distribution of Tumor Diameter (n=47)

Table 5.11 shows that participants who had tumor diameter less than 5 cm were 26 (55.3%), while participants who had tumor diameter greater than 5 cm were 21 (44.7%).

Tumor Diameter (cm)	Frequency	Percentage(%)
<5	26	55.3
>5	21	44.7
Total	47	100.0

Table 5.12: Frequency Distribution of Plasma Albumin (n=47)

Table 5.12 shows that participants who had plasma albumin less than 5 g/L were 11 (23.4%), while participants who had plasma albumin greater than 5 g/L were 36 (76.6%).

Plasma Albumin (g/L)	Frequency	Percentage(%)
<5	11	23.4
>5	36	76.6
Total	47	100.0

Table 5.13: Frequency Distribution of ASA Score (n=47)

Table 5.13 shows that participants with ASA Physical Status Class 1-2 were 32 (68.1%), while participants with ASA Physical Status Class 3-4 were 15 (31.9%).

ASA Score	Frequency	Percentage(%)
1-2	32	68.1
3-4	15	31.9
Total	47	100.0

Table 5.14: Frequency Distribution of Operation Time (n=47)

Table 5.14 shows that participants who had operation time less than 5 hours were 29 (61.7%), while participants who had operation time greater than 5 hours were 18 (38.3%).

Operation Time (h)	Frequency	Percentage(%)
<5	29	61.7
>5	18	38.3
Total	47	100.0

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Table 5.15: Frequency Distribution of Blood Loss (n=47)

Table 5.15 shows that participants with estimated blood loss below 500 mL were 28 (59.6%), while participants with estimated blood loss above 500 mL were 19 (40.4%).

Blood Loss	Frequency	Percentage(%)
<500	28	59.6
>500	19	40.4
Total	47	100.0

Table 5.16: Frequency Distribution of Operation Method (n=47)

Table 5.16 shows that the most frequently performed operation was hemihepatectomy, which was performed in 31 participants (66.0%), followed by segmentectomy in 9 participants (19.1%), hepatolobectomy in 4 participants (8.5%), and extended hemihepatectomy in 3 participants (6.4%).

Operation Method	Frequency	Percentage(%)
Segmentectomy	9	19.1
Hepatolobectomy	4	8.5
hemihepatectomy	31	66.0
extended hemihepatectomy	3	6.4
Total	47	100.0

Table 5.17: Frequency Distribution of Biliary Fistula (n=47)

Table 5.17 shows that participants who had positive biliary fistula were 6 (12.8%), while participants with negative biliary fistula were 41 (87.2%).

Biliary Fistula	Frequency	Percentage(%)
Positive	6	12.8
Negative	41	87.2
Total	47	100.0

Table 5.18: Frequency Distribution of Drainage Time (n=47)

Table 5.18 shows that participants who had drainage time less than 72 hours were 12 (25.5%), while participants who had drainage time greater than 72 hours were 35 (74.5%).

Drainage Time	Frequency	Percentage(%)
<72	12	25.5
>72	35	74.5
Total	47	100.0

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6 DISCUSSION

This study was conducted to assess postoperative complications after liver resection for hepatocellular carcinoma in patients treated at Shaikh Zayed Hospital Lahore. The findings revealed that patients undergoing liver resection for hepatocellular carcinoma experienced a range of postoperative complications, with biliary fistula being the most frequently observed complication. The study further demonstrated that certain demographic and clinical factors, including age, gender, comorbidities, tumor characteristics, and operative parameters, were associated with the occurrence of postoperative complications. These findings indicate that postoperative morbidity remains an important concern in liver resection for hepatocellular carcinoma and requires greater attention from surgical teams and hospital management.

Regarding body mass index, the present study demonstrated that 44.7% of patients had normal BMI, while 21.3% were obese, 19.1% were overweight, and 14.9% were underweight. These findings indicate that patients undergoing liver resection for hepatocellular carcinoma present with varying nutritional status. Similar observations were reported by Yang et al. (2023), who concluded that although obesity has become an increasingly important risk factor for hepatocellular carcinoma because of metabolic dysfunction-associated steatotic liver disease, many patients continue to have normal body weight at the time of surgery. They further emphasized that nutritional assessment should not rely solely on body mass index because chronic liver disease may mask underlying malnutrition. These findings support the importance of comprehensive nutritional evaluation before liver resection. (Yang et al., 2024).

