Postoperative complications in patients with chemotherapy-induced acute myeloid leukemia (Review)

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Abstract. The present comprehensive review examines the latest clinical and translational research on postoperative complications in adult patients with chemotherapy-treated acute myeloid leukemia (AML) undergoing elective and emergency surgery. Patients with chemotherapy-treated AML face a markedly elevated risk of postoperative complications, with nearly one-half of patients experiencing complications such as severe infections and bleeding, with associated postoperative mortality rates of 10-20%. These risks are primarily driven by profound neutropenia and thrombocytopenia, impairing immune defense and hemostasis. A key clinical implication is that meticulous perioperative management can improve outcomes despite immunosuppression. Whenever possible, elective surgeries should be deferred until bone marrow recovery, with neutrophils at >1,000/μl and platelets at >50x10^9/l. Management requires a multidisciplinary approach, involving hematologists optimizing blood counts with growth factors and transfusions, and infectious disease specialists guiding broad-spectrum antibiotic and antifungal prophylaxis. In urgent surgeries, aggressive supportive measures (colony-stimulating factors, transfusions and antimicrobials) are critical to prevent early infectious complications. Postoperatively, vigilant monitoring and early intervention are essential. This strategy includes intensive care support when indicated, surveillance for subtle signs of infection or bleeding, and the routine implementation of mechanical thromboprophylaxis. By adopting this strategy, teams can mitigate complications and improve outcomes for this high-risk population. Further research and coordinated clinical guidelines are required to refine perioperative strategies and improve outcomes.

Contents

1. Introduction

Acute myeloid leukemia (AML) is an aggressive hematological malignancy characterized by the clonal proliferation of myeloid precursors, which leads to bone marrow failure and cytopenias. AML predominantly affects older adults, with a median age at diagnosis of roughly 68-70 years, and around 60-70% of newly diagnosed cases occurring in patients aged 60 years or older (1,2), a population often burdened with comorbidities that complicate management. Both the underlying disease and intensive chemotherapy required for treatment profoundly impair immune defenses and tissue repair. Leukemic marrow infiltration, combined with cytotoxic treatment, induces severe neutropenia and broader leukocyte dysfunction, disrupting the initial phase of wound healing. As neutrophils are critical orchestrators of early wound healing and infection control, their depletion results in a high risk of infections, and compromises the inflammatory response needed for tissue repair (3,4). Furthermore, chemotherapy damages rapidly dividing normal cells, such as fibroblasts, keratinocytes and endothelial cells, thereby impeding collagen deposition and angiogenesis, exacerbating the risk of wound dehiscence, anastomotic leakage and impaired healing (5,6). Recovery of adaptive immunity is also delayed; T-cell and

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Abbreviations: AML, acute myeloid leukemia; ANC, absolute neutrophil count; DIC, disseminated intravascular coagulation; DVT, deep vein thrombosis; G-CSF, granulocyte colony-stimulating factor; SSI, surgical site infection; VTE, venous thromboembolism

Key words: acute myeloid leukemia, neutropenia, surgical complications, immunosuppression, postoperative infections

B-cell function can remain diminished for weeks to months after intensive chemotherapy (7,8). Repeated chemotherapy cycles or stem cell transplantation may induce hypogammaglobulinemia, further compromising humoral immunity (8).

AML and its treatment disrupt hemostasis and end-organ function. Certain subtypes, particularly acute promyelocytic leukemia (APL), can precipitate disseminated intravascular coagulation (DIC) at presentation (9,10). Chemotherapy and infections may also trigger DIC and simultaneously induce a prothrombotic state via inflammatory cytokines and endothelial activation. This paradoxical milieu confers a risk of both hemorrhagic and thromboembolic complications; one study in patients with acute leukemia reported a 24% incidence of major bleeding and a 26% incidence of venous thromboembolism during induction therapy (11). Chemotherapy-related toxicity may further compromise organ systems; anthracycline may cause cardiomyopathy and arrhythmias (12), and other agents may induce hepatotoxicity with impairment of coagulation factor synthesis (13) or acute kidney injury (14). Consequently, many patients with AML have diminished physiological reserves and a reduced capacity to tolerate perioperative stress.

