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Postoperative Outcomes and Their Determinants in Perforated Duodenal Ulcers

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Abstract

Background: Perforated peptic ulcer remains a serious surgical emergency associated with considerable postoperative morbidity and mortality, particularly in patients presenting late with peritonitis, sepsis, advanced age, malnutrition, or multiple comorbidities. Postoperative outcomes are influenced by several interrelated patient-, disease-, procedure-, and healthcare-related factors. Early complications include surgical-site infection, intra-abdominal abscess, anastomotic leakage, respiratory complications, septicemia, and multiorgan failure, whereas long-term outcomes may involve recurrent ulceration, gastric outlet obstruction, impaired functional recovery, and reduced quality of life. Surgical technique, timing of intervention, physiological condition at presentation, nutritional status, Helicobacter pylori eradication, perioperative critical care, and implementation of enhanced recovery protocols may substantially affect recovery, hospital stay, recurrence, and survival. This review discusses the principal postoperative outcomes following surgery for perforated peptic ulcer and summarizes the major determinants associated with favorable and poor prognosis.

Keywords: Perforated peptic ulcer; Postoperative outcomes; Postoperative complications; Morbidity; Mortality; Prognostic factors; Surgical repair; Helicobacter pylori.

Introduction:

Perforated peptic ulcer remains a serious surgical emergency associated with considerable postoperative morbidity and mortality. Peptic ulcer formation results primarily from an imbalance between aggressive acid-peptic factors and the protective mechanisms of the gastroduodenal mucosa. Under normal conditions, the mucosal barrier is maintained through bicarbonate and mucus secretion, epithelial regeneration, tight intercellular junctions, and adequate mucosal blood flow. When gastric acid and pepsin activity exceed these protective mechanisms, mucosal injury and ulceration may occur. Excessive acid secretion, impaired bicarbonate production, and disruption of mucosal defenses, particularly in association with *Helicobacter pylori* infection, contribute substantially to ulcer development and its complications **(1).**

Perforation represents one of the most severe complications of peptic ulcer disease. Leakage of gastroduodenal contents into the peritoneal cavity causes chemical peritonitis, followed by bacterial contamination, systemic inflammation, sepsis, and potentially multiorgan dysfunction. The severity of this physiological insult is influenced by the size and location of the perforation, the duration of peritoneal contamination, the patient's physiological reserve, and the timing of surgical intervention. Delays exceeding 24 hours from symptom onset markedly increase postoperative morbidity and mortality because ongoing contamination promotes progressive sepsis and irreversible organ dysfunction **(2).**

Postoperative outcomes following surgical treatment are determined by a complex interaction of patient-, disease-, procedure-, and healthcare-related factors. Patient characteristics such as advanced age, frailty, diabetes mellitus, chronic kidney disease, cardiovascular disease, immunosuppression, obesity, and malnutrition increase susceptibility

to postoperative complications and reduce tolerance to surgical stress. Patients presenting with shock, severe sepsis, respiratory compromise, or multiorgan dysfunction are particularly vulnerable to poor outcomes despite urgent operative management and aggressive resuscitation **(3).**

Early postoperative complications include surgical-site infection, wound breakdown, intra-abdominal abscess, persistent peritonitis, leakage from the repair site, fistula formation, pneumonia, respiratory failure, septicemia, and multiorgan failure. These complications may prolong intensive care and hospital stay, delay oral feeding and mobilization, increase the need for additional procedures, and contribute substantially to early postoperative mortality. Their occurrence is influenced by the degree of contamination, duration of surgery, blood loss, technical quality of repair, perioperative antibiotic administration, and adequacy of postoperative monitoring and source control **(4).**

The selected surgical technique also has an important influence on postoperative recovery. Simple closure with an omental patch remains widely used because it is rapid, technically straightforward, and appropriate for unstable or high-risk patients. Definitive acid-reducing procedures may offer greater protection against recurrence but require longer operative time and greater surgical expertise. Laparoscopic repair may reduce postoperative pain, wound complications, and hospital stay compared with open surgery; however, severe sepsis, diffuse peritonitis, hemodynamic instability, limited resources, and lack of surgical expertise may restrict its use **(5).**