The present study also found that 36.2% of patients had a history of smoking, whereas alcohol consumption was reported by 19.1% of patients. These findings reflect the presence of well recognized lifestyle related risk factors among a considerable proportion of patients with hepatocellular carcinoma. European Association for the Study of the Liver (EASL) Clinical Practice Guidelines (2018) reported that smoking and excessive alcohol consumption contribute to hepatocarcinogenesis through chronic liver injury, oxidative stress, and progression to cirrhosis. Although alcohol consumption was relatively less frequent in the present study, smoking remained common, indicating the need for effective preventive strategies, smoking cessation programs, and patient education to reduce future liver disease burden. (EASL, 2018).

The present study found that postoperative infectious complications remain an important concern following open hepatectomy for hepatocellular carcinoma. These findings are comparable with the study conducted by Pu et al., who analyzed a large multicenter cohort of patients and reported that open hepatectomy was associated with significant incidences of overall infection, incisional surgical site infection, organ/space SSI, and remote infection. The study further demonstrated that open hepatectomy was associated with higher 30-day morbidity and longer postoperative hospital stays compared with the laparoscopic approach. The agreement between the present study and previous literature suggests that infectious complications remain a significant source of postoperative morbidity in patients undergoing open hepatectomy for hepatocellular carcinoma, highlighting the need for meticulous surgical technique, appropriate perioperative antibiotic prophylaxis, and careful postoperative monitoring to reduce these complications. (Pu et al.).

The present study found that biliary fistula was observed in 6 patients (12.8%), while the majority of patients (n=41, 87.2%) did not develop this complication. These findings are comparable with the study conducted by Shehta et al., who reviewed 293 patients who underwent hepatic resection for HCC and reported that bile leakage occurred in 17 patients (5.8%). Their study further demonstrated that longer hospital stay (15 vs 5 days, p=0.001), higher grades of post-hepatectomy liver failure, and abdominal collections were significantly associated with bile leakage. Furthermore, Child-Pugh class, macroscopic portal vein invasion, liver resection extent (minor/major), and Pringle's maneuver use were identified as the main independent risk factors for

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bile leakage on multivariate analysis. The agreement between the present study and previous literature suggests that biliary fistula remains one of the commonest morbidities after hepatic resection for HCC, and careful patient selection, meticulous surgical technique, and close postoperative monitoring are essential to reduce its occurrence. (Shehta et al.).

The present study included patients who underwent open hepatectomy for hepatocellular carcinoma, which remains the standard surgical approach in many centers. These findings are comparable with the study conducted by Tian et al., who analyzed 1773 HCC patients and reported that open liver resection was associated with higher intraoperative blood loss, longer postoperative hospital stays, and higher postoperative complications (32.8%) compared with laparoscopic liver resection. However, their study demonstrated that overall survival and disease-free survival had no significant difference between laparoscopic and open approaches. (Tian et al.).

In the current research, liver resection for hepatocellular carcinoma takes place with a number of complications, with biliary fistula being the most frequently observed complication. A total of 47 patients were included in this study, of which 20 were males and 27 were females.

7 CONCLUSION

This study concluded that patients undergoing liver resection for hepatocellular carcinoma experience a range of postoperative complications. Biliary fistula was the most frequently observed complication. Hypertension, diabetes, and coronary disease were common comorbidities in this patient population. Hemihepatectomy was the most frequently performed surgical procedure. Although biliary fistula was the main postoperative complication observed, no cases of post-hepatectomy liver failure or mortality were recorded. These findings highlight the importance of careful patient selection, meticulous surgical technique, and close postoperative monitoring to reduce biliary fistula and improve patient outcomes.

Recommendations

- Preoperative optimization of modifiable risk factors including diabetes mellitus, hypertension, and nutritional status should be prioritized to improve surgical outcomes and reduce postoperative morbidity.
- Enhanced Recovery After Surgery (ERAS) protocols should be implemented to standardize perioperative care, reduce postoperative complications, and shorten hospital stay.
- Larger multicenter prospective studies with long-term follow-up should be conducted to evaluate risk factors and long-term oncological outcomes in patients undergoing liver resection for hepatocellular carcinoma.

Limitations

- This study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings across Pakistan.
- The relatively small sample size (N=47) may have limited the statistical power to detect significant associations between risk factors and postoperative complications.
- The study did not include long-term follow-up data to evaluate survival outcomes or tumor recurrence rates.