The standard treatment for AML is intensive cytotoxic chemotherapy, such as anthracycline and cytarabine induction, typically followed by consolidation chemotherapy or hematopoietic stem cell transplantation (15). While surgery is not a primary treatment for AML, patients with chemotherapy-treated AML may require surgical procedures for treating unrelated conditions or acute complications. Notably, these patients face a markedly elevated risk of adverse surgical outcomes, particularly in emergency settings; they present unique challenges, including chemotherapy-induced neutropenia, anemia and thrombocytopenia, resulting in an immunocompromised and coagulopathic state, increasing the risk of postoperative infections and bleeding (16). The present comprehensive review examines the latest clinical and translational research on postoperative complications in adult patients with chemotherapy-treated AML undergoing elective (Table I) (17-20) and emergency (Table II) (21-23) surgery. The spectrum of surgical and medical complications is detailed, risk stratification is discussed and management strategies are outlined. Key risk mitigation strategies and clinical recommendations are summarized in Table III (20,22,24-29).

2. Surgical risk stratification

Patients with AML experience high early mortality, with ~6-7% 30-day and 22-41% 90-day mortality, far exceeding typical general surgical 30-day mortality rates (<5%) (30). Nearly one-third of patients with chemotherapy-treated AML develop major postoperative complications, and several studies have reported overall complication rates >50% (22,31,32). A study by O'Brien *et al* (33) examining 30-day mortality following chemotherapy among 1,976 patients with cancer found an overall rate of 8.1%, with 77% of deaths attributed to disease progression and 7.5% to chemotherapy toxicity. Similarly, 30-day postoperative mortality in this population has been reported ranging from ~10% for elective procedures to >20% for emergencies (34,35). Hospital length of stay is often two-to three-fold, and numerous patients require extended intensive care due to complications such as sepsis or respiratory failure. In the long term, a major postoperative complication can delay subsequent cancer therapy, potentially allowing disease progress or the development of resistance. Therefore, meticulous preoperative risk stratification is essential in patients with chemotherapy-treated AML. Standard preoperative assessment tools may fail to capture the unique risks of severe immunosuppression. In addition to routine evaluations, specific attention should be paid to the hematological parameters, infectious status and timing of surgery relative to chemotherapy, thus requiring multidisciplinary input.

Hematological parameters. A detailed review of blood counts is critical. Severe neutropenia or lymphopenia indicates a high risk of infection. Thrombocytopenia should be quantified and corrected preoperatively; A review of the evolution of guidelines for the minimum platelet count threshold prior to invasive procedures in cirrhosis recommends a platelet count of at least $50x10^9$/l for major invasive procedures to mitigate bleeding risk (36). Coagulation studies, including assessment of prothrombin time, international normalized ratio, activated partial thromboplastin time and fibrinogen level, should be performed to detect DIC or coagulopathy. Any significant abnormalities may require correction with plasma or cryoprecipitate. Anemia is nearly ubiquitous in patients with post-chemotherapy AML. Maintaining a hemoglobin level >8-10 g/dl through transfusion, adjusted for the patient's cardiovascular status, optimizes tissue oxygen delivery (37,38).