Postoperative recovery is commonly assessed through mortality, morbidity, intensive care requirements, duration of hospitalization, resumption of oral intake, early mobilization, functional recovery, and quality of life. Prolonged intensive care and hospital admission are often indicators of persistent infection, organ dysfunction, frailty, or delayed recovery. Conversely, early feeding, adequate pain control, pulmonary rehabilitation, and early mobilization may reduce ileus, respiratory complications, thromboembolic events, and functional decline. Enhanced Recovery After Surgery protocols incorporate these measures and have been associated with shorter hospital stays and improved recovery after abdominal surgery **(6).**

Long-term outcomes remain dependent on control of the underlying ulcer disease. Persistent *Helicobacter pylori* infection, continued use of non-steroidal anti-inflammatory drugs, inadequate acid suppression, and poor adherence to follow-up increase the risk of recurrent ulceration, re-perforation, gastric outlet obstruction, and the need for further surgical or endoscopic intervention. Eradication of *H. pylori*, avoidance of ulcerogenic medications, and appropriate medical therapy are therefore essential components of postoperative management and recurrence prevention **(7).**

Risk-stratification systems, including the Boey score and the Peptic Ulcer Perforation score, are useful for identifying patients at increased risk of postoperative morbidity and mortality. These tools incorporate factors such as age, shock at admission, comorbidities, delayed presentation, and laboratory abnormalities. In addition, biomarkers including lactate, C-reactive protein, and procalcitonin may support assessment of disease severity and help guide resuscitation, intensive care admission, and perioperative management **(8).**

Despite advances in resuscitation, antimicrobial therapy, anesthesia, minimally invasive surgery, and critical care, adverse postoperative outcomes remain common, especially among elderly, malnourished, septic, and late-presenting patients. A comprehensive understanding of the determinants of morbidity, mortality, hospital stay, recurrence, and quality of life is therefore necessary to improve clinical decision-making and perioperative care. Accordingly, this review aimed to summarize the principal early and long-term postoperative outcomes following surgery for perforated peptic ulcer and to identify the major patient-, disease-, surgical-, and healthcare-related factors that influence prognosis.

Early Postoperative Complications

Surgical site infections (SSIs) remain among the most common and clinically significant postoperative complications, carrying implications for both morbidity and healthcare costs. They arise from a combination of perioperative contamination, patient comorbidities, and intraoperative technical factors. When superficial, SSIs may

prolong hospitalization and delay recovery; however, deeper infections such as intra-abdominal abscesses can lead to severe systemic compromise and require additional interventions including reoperation or percutaneous drainage. Furthermore, **anastomotic leaks may evolve into fistulae**, which are notoriously difficult to manage and often necessitate prolonged nutritional support, wound care, and multiple procedures **(9).**

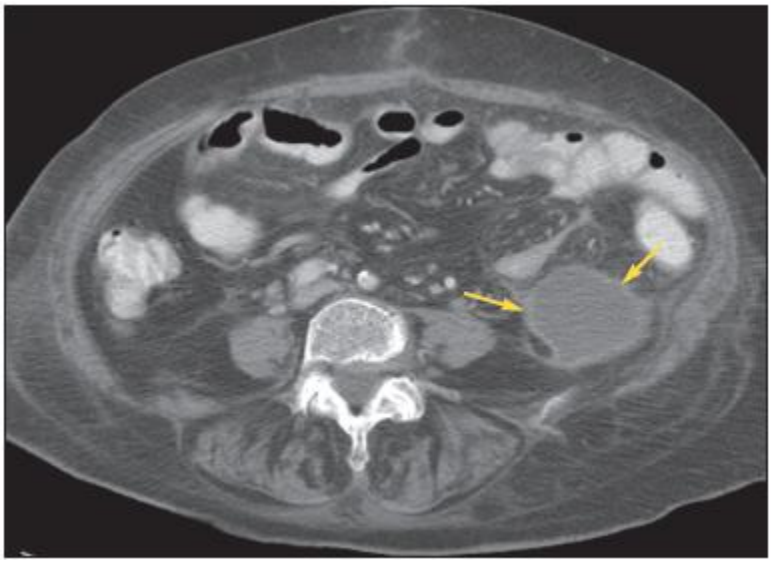

Figure (1): CT Image of Postoperative Abscess Formation (9).