8 REFERENCES

Jin S, Fu Q, Wuyun G, Wuyun T. Management of posthepatectomy complications. World J Gastroenterol 2013; 19(44): 7983-7991. Available from: URL: http://www.wjgnet.com/1007-9327/full/v19/i44/7983.htm. DOI: http://dx.doi.org 10.3748/wjg.v19.i44.7983

Cannella, R., Zins, M. & Brancatelli, G. ESR Essentials: diagnosis of hepatocellular carcinoma—practice recommendations by ESGAR. Eur Radiol 34, 2127–2139 (2024). https://doi.org/10.1007/s00330-024-10606-w

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Hwang SY, Danpanichkul P, Agopian V, Mehta N, Parikh ND, Abou-Alfa GK, et al. Hepatocellular carcinoma: updates on epidemiology, surveillance, diagnosis and treatment. Clin Mol Hepatol. 2025;31(Suppl):S228-S254. https://doi.org/10.3350/cmh.2024.0824

Huang, D. Q., Singal, A. G., Kono, Y., Tan, D. J. H., El-Serag, H. B., & Loomba, R. (2022). Changing global epidemiology of liver cancer from 2010 to 2019: NASH is the fastest growing cause of liver cancer. Cell metabolism, 34(7), 969–977.e2. https://doi.org/10.1016/j.cmet.2022.05.003

Mauro E, de Castro T, Zeitlhoefler M... hepatocellular carcinoma: Epidemiology, diagnosis and treatment. JHEP Reports, 2025; 7. https://doi.org/10.1016/j.jhepr.2025.101571

Amin, N.; Anwar, J.;Sulaiman, A.; Naumova, N.N.; Anwar,N. Hepatocellular Carcinoma: A Comprehensive Review. Diseases 2025,13, 207. https://doi.org/10.3390/diseases13070207

Gabbia, D.; De Martin, S. insights into Hepatocellular Carcinoma: From Pathophysiology to Novel Therapies. Int. J. Mol. Sci. 2024, 25, 4188. https://doi.org/10.3390/ijms25084188

Zhao J, Hu Z, Zheng X, Lin Y, Liu X, Zhang J, Peng J and Gao H (2024) Blood biomarkers of hepatocellular carcinoma: a critical review. Front. Cell Dev. Biol. 12:1489836. doi:10.3389 fcell.2024.1489836

Singal, A. G., Llovet, J. M., Yarchoan, M., Mehta, N., Heimbach, J. K., Dawson, L. A., Jou, J. H., Kulik, L. M., Agopian, V. G., Marrero, J. A., Mendiratta-Lala, M., Brown, D. B., Rilling, W. S., Goyal, L., Wei, A. C., & Taddei, T. H. (2023). AASLD Practice Guidance on prevention, diagnosis, and treatment of hepatocellular carcinoma. Hepatology (Baltimore, Md.), 78(6), 1922–1965. https://doi.org/10.1097/HEP.0000000000000466

Sangro B, Argemi J, Ronot M ... EASL Clinical Practice Guidelines on the management of hepatocellular carcinoma Journal of Hepatology, 2024; 82, 315-374 https://doi.org/10.1016/j.jhep.2024.08.028

Kinsey, E.; Lee, H.M. Management of Hepatocellular Carcinoma in 2024: The Multidisciplinary Paradigm in an Evolving Treatment Landscape. Cancers 2024, 16, 666. https://doi.org/10.3390/cancers16030666

Morise Z, Kawabe N, Tomishige H, Nagata H, Kawase J, Arakawa S, Yoshida R and Isetani M (2014) Recent Advances in Liver Resection for Hepatocellular Carcinoma. Front. Surg. 1:21. doi: 10.3389/fsurg.2014.00021

Lee, J.S.; Choi, H.W.; Kim, J.S.; Lee, T.Y.; Yoon, Y.C.Update on Resection Strategies for Hepatocellular Carcinoma: A Narrative Review. Cancers 2024, 16, 4093. https://doi.org/10.3390/cancers16234093

Suresh N, Ng CK, Blanco-Colino R, Hakeem AR. Contemporary perspectives on laparoscopic liver resection for hepatocellular carcinoma: unravelling the potential and limitations. Hepatoma Res 2024;10:26. https://dx.doi.org/10.20517/2394-5079.2024.07