Infectious status. A comprehensive preoperative assessment must evaluate the patient's current infection status and colonization history. Fever may be the only sign of serious infection in these population, and untreated infections can progress rapidly. Therefore, preoperative fever or signs of infection should prompt a thorough diagnostic workup and administration of empiric broad-spectrum antibiotics preoperatively. Neutropenia has been identified as an independent predictor of postoperative mortality (21). A single-center series of 237 patients with neutropenia undergoing abdominal surgery reported an overall postoperative mortality of 11.8%; this rate increased to 16.4% for urgent operations but was only 1.4% for elective cases (22). Notably, severe neutropenia, defined as an absolute neutrophil count (ANC) $<0.5x10^9$/l, was associated with a high mortality rate of ~50% (22). Patients with AML are often colonized with multidrug-resistant organisms due to prior broad-spectrum antibiotic exposure during neutropenic fever episodes (39). Nutritional status is also a key determinant of postoperative infection risk. Chemotherapy frequently induces weight loss and hypoalbuminemia, both of which are correlated with impaired immunity and delayed wound healing. Malnutrition has been consistently linked to higher rates of postoperative complications, particularly surgical site infections (SSIs) and pneumonia, highlighting its independent prognostic significance (40,41).

Timing of surgery relative to chemotherapy. Whenever feasible, elective surgery should be scheduled during periods of marrow recovery. Following induction chemotherapy for AML, patients typically have a several-week aplastic phase before blood count recovery if remission is achieved. Elective procedures should ideally be deferred until neutrophils and platelets rebound to

Table I. Common postoperative complications in patients with chemotherapy-treated acute myeloid leukemia receiving elective surgery.

First author, year	Patient population	Surgical context	Key postoperative complications reported	Key findings	(Refs.)
Chen *et al*, 2020	141 patients with colorectal liver metastases (all received neoadjuvant chemotherapy)	Elective liver resection	Overall complications: 54.6% had any complication; 19.9% had major complications (Clavien≥III). Neutropenia subset: Patients with severe neutropenia had 4x higher odds of major complications	Neoadjuvant chemotherapy-induced neutropenia (grade 3/4) was an independent predictor of major postoperative complications (OR, ~4.08). Indicates deep myelosuppression can adversely affect surgical recovery.	(17)
Hara *et al*, 2021	100 esophageal cancer patients (52 with chemotherapy-induced leukopenia)	Elective esophagectomy	Overall morbidity: ~40% (no difference between groups). Mortality: No significant difference leukopenia vs. normal WBC count	Small study; found no clear association between pre-operative leukopenia and outcomes in elective esophagectomy. Possibly due to aggressive prophylactic measures and selection of stable patients. Suggests if well-managed, elective surgery can proceed safely even with mild leukopenia.	(18)
Nematolahi *et al*, 2025	Pooled analysis of 21 studies (266 patients with NE)	Conservative vs. surgical management of NE	Mortality: Medically managed NE, ~31%. Surgically managed NE, ~23%	Historically, NE untreated had 50-100% mortality. Modern management (antibiotics ± surgery) reduces mortality to 23-31%. Surgical intervention in NE, when indicated (perforation and peritonitis), can improve outcomes slightly, though selection bias exists. Early recognition and treatment (medical or surgical) are key to survival.	(19)
Zarain-Obrador *et al*, 2021	1,727 patients undergoing colorectal surgery	Elective colorectal resections	SSI rate: (not explicitly given here, but neutropenic vs. normal comparison). Finding: Preoperative neutropenia was an independent predictor of SSI	Neutropenic patients had significantly higher SSI rates. Highlighted that low pre-operative absolute neutrophil count correlates with increased risk of wound infection. Reinforces immunosuppression as a risk factor for SSI in colorectal surgery.	(20)

NE, neutropenic enterocolitis; SSI, surgical site infection; WBC, white blood cell; OR, odds ratio.

Table II. Common postoperative complications in chemotherapy-treated acute myeloid leukemia patients receiving emergency surgery.