The determinants of these complications are multifactorial. Patient-related risk factors such as diabetes mellitus, obesity, immunosuppression, and malnutrition significantly predispose individuals to infection. Surgical determinants include prolonged operative times, excessive blood loss, and the use of contaminated surgical fields. Preventive strategies, therefore, emphasize strict aseptic technique, appropriate perioperative antibiotic prophylaxis, meticulous tissue handling, and enhanced recovery protocols (**10).**

Respiratory complications constitute another important category of early postoperative morbidity. Pneumonia frequently results from impaired pulmonary clearance mechanisms due to anesthesia, prolonged mechanical ventilation, or postoperative pain limiting effective coughing and mobilization. Aspiration, poor pulmonary hygiene, and underlying chronic lung disease further exacerbate susceptibility. These infections are associated with increased intensive care utilization, longer hospital stays, and elevated mortality rates. In severe cases, acute respiratory distress syndrome (ARDS) may develop, characterized by diffuse alveolar damage, hypoxemia refractory to oxygen therapy, and significant systemic inflammatory response **(11).**

Preventing respiratory complications requires a proactive approach. Perioperative strategies such as preoperative pulmonary optimization, smoking cessation, lung expansion maneuvers, early mobilization, and adequate pain control play crucial roles. Enhanced recovery programs advocate for multimodal analgesia to reduce opioid-induced respiratory depression and encourage deep breathing exercises. In high-risk patients, judicious use of non-invasive ventilation and vigilant monitoring in the immediate postoperative period can reduce the incidence and severity of complications **(12).**

Septicemia represents one of the most life-threatening postoperative complications, arising most commonly from uncontrolled infections such as anastomotic leaks, intra-abdominal abscesses, or overwhelming pneumonia. Once bacteria or their toxins disseminate into the bloodstream, a systemic inflammatory cascade ensues, potentially progressing to sepsis and septic shock. In this state, microvascular dysfunction, coagulopathy, and impaired perfusion

drive a downward spiral of organ dysfunction. If not rapidly recognized and aggressively managed, the condition advances to multiorgan failure, which carries a high mortality rate despite modern intensive care measures **(13).**

Determinants of septicemia and multiorgan failure extend beyond the immediate surgical insult to include patient frailty, advanced age, and the presence of comorbidities such as chronic kidney disease, diabetes, and cardiovascular compromise. Timely diagnosis through clinical vigilance, biomarkers, and imaging is essential. Management revolves around early and appropriate antimicrobial therapy, aggressive source control, hemodynamic stabilization, and organ support in the intensive care unit. Preventive measures, including meticulous surgical technique and perioperative infection surveillance, remain the cornerstone of reducing incidence **(4).**

Mortality and Morbidity Trends

Short-term postoperative survival is primarily determined by immediate surgical success, the presence of complications, and the adequacy of perioperative care. Advances in anesthesia, surgical techniques, and critical care have contributed to significant reductions in early postoperative mortality over the past decades. Despite these improvements, early deaths often remain linked to sepsis, cardiovascular collapse, and respiratory failure, highlighting the need for vigilant perioperative monitoring and timely interventions. Morbidity during this phase is often characterized by wound complications, infections, and organ dysfunction, which, while not always fatal, may prolong hospitalization and impair functional recovery **(14).**

In contrast, long-term survival is strongly influenced by underlying disease pathology, comorbid conditions, and the patient's overall physiological reserve. For instance, in oncologic surgery, long-term outcomes are determined not only by perioperative recovery but also by disease recurrence and progression. Moreover, complications arising in the early postoperative period, such as fistulae or sepsis, may have enduring consequences, reducing quality of life and long-term survival rates. Therefore, assessing postoperative outcomes requires a comprehensive view that extends beyond 30-day mortality to encompass functional recovery, disease-specific survival, and quality-adjusted life years **(15).**

Certain populations face disproportionately higher risks of mortality and morbidity after major surgery. The elderly, in particular, often present with diminished physiological reserves and reduced tolerance to surgical stress. Age-related changes in cardiovascular, respiratory, and immune systems contribute to a higher susceptibility to complications such as pneumonia, renal failure, and wound breakdown. Additionally, cognitive decline and frailty can complicate recovery, leading to functional dependence even in the absence of life-threatening complications **(16).**