Patel, J., Jones, C. N., & Amoako, D. (2022). Perioperative management for hepatic resection surgery. BJA Education, 22(9), 357–363. https://doi.org/10.1016/j.bjae.2022.05.002

Lee, J.S.; Choi, H.W.; Kim, J.S.; Lee, T.Y.; Yoon, Y.C. Update on Resection Strategies for Hepatocellular Carcinoma: A Narrative Review. Cancers 2024, 16, 4093. https://doi.org/10.3390/cancers16234093

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Kubo N, Shirabe K. Treatment strategy for isolated bile leakage after hepatectomy:Literature review. Ann Gastroenterol Surg. 2020;4:47–55. https://doi.org/10.1002/ags3.12303

Quireze Junior, C., Coelho, F. F., Lima, A. S., Marques, H. P., Palavecino, M., Pawlik, T., Adam, R., Soubrane, O., Herman, P., & Cotta-Pereira, R. L. (2024). Complications after hepatectomy. ABCD. Arquivos Brasileiros de Cirurgia Digestiva (São Paulo), 37, e1856. https://doi.org/10.1590/0102-6720202400062e1856

Rahbari, N. N., Garden, O. J., Padbury, R., Maddern, G., Koch, M., Hugh, T. J., Fan, S. T., Nimura, Y., Figueras, J., Vauthey, J. N., Rees, M., Adam, R., Dematteo, R. P., Greig, P., Usatoff, V., Banting, S., Nagino, M., Capussotti, L., Yokoyama, Y., Brooke-Smith, M., ... Weitz, J. (2011). Post-hepatectomy haemorrhage: a definition and grading by the International Study Group of Liver Surgery (ISGLS). HPB : the official journal of the International Hepato Pancreato Biliary Association, 13(8), 528–535. https://doi.org/10.1111/j.1477-2574.2011.00319.x

Lepere, V., Vanier, A., Loncar, Y., Lemoine, L., Vaillant, J. C., Monsel, A., Savier, E., Coriat, P., & Eyraud, D. (2017). Risk factors for pulmonary complications after hepatic resection: role of intraoperative hemodynamic instability and hepatic ischemia. BMC anesthesiology, 17(1), 84. https://doi.org/10.1186/s12871-017-0372-9

Kim, M., Kiran, R. P., & Li, G. (2019). Acute kidney injury after hepatectomy can be reasonably predicted after surgery. Journal of hepato-biliary-pancreatic sciences, 26(4), 144–153. https://doi.org/10.1002/jhbp.615

Tang, H., Lu, W., Yang, Z., Jiang, K., Chen, Y., Lu, S., & Dong, J. (2017). Risk factors and long-term outcome for postoperative intra-abdominal infection after hepatectomy for hepatocellular carcinoma. Medicine, 96(17), e6795. https://doi.org/10.1097/MD.0000000000006795

Zhou, Y. M., Zhang, X. F., Li, B., Sui, C. J., & Yang, J. M. (2015). Postoperative complications affect early recurrence of hepatocellular carcinoma after curative resection. BMC cancer, 15, 689. https://doi.org/10.1186/s12885-015-1720-0

Hafeez Bhatti, Abu Bakar, Dar, Faisal Saud, Waheed, Anum, Shafique, Kashif, Sultan, Faisal, Shah, Najmul Hassan, Hepatocellular Carcinoma in Pakistan: National Trends and Global Perspective, Gastroenterology Research and Practice, 2016, 5942306, 10 pages, 2016. https://doi.org/10.1155/2016/5942306

Zhang, H., Kang, D., Liu, F., Li, B., Zhang, W., & Wei, Y. (2022). Risk factors associated with postoperative complications and prolonged postoperative length of stay after laparoscopic liver resection. Video surgery and Other invasive Techniques, 17(3), 515–523. https://doi.org/10.5114/wiitm.2022.118104

Yang, S., Ni, H., Zhang, A. et al. Impact of postoperative morbidity on the prognosis of patients with hepatocellular carcinoma after laparoscopic liver resection: a multicenter observational study. Sci Rep 15, 1724 (2025). https://doi.org/10.1038/s41598-024-85020-9

Yang, S., Ni, H., Zhang, A. et al. Body mass index is a risk factor for postoperative morbidity after laparoscopic hepatectomy of hepatocellular carcinoma: a multicenter retrospective study. J Cancer Res Clin Oncol 150, 445 (2024). https://doi.org/10.1007/s00432-024-05979-w