First author, year	Patient population	Surgical context	Key postoperative complications reported	Key findings	(Refs.)
Sullivan *et al*, 2012	1,912 patients (956 recent chemotherapy vs. 956 non-chemotherapy), mixed cancers (many hematological)	Emergent abdominal surgeries	Mortality: Chemotherapy 22% vs. non-chemotherapy 10%. Major complications: Chemotherapy 44 vs. 39% in non-chemotherapy (P=0.033)	Pre-operative leukopenia was an independent predictor of death; chemotherapy within 30 days associated with higher 30-day mortality and morbidity.	(21)
Jolissaint *et al*, 2019	237 neutropenic patients (ANC <1,500)	Emergent and urgent abdominal surgeries	Overall 30-day mortality: 11.8%. Morbidity: 54.5% (anycomplication). Mortality if ANC<500: ~50%	Urgent surgery had much higher mortality (16.4%) than elective surgery (1.4%). Profound neutropenia (<0.5) and bowel perforation were associated with mortality. Early surgical intervention recommended for acute surgical abdomen to avoid delays.	(22)
Gulack *et al*, 2015	106 neutropenic vs. 212 non-neutropenic patients (matched)	Emergent abdominal surgeries	Serious complications: Higher in neutropenic group; Mortality: Higher in neutropenic group.	Preoperative leukopenia associated with worse outcomes (more complications and longer hospital stay), but outcomes were 'not prohibitive,' meaning surgery can be life-saving and occasionally successful. Authors caution against reflexively denying surgery solely due to neutropenia.	(23)

ANC, absolute neutrophil count; NE, neutropenic enterocolitis; WBC, white blood cell.

Table III. Risk mitigation strategies and clinical recommendations.

Domain	Strategy/recommendation	Evidence
Timing of surgery	Defer elective surgery until ANC >1,000/μl, platelets >50x10^9/l. Expedite urgent cases rather than delay.	Jolissaint *et al* (22) findings on earlier intervention benefits
Preoperative optimization	Treat infections with broad-spectrum antibiotics. Transfuse platelets to >50,000. Consider G-CSF for profound neutropenia. Provide nutritional support.	AAFP guidance (24); Zarain-Obrador *et al* (20) SSI risk data
Intraoperative management	Use full monitoring. Prefer minimally invasive approaches. Maintain strict asepsis. Implement DVT prophylaxis.	Jolissaint *et al* (22) recommendations; standard ACCP/ASCO guidelines (25); enhanced recovery protocols
Postoperative antibiotics	Continue broad-spectrum coverage until neutrophil recovery or 5-7 days. Add antifungals for prolonged neutropenia.	AGIHO guidelines (26); NE outcomes showing high mortality with fungal infection (27)
Growth factor support	Use G-CSF for prolonged neutropenia (ANC <0.5x10^9/l), especially with infection.	Narrative reviews and case reports supporting G-CSF use (28)
VTE prophylaxis	Use mechanical prophylaxis initially. Start pharmacological prophylaxis when platelets ≥30-50,000.	AAFP guidance (24); general cancer surgery guidelines adapted for thrombocytopenia
Transfusion strategy	Maintain platelets >50,000 for surgery/bleeding. Keep hemoglobin at 8-10 g/dl. Use leukoreduced, irradiated products.	AAFP and ASCO transfusion guidelines (24,25); standard oncology transfusion practices
Monitoring	Consider ICU care for 24-48 h. Check CBC daily. Monitor inflammatory markers. Perform early imaging for complications.	Bouteloup meta-analysis (29)
Adjunctive care	Use PPIs for stress ulcer prophylaxis. Continue opportunistic infection prophylaxis. Implement early physiotherapy.	Standard ICU protocols

AAFP, American Academy of Family Physicians; ACCP, American College of Chest Physicians; AGIHO, Arbeitsgemeinschaft Infektionen in der Hämatologie und Onkologie (Infectious Diseases Working Party of the German Society of Hematology and Medical Oncology); ANC, absolute neutrophil count; ASCO, American Society of Clinical Oncology; CBC, complete blood count; DVT, deep vein thrombosis; G-CSF, granulocyte colony-stimulating factor; ICU, intensive care unit; PPI, proton pump inhibitor; SSI, surgical site infection; VTE, venous thromboembolism.

safer levels, with an ANC >1,000/μl and platelets at >50x10^9/l at minimum (42,43). This strategy is supported by clinical observations; patients undergoing elective surgery in a non-neutropenic state have markedly lower morbidity than those operated on while neutropenic (22). However, emergent surgical indications cannot await count recovery, and in such cases, the risks should be accepted and mitigated proactively.