Comorbid conditions such as diabetes, chronic kidney disease, and cardiovascular disorders further compound postoperative risk. Patients presenting late, often with advanced disease or complications such as perforation and sepsis, face even greater odds of adverse outcomes. Delayed presentation not only limits the feasibility of minimally invasive approaches but also increases the likelihood of emergency interventions, which inherently carry higher mortality **(3).**

Postoperative mortality rates vary considerably across regions, reflecting disparities in healthcare infrastructure, access to timely surgery, and quality of perioperative care. In high-income countries, reported short-term mortality after major abdominal surgery is often below 5%, owing to well-established perioperative protocols, availability of intensive care, and advanced infection control measures. In contrast, low- and middle-income regions frequently report substantially higher mortality rates, sometimes exceeding 15–20%, particularly for emergency procedures **(17).**

Literature also underscores the impact of socioeconomic and systemic factors on outcomes. For example, registry-based data from Europe and North America demonstrate steady improvements in survival due to centralization of complex surgeries in high-volume centers. Conversely, in resource-limited settings, outcomes are adversely affected by late-stage presentations, shortages of essential medications, and limited capacity for early recognition and treatment

of complications. Regional mortality trends not only reflect patient-level determinants but also broader health system inequities, underscoring the need for global initiatives to improve surgical safety and accessibility **(18).**

Hospital Stay and Recovery Parameters

The requirement for intensive care unit (ICU) admission after surgery is generally dictated by the severity of the patient's preoperative condition, intraoperative challenges, and the occurrence of postoperative complications. Patients with hemodynamic instability, severe sepsis, or respiratory compromise often necessitate ICU-level support for close monitoring, invasive ventilation, and organ support therapies. The early postoperative period is particularly critical, as it is during this phase that life-threatening complications such as septic shock, acute kidney injury, and respiratory failure are most likely to manifest **(19).**

The duration of ICU stay varies depending on the rapidity of physiological stabilization and the effectiveness of postoperative management. Short stays may reflect well-controlled surgical recovery, while prolonged ICU admissions often signal the presence of persistent complications or underlying frailty. Prolonged intensive care, however, carries its own risks, including nosocomial infections, muscle wasting, and psychological effects such as post-ICU syndrome. Therefore, judicious triaging, early recognition of recovery milestones, and timely transition to ward-based care are essential in balancing the benefits of ICU admission with the risks of extended intensive care exposure **(20).**

The length of hospital stay serves as a vital marker of postoperative recovery and healthcare resource utilization. Patients with uncomplicated surgical courses and rapid recovery typically achieve discharge within a predictable timeframe, often within one to two weeks for major abdominal operations. However, prolonged stays are frequently associated with surgical site infections, delayed wound healing, anastomotic complications, or systemic issues such as pneumonia and renal impairment. Each additional day of hospitalization not only increases healthcare costs but also heightens the risk of hospital-acquired infections and functional decline, particularly among elderly patients **(21).**

Determinants of hospital stay length extend beyond medical complications to include institutional factors such as availability of rehabilitation services, discharge planning efficiency, and socioeconomic considerations. Enhanced Recovery After Surgery (ERAS) protocols have been shown to reduce hospital stay by promoting early feeding, mobilization, and multimodal analgesia. Nevertheless, the success of these protocols depends on patient adherence, surgical expertise, and institutional support **(6).**

Resumption of oral intake is a critical milestone in postoperative recovery, symbolizing the restoration of gastrointestinal function and the patient's ability to tolerate nutrition without complications. Early initiation of oral feeding, often within 24–48 hours after surgery, has been associated with reduced ileus, lower infection rates, and improved overall outcomes. Conversely, delayed tolerance may result from postoperative ileus, anastomotic leakage, or intra-abdominal sepsis, necessitating prolonged parenteral or enteral nutritional support **(22).**

Similarly, early mobilization plays a pivotal role in preventing thromboembolic events, preserving muscle strength, and accelerating return to baseline functional capacity. Prolonged bed rest, once considered protective, is now recognized as a risk factor for complications such as pneumonia, venous thromboembolism, and deconditioning. Encouraging patients to ambulate within the first postoperative days, supported by adequate analgesia and physiotherapy, is now a standard element of modern recovery protocols (**23).**