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Vaghiri, S., Prassas, D., Mustafov, O. et al. Which factors predict tumor recurrence and survival after curative hepatectomy in hepatocellular carcinoma? Results from a European institution. BMC Surg 24, 101 (2024). https://doi.org/10.1186/s12893-024-02399-y

Li, J.-D., Zhou, Y.-H., Xu, X., Gu, W.-M., Lau, W. Y., Jia, H.-D., Lv, G.-Y., Pawlik, T. M., Chen, Z.-X., Guan, M.-C., Chen, Z.-Y., Liang, Y.-J., Wang, M.-D., Wang, H., Shen, F., Wang, X.-M., Chen, Z., Chen, L.-L., Yao, L.-Q., ... Pu, J.-L. (2023). Postoperative infectious complications following laparoscopic versus open hepatectomy for hepatocellular carcinoma: a multicenter propensity score analysis of 3876 patients. International Journal of Surgery, 109(8), 2267–2275. https://doi.org/10.1097/JS9.0000000000000446

Tian F, Leng S, Chen J, Cao Y, Cao L, Wang X, Li X, Wang J, Zheng S and Li J (2023) Long-term outcomes of laparoscopic liver resection versus open liver resection for hepatocellular carcinoma: A single-center 10-year experience.Front. Oncol. 13:1112380. doi: 10.3389/fonc.2023.1112380

Shehta, A., Farouk, A., Said, R., El Nakeeb, A., Aboelenin, A., Elshobary, M., Fouad, A., & Elghawalby, A. N. (2022). Bile leakage after hepatic resection for hepatocellular carcinoma: Does it impact the short- and long-term outcomes? Journal of Gastrointestinal Surgery, 26(10), 2070–2081. https://doi.org/10.1007/s11605-022-05433-7

Li Y-R, Meng X-Y, Zong R-Q and Wu F-X (2021) Association Between Procalcitonin and Post-hepatectomy Liver Failure in Hepatocellular Carcinoma Patients. Front. Pharmacol. 12:791322. doi: 10.3389/fphar.2021.791322

Halkic, N., Demartines, N., Uldry, E., Melloul, E., Joliat, G.-R., Labgaa, I., Piazza, G., Schneider, M., Kawaguchi, Y., & Kobayashi, K. (2021). Probability of Postoperative Complication after Liver Resection: Stratification of Patient Factors, Operative Complexity, and Use of Enhanced Recovery after Surgery. Journal of the American College of Surgeons, 233(3), 357 368e1-368 368e2. https://doi.org/10.1016/j.jamcollsurg.2021.05.020

Chen Y, Liu Z, Mo Y, Li B, Zhou Q, Peng S, Li S and Kuang M (2021) Prediction of Post-hepatectomy Liver Failure in Patients With Hepatocellular Carcinoma Based on Radiomics

Using Gd-EOB-DTPA-Enhanced MRI: The Liver Failure Model. Front. Oncol. 11:605296. doi: 10.3389/fonc.2021.605296

Nakano, R., Ohira, M., Kobayashi, T., Imaoka, Y., Mashima, H., Yamaguchi, M., Honmyo, N., Okimoto, S., Hamaoka, M., Shimizu, S., Kuroda, S., Tahara, H., Ide, K., & Ohdan, H. (2018). Independent risk factors that predict bile leakage after hepatectomy for hepatocellular carcinoma: Cohort study. International Journal of Surgery, 57, 1–7. https://doi.org/10.1016/j.ijsu.2018.07.005

Rahnemai-Azar AA, Cloyd JM, Weber SM, Dillhoff M, Schmidt C, Winslow ER, et al. Update on liver failure following hepatic resection: strategies for prediction and avoidance of post-operative liver insufficiency. J Clin Transl Hepatol 2018;6(1):97–104. doi: 10.14218/JCTH.2017.00060.

Zhao Y, Jin Y, Wu Y. Postoperative infectious complications after liver resection for hepatocellular carcinoma. J Can Res Ther 2016;12:C268-70.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Ishii M, Mizuguchi T, Harada K, Ota S, Meguro M, Ueki T, Nishidate T, Okita K, Hirata K. Comprehensive review of post liver resection surgical complications and a new universal classification and grading system. World J Hepatol 2014; 6(10): 745-751 http://dx.doi.org/10.4254/wjh.v6.i10.745