Multidisciplinary input. Risk stratification requires a multidisciplinary approach. Key prognostic indicators include preoperative ANC (<500/μl indicates very high risk) (44), persistent neutropenia (45), disease phase (46), surgical urgency (47), underlying diagnosis (48), age or organ failure (49). The surgical team should coordinate with the hematology/oncology teams to understand the patient's leukemia status, including remission status, timing of last chemotherapy and planned treatments. Hematologists can facilitate growth factor support, such as use of granulocyte colony-stimulating factor (G-CSF), to hasten neutrophil recovery perioperatively (34,35). An infectious disease consultation is also recommended to guide appropriate prophylactic antimicrobial therapy.

3. Postoperative complications

The postoperative period represents the point of greatest vulnerability for patients with chemotherapy-treated AML, where the physiological stress of surgery intersects with their underlying compromised immune-hemostatic state.

Infectious complications. Infections are the most prevalent and dangerous postoperative complication in patients with immunosuppressed AML due to the lack of a robust immune defense.

Preoperative neutropenia is an independent predictor of SSI (20). In patients with neutropenia, SSIs may present subtly, as the classic indications for infection, such as rubor, heat and pain, are often clinically less apparent. Initial indications are often fever or unexpected wound drainage. However, when neutrophils are absent, pus formation is minimal; therefore, wound infection might only show clear or slightly turbid fluid until later (50,51).

Following abdominal surgery, patients with neutropenia are at a high risk of intra-abdominal abscesses and anastomotic leaks, leading to peritonitis. Neutropenic enterocolitis is a distinct entity, and while typically not postoperative in origin, it may be precipitated or exacerbated by intestinal manipulation in a neutropenic patient (19).

Systemic infection is a leading cause of postoperative mortality in the patients with neutropenia (34,35). Early postoperative sepsis can originate from an anastomotic leak, pneumonia, urinary tract infection or central-line infection. Progression from stable neutropenia to septic shock can be rapid, with early indicators limited to fever and mild tachycardia (52).

Postoperative pneumonia is common in patients with AML. Patients are often colonized by nosocomial organisms from prior hospitalization. Mucositis and oropharyngeal colonization by gram-negative bacteria or fungi can lead to aspiration pneumonia (53). Radiographic presentations are often atypical; chest x-ray may show only faint infiltrates rather than dense lobar consolidations or abscesses. High-resolution computed tomography provides a much higher yield for detecting pulmonary infections (54), revealing subtle findings, such as ground-glass opacities or small nodules that are frequently missed on standard radiographs (54).

The risk of opportunistic infections increases with the duration of postoperative neutropenia. Fungal infections, particularly invasive candidiasis and aspergillosis, pose a major threat (55). The mortality rate among neutropenic patients with intra-abdominal candidiasis was 81.8%, whereas the mortality rate among non-neutropenic patients was ~24.3% (56).

Hematological and bleeding complications. Bleeding is not merely a nuisance complication; it serves as a marker for and actively contributes to worse outcomes. Among patients with acute leukemia receiving induction chemotherapy, those who experienced major bleeding had significantly worse overall survival rates than those who did not (11,57). Therefore, bleeding complications represent a significant postoperative concern in patients with chemotherapy-treated AML.

Patients may develop prolonged sanguineous drainage from the incision or drain region due to impaired clot formation. In patients with thrombocytopenia, clots fail to stabilize, leading to postoperative bleeding even from well-ligated vessels. Prophylactic platelet transfusions are typically administered immediately postoperatively to maintain a platelet count of $>50x10^9$/l until the risk of bleeding is low (58).