Recurrent Ulceration and Long-term Outcomes

Recurrent ulceration remains a significant long-term concern, particularly in patients with incomplete risk factor management. Re-perforation, while less common than initial perforation, carries higher mortality due to patient frailty, adhesions from previous surgery, and delayed recognition. Structural complications such as gastric outlet obstruction or strictures may arise as sequelae of chronic ulcer disease, leading to persistent symptoms, nutritional deficiencies, and the need for further surgical or endoscopic interventions **(24).**

Determinants of recurrence include persistent Helicobacter pylori infection, continued use of ulcerogenic medications such as non-steroidal anti-inflammatory drugs (NSAIDs), and inadequate acid suppression. Patients with poor adherence to medical therapy or limited access to follow-up care are particularly vulnerable. Consequently, long-term outcomes can only be optimized through comprehensive management strategies that address not just the acute surgical repair, but also the underlying drivers of ulcer disease **(25).**

The discovery of Helicobacter pylori as a central etiological factor in peptic ulcer disease has revolutionized recurrence prevention. Eradication therapy, typically involving a combination of proton pump inhibitors and antibiotics, has been shown to markedly reduce rates of ulcer recurrence and complications. Without eradication, patients remain at high risk of re-ulceration and its sequelae, even after successful surgical intervention. Postoperative care must incorporate routine testing and treatment for H. pylori where resources allow **(7).**

Successful eradication also carries broader implications, reducing the need for long-term acid suppression and diminishing the risk of gastric malignancy. However, challenges remain, including rising antibiotic resistance and incomplete treatment adherence in some populations. Ensuring follow-up testing to confirm eradication is therefore a crucial component of postoperative care. In regions with high prevalence of H. pylori, prioritizing eradication efforts offers a cost-effective strategy for reducing long-term morbidity and improving quality of life **(26).**

Quality of life (QoL)

Beyond survival and recurrence rates, quality of life (QoL) is an essential dimension of postoperative outcomes. Patients recovering from perforated peptic ulcer surgery often report significant improvements once pain and acute complications resolve, but some may experience persistent dyspeptic symptoms, altered eating habits, or psychological distress. Functional recovery varies, with younger patients typically regaining full capacity, while elderly or comorbid individuals may face lingering limitations **(27).**

The long-term impact of surgery on QoL is shaped by recurrence prevention, nutritional rehabilitation, and support for psychosocial adaptation. Comprehensive care models that integrate medical therapy, dietary counseling, and mental health support are essential in achieving holistic recovery. Importantly, enhancing QoL also depends on minimizing postoperative complications, as patients with reoperations or prolonged hospitalizations often report reduced satisfaction and functional independence **(28).**

Impact of Surgical Technique on Outcomes

The choice of surgical technique has a profound influence on postoperative outcomes, both in the early period and long-term. Simple closure with an omental (Graham) patch remains the most widely used approach in emergency settings because it is quick, technically less demanding, and effective in sealing perforations. It is particularly suited for unstable or elderly patients where operative time must be minimized. However, while it addresses the acute problem, it does not prevent future ulcer recurrence since acid secretion remains unaltered. In contrast, definitive anti-ulcer surgeries such as truncal vagotomy with antrectomy or highly selective vagotomy provide durable protection by reducing gastric acid secretion, but they carry greater operative risk and require more surgical expertise **(29).**

The development of laparoscopic approaches has significantly advanced this field by offering reduced postoperative pain, quicker return of gastrointestinal function, and shorter hospital stays compared to open repair. Randomized and observational studies suggest comparable success rates in terms of ulcer closure, with the added benefit of fewer wound infections and improved patient satisfaction. Nevertheless, not all patients are candidates for laparoscopy, as severe sepsis, diffuse peritonitis, or hemodynamic instability can make pneumoperitoneum unsafe and prolong surgical time **(30).**

Surgeon expertise and hospital resources play an equally crucial role in determining outcomes regardless of the chosen technique. High-volume centers with experienced gastrointestinal surgeons and well-equipped operating theaters consistently report better morbidity and mortality profiles. In contrast, low-resource hospitals often face

limitations such as delayed access to surgery, lack of critical care support, or inadequate perioperative monitoring, which may negate the potential benefits of any surgical technique **(5).**