Patients with APL can present with DIC, and severe infections can trigger DIC postoperatively (59). This condition may manifest as oozing from intravenous sites, mucous membranes and surgical wounds.

Bleeding at specific sites. Certain surgeries pose unique bleeding risks. For example, low platelet counts predispose patients to intraluminal bleeding from anastomotic staple or suture lines following gastrointestinal surgery (60,61).

Transfusion-related complications. Managing bleeding often requires multiple transfusions, which carries risks. Volume overload can precipitate heart failure or pulmonary edema, particularly in older patients with AML who may have reduced cardiac function. Transfusion reactions or alloimmunisations can complicate further transfusions (62,63).

Delayed wound healing and anastomotic leaks. Wound healing impairment is a direct consequence of the compromised regenerative capacity in patients with chemotherapy-treated AML.

Surgical incisions in patients with neutropenia often result in slow healing, significantly prolonging the typical healing timeline. Cioce *et al* noted that leukopenia may disrupt wound healing due to impaired inflammatory cell communication and prolonged inflammation (64).

In severe cases, surgical incision may undergo partial or complete dehiscence. Malnutrition and chronic steroid use may further exacerbate the risk in this population (65). Dehiscence typically manifests at 7-14 days postoperatively (66).

Anastomotic leakage is potentially the most dreaded complication of colorectal or intestinal surgery, and immunosuppressed patients are particularly vulnerable. In neutropenic patients, even if the anastomosis is well-constructed, the risk of leakage is elevated due to impaired healing, as is the inability to maintain a minor leak that might have normally sealed spontaneously (17).

Thromboembolic events. Although bleeding is the dominant issue, paradoxical thromboembolic complications occur with an increased frequency. One study reported that 65 out of 250 (26%) patients with acute leukemia developed venous thromboembolism (VTE) during induction therapy (11). Postoperative immobility, the presence of central venous catheters and certain chemotherapeutic agents (such as Cisplatin, Thalidomide, Tamoxifen and Doxorubicin), elevate the risk of deep vein thrombosis (DVT) and pulmonary embolism (67-69). Indwelling catheters can precipitate local thrombosis in the subclavian, jugular or femoral veins. Pharmacological prophylaxis with low-dose unfractionated heparin or low-molecular-weight heparin is typically initiated once the postoperative bleeding risk is deemed acceptable. While all surgical patients should generally receive VTE prophylaxis, initial management in thrombocytopenic patients often relies on mechanical methods (70,71).

4. Management strategies

A large National Surgical Quality Improvement Program analysis found that preoperative leukopenia (<4,000/μl) alone was not significantly associated with increased postoperative morbidity or mortality after controlling for other factors (30). This finding indicates that neutropenia does not automatically preclude surgery if managed appropriately. With careful patient selection and optimization, acceptable outcomes may be achieved. Therefore, a proactive, multipronged approach is required to mitigate risks for patients with AML throughout the perioperative period.

Preoperative optimization. Elective surgery should be scheduled for when blood counts have recovered. Whenever feasible, surgeons should avoid operating during the nadir of chemotherapy-induced neutropenia (28). There must be coordination with oncologists to determine if chemotherapy can be delayed or if growth factors can be used to expedite recovery.

Proactive transfusion should be performed to optimize hemoglobin and platelet counts preoperatively. The transfusion of 1 or 2 units of platelets on the day of surgery occurs frequently, even with a count is 50-70x10^9/l, which is an adequate threshold for most non-neurosurgical operations (72). For major surgeries with a high bleeding risk, the maintenance of platelet counts >100x10^9/l is recommended to provide a safety margin.

All active infections should be preoperatively identified and treated. Decolonization protocols, such as chlorhexidine baths and nasal mupirocin for methicillin-resistant *Staphylococcus aureus* carriers, should be implemented to reduce the risk of endogenous infection (73,74). Prophylactic broad-spectrum antibiotics should be administered perioperatively to patients with profound neutropenia. Per the Infectious Diseases Society of America/American Society of Clinical Oncology guidelines, broad-spectrum antibiotics should be continued until the patient is stable and afebrile, and the neutrophil count has recovered to 500/μl (75).

Correct malnutrition is also important for preoperative optimization. A number of cancer centers administer immunonutritional formulas, enriched with arginine, glutamine and omega-3 fatty acids, preoperatively for 5-7 days in malnourished surgical patients, which has been shown to reduce infectious complications in gastrointestinal cancer procedures (76,77).

Intraoperative strategies. Surgical morbidity can be minimized through several key strategies. These include utilizing experienced surgical teams to reduce operative time, handling tissues gently to prevent necrotic foci for infection and employing prophylactic measures, such as subcutaneous heparin and sequential compression devices, to reduce DVT risk. Furthermore, ensuring effective intraoperative antibiotic coverage, with appropriate redosing during lengthy procedures, and responding to contamination events, such as bowel content spillage, with thorough lavage and potential drain placement are critical (78).

Anesthetic preparation. Anesthesiologists should employ strategies to reduce the immunosuppressive effects of surgery. These include maintaining normothermia with warming devices, potentially using a high fraction of inspired oxygen to optimize tissue oxygenation and providing adequate analgesia to mitigate excessive stress responses (58,79).

Blood product support. Transfusions can be performed to maintain hemoglobin at an acceptable range (often ≥8 g/dl, or higher in patients with coronary disease). If the preoperative platelet count is 50-70x10^9/l, intraoperative consumption and dilution should be anticipated, with additional platelets added intraoperatively to maintain hemostasis. Surgeons should be prepared to administer freshly frozen plasma or cryoprecipitate if coagulopathy is evident or massive transfusion is anticipated (80,81).

Broad-spectrum antibiotic prophylaxis should be administered with an extended duration. In patients with neutropenia, surgeons frequently continue coverage beyond the usual 24-h window (82). For high-risk surgeries, particularly gastrointestinal procedures, several protocols also include antifungal coverage during and after the operation due to the risk of fungal infection in this population (83).

Surgeons often adapt their approach to mitigate risks. Core principles include minimizing operative time and tissue trauma. Less invasive techniques, such as laparoscopy, are favored in order to reduce the risk of SSI and potentially attenuate the inflammatory response (84,85). In select cases, a more conservative procedure may be warranted; for example, for a with neutropenic patient with AML and colon cancer, a surgeon might choose a diverting stoma over a primary anastomosis after resection to avoid the severe outcome of an anastomotic leak (86).

Postoperative management

Intensive monitoring. Patients should be closely monitored for signs of complications. Numerous centers manage patients with AML in intermediate or intensive care units for at least the first 48-72 h postoperatively, even after elective surgery, to enable a rapid response to any clinical deterioration.

Infection prevention. Broad-spectrum antibiotics should be continued as indicated. A patient with AML undergoing bowel surgery might receive an agent such as piperacillin-tazobactam until neutrophils recover to >1,000/μl or for a minimum of 5-7 days postoperatively, rather than the typical 24-h prophylaxis (28,87). Strict hygiene and isolation protocols are implemented by healthcare providers, including hand hygiene and the use of masks/gowns.

Early mobilization and respiratory therapy. Patients should be mobilized as early as possible to prevent pneumonia and DVT. This can be challenging for severely weak patients; however, even sitting in a chair, performing incentive spirometry and chest physiotherapy, and conducting range-of-motion exercises is beneficial (88,89).

Mechanical prophylaxis should be immediately implemented postoperatively. Pharmacological prophylaxis with low-dose heparin or enoxaparin can be implemented as soon as the bleeding risk is controlled, typically within 48-72 h, provided no active bleeding was manifested, and platelets are reasonably maintained (≥30-50x10^9/l) (90).