The impact of surgical technique on outcomes cannot be divorced from patient characteristics and contextual realities. For a frail patient with multiple comorbidities, a rapid omental patch closure may be the most life-saving choice, whereas a younger, stable patient may benefit from laparoscopic or definitive anti-ulcer surgery. Similarly, in a tertiary care center, advanced minimally invasive procedures can be safely pursued, while in resource-limited environments, the focus must remain on prompt and safe closure by the most feasible means **(31).**

Predictors of Poor Prognosis: Evidence from Literature

Delays beyond 24 hours from symptom onset markedly increase morbidity and mortality, as ongoing peritoneal contamination progresses to sepsis, organ dysfunction, and irreversible physiological decline. The reasons for delay are multifactorial, ranging from late presentation and misdiagnosis to systemic barriers such as inadequate emergency surgical capacity, particularly in rural or resource-limited settings (**2).**

Severe sepsis or septic shock is another crucial determinant of prognosis at presentation. Patients in this category often arrive in advanced stages of physiological compromise, with hypotension, metabolic acidosis, and multi-organ dysfunction. Even with urgent surgery and aggressive resuscitation, the systemic inflammatory cascade frequently results in poor outcomes. Literature demonstrates that adherence to structured sepsis management protocols, including early antibiotics and hemodynamic optimization, improves survival, but mortality remains disproportionately high in this group **(32).**

Risk stratification scores, such as the Boey score and the Peptic Ulcer Perforation (PULP) score, further help identify patients at greatest risk of adverse outcomes. These tools incorporate clinical factors such as age, shock at admission, comorbid illness, and biochemical parameters, correlating strongly with postoperative mortality. High scores consistently predict worse outcomes, enabling clinicians to triage patients to more aggressive resuscitation, closer monitoring, or specialized centers when available. Their validation across multiple populations reinforces their importance in evidence-based decision-making **(33).**

Nutritional status has emerged as a critical predictor of prognosis. Hypoalbuminemia and malnutrition are strongly linked with impaired wound healing, increased risk of infection, and prolonged recovery. Malnourished patients often lack the physiological reserve needed to withstand major surgery or combat postoperative sepsis. This recognition has fueled interest in preoperative optimization or "prehabilitation," particularly in elective ulcer surgery, though its application in emergencies remains limited **(34).**

Future Directions in Improving Outcomes

The use of biomarkers such as procalcitonin, C-reactive protein, and lactate levels offers the potential for more precise assessment of sepsis severity and operative risk. These markers, when combined with clinical scoring systems, may allow clinicians to intervene earlier, optimize perioperative management, and allocate ICU resources more effectively. Advances in point-of-care testing could further enhance decision-making in emergency settings, particularly in resource-constrained hospitals where rapid diagnostics are often lacking **(8).**

Predictive models that integrate clinical, laboratory, and imaging data are likely to shape the next generation of decision-making. Machine learning algorithms, trained on large datasets, can potentially outperform conventional scoring systems in forecasting outcomes and guiding individualized treatment plans. Such tools could identify patients who would benefit most from aggressive interventions versus those for whom conservative or palliative strategies may be more appropriate. The future of care, therefore, lies in a data-driven, patient-centered model that blends clinical expertise with technological innovation to optimize outcomes in this high-risk population **(35).**

Enhanced Recovery After Surgery (ERAS) protocols represent another promising avenue. Emphasizing multimodal analgesia, early oral feeding, and early mobilization, ERAS has demonstrated reductions in hospital stay, morbidity, and overall healthcare costs across a range of abdominal procedures. While its implementation in emergency ulcer surgery faces challenges, preliminary data suggest that adopting elements of ERAS even in urgent contexts can accelerate recovery and improve outcomes **(21).**

The growing role of minimally invasive surgery, particularly laparoscopy, in high-risk patients also warrants attention. Innovations in surgical technology, including better energy devices and high-definition visualization, have expanded the feasibility of laparoscopy even in complex emergency cases. As surgeon expertise grows and infrastructure improves, more patients including the elderly and those with comorbidities may benefit from the reduced physiological stress and faster recovery associated with minimally invasive techniques **(36).**

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