Bleeding management. Meticulous monitoring of wound exudates and hemoglobin is required. Marked levels of sanguineous output or declining hemoglobin levels should be monitored early and a return to the operating room should be considered if necessary. Platelet transfusion support should be continued until adequate healing is observed.

Post-operative administration of G-CSF expedites neutrophil recovery. Although definitive guidelines are lacking, a number of clinicians administer G-CSF if the patient remains neutropenic, particularly in the setting of active infection, to facilitate marrow recovery (28).

5. Future directions and research needs

As oncological care improves, more patients with AML will survive initial chemotherapy and develop surgical needs. However, current perioperative guidance for these cases relies primarily on limited retrospective studies and expert

opinions, revealing substantial knowledge gaps. Future research should prioritize prospective studies and multicenter registries to develop validated risk-prediction models tailored to this high-risk population. These models should incorporate key prognostic variables identified in existing data, such as preoperative ANC, serum albumin level and surgical urgency (emergency vs. elective). Targeted clinical trials are also essential to optimize perioperative management strategies, including comparing hematopoietic growth factor use, such as perioperative G-CSF administration vs. no G-CSF administration, to facilitate neutrophil recovery, evaluating prolonged vs. standard-duration antibiotic prophylaxis, and assessing primary anastomosis vs. diverting stoma in emergency abdominal surgeries for neutropenic patients. The outcomes of these studies would directly inform evidence-based protocols, reducing the current reliance on expert opinions in managing this unique cohort.

Translational research on perioperative immune support is crucial. Strategies to transiently boost immune function during surgery can mitigate complications in immunosuppressed patients. Immunostimulatory cytokine therapies, such as recombinant interleukin-7, have demonstrated the ability to restore adaptive immunity and significantly reduce secondary infection rates in critical illness (91), suggesting potential benefits for neutropenic surgical patients. Additionally, adjunctive administration of intravenous immunoglobulins has shown promise in lowering the incidence of infection among patients with immunosuppressed AML (92). Optimizing nutritional status via immunonutrition is a promising adjunct. Rigorous evaluation of these immune support interventions, alongside established measures, such as G-CSF, may help overcome immunological deficits in this population. Preventive approaches, such as interventions to reduce the incidence of chemotherapy-associated neutropenic enterocolitis, warrant investigation, as this life-threatening condition frequently precipitates emergent surgery in patients with leukemia. Finally, professional organizations should work toward developing dedicated guidelines for managing surgical emergencies in neutropenic or chemotherapy-immunosuppressed patients, as current guidelines remain fragmented. By pursuing specific research directions and interventions, the perioperative care of patients with AML undergoing surgery can be significantly improved.

6. Conclusion

Patients with chemotherapy-induced AML represent one of the most challenging populations in general surgery due to profound immunosuppression, thrombocytopenia and chemotherapy-related organ damage. These factors create a high-risk environment for postoperative complications, including severe infections, bleeding disorders and impaired wound healing, and elevated mortality rates.

Improving outcomes depends on meticulous multidisciplinary care throughout the perioperative period. Preoperatively, this requires optimizing the patient's condition and appropriately timing the interventions. Intraoperatively, teams should adapt surgical and anesthetic techniques to minimize additional physiological stress. Postoperatively, vigilant monitoring and prompt intervention are essential to prevent even subtle complications. Despite the best efforts, postoperative morbidity and mortality rates remain significantly higher in these patients than in the general population, necessitating transparent discussions with patients and families about the expected outcomes and alignment of surgical interventions with the overall goals of care.

Further research is required to refine these approaches for this unique patient population. Until then, clinicians should adhere to current best practices while adapting to each patient's unique needs. Strong collaboration among hematologists, surgeons, intensivists and other specialists is crucial, as these cases span multiple specialties. With rigorous perioperative planning and execution, a number of patients with AML can overcome the immediate challenges of surgery, allowing them to continue their fight against leukemia with the prospect of remission and recovery.

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Competing interests

The authors declare that they have no competing interests.

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