Perioperative Precision Medicine

Zentime

PERSPECTIVE

# Proactive care: A new era in perioperative management of sepsis

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Received March 6, 2026; Accepted August 4, 2026; Published October 31, 2026

DOI: 10.61189/541735urfixq

## 1 INTRODUCTION

Sepsis remains one of the leading causes of morbidity and mortality in surgical patients. The perioperative period has been linked with surgical trauma, infection and immune perturbation. Surgical stress may exacerbate systemic inflammation and contribute to organ dysfunction. Sepsis, in contrast, modifies perioperative haemodynamics and surgical outcomes, emphasizing urgent diagnosis and management.

Routine perioperative management of sepsis remains mostly reflexive and arbitrary, hinging on clinical intuition and transitory-monitoring techniques, with restricted adoption of early identification and risk stratification systems. A combination of non-standardized workflows surrounding transfusion, cell salvage, antibiotic selection and postoperative wound management processes, gaps in knowledge among some clinicians on the transfusion process and fragmentation of communication between nursing and clinical teams have contributed to these critical deficiencies continuing along individual key steps of care [1]. Without interdisciplinary collaboration and formalized root-cause analysis, interventions are delayed and the therapeutic window is narrowed. This reactive paradigm is not continuous or forward-looking, and thus may not fully address the needs of early risk reduction to the improvement of outcomes.

Perioperative rescue alone is unlikely to impact prognosis. An advanced mechanistic understanding of sepsis and clinical evidence have demonstrated that septic patients have existing immune dysregulation, diminished organ reserve and metabolic instability prior to surgery—parameters associated with postoperative complications and mortality. With such a paradigm shift, preoperative optimization has emerged to facilitate earlier characterization of and intervention for individuals at risk in order to restore resilience. This transforms perioperative management from reactive to preventive, with the goal of risk reduction before irreversible deterioration.

## 2 PREOPERATIVE RISK ASSESSMENT IN SEPSIS

### 2.1 Definition and criteria for identifying high-risk patients

Patients at high preoperative risk for sepsis are those in whom perioperative infection may progress to organ dysfunction, thereby increasing mortality. Identification requires multidimensional evaluation integrating infection source and burden, Sequential Organ Failure Assessment (SOFA)/quick Sequential Organ Failure Assessment (qSOFA), lactate, immunosuppression, and comorbidities—including age, diabetes, and chronic organ dysfunction—while accounting for surgical type and urgency. Earlier studies have suggested that postoperative

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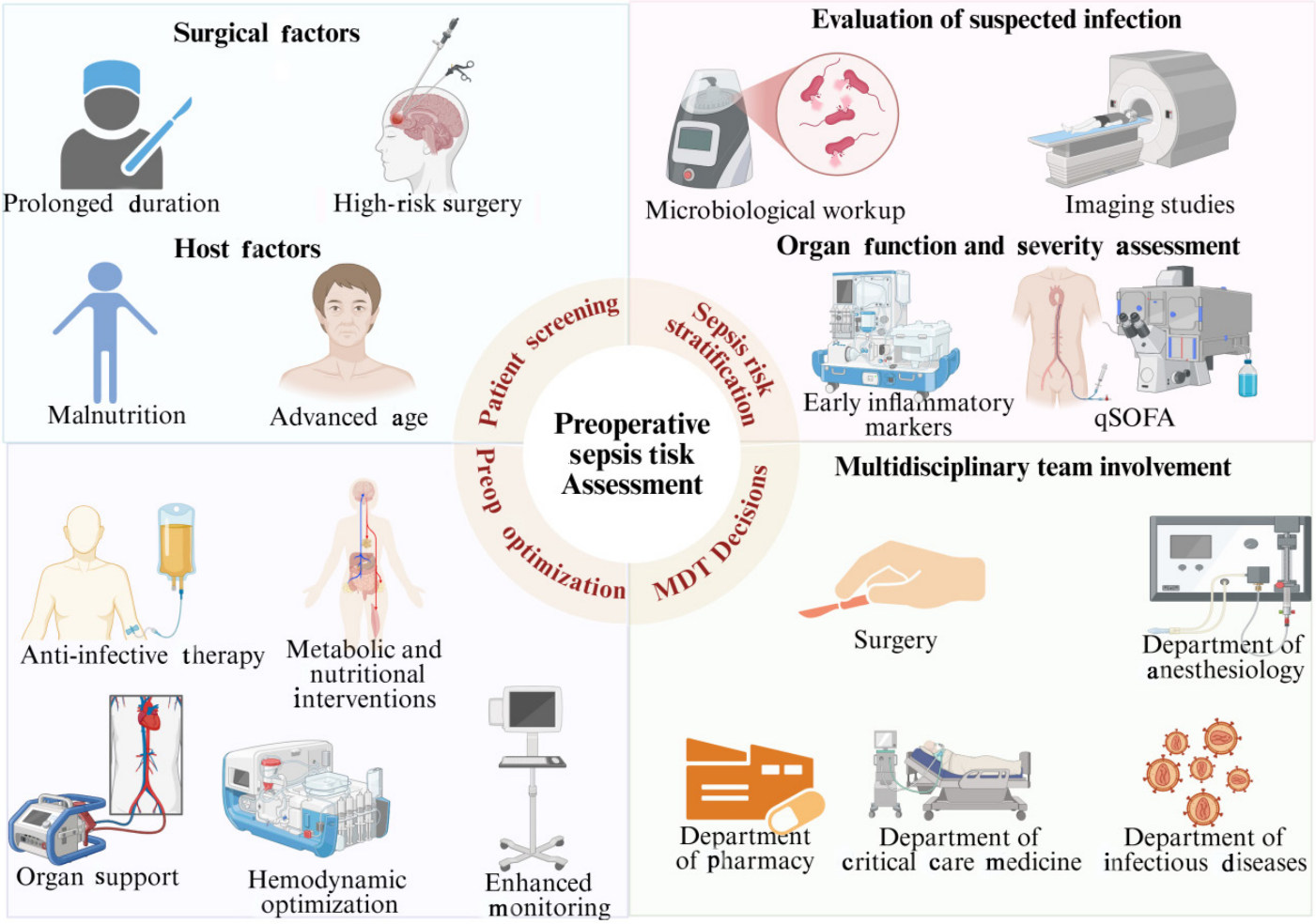



**Figure 1. Conceptual framework for preoperative sepsis risk assessment in high-risk surgical patients.** The framework illustrates a multidimensional approach incorporating surgery-related risk factors, structured infection assessment pathways, multidisciplinary decision support, and corresponding antimicrobial and organ-support strategies. This figure was created with BioRender. MDT, multidisciplinary team; qSOFA, quick Sequential Organ Failure Assessment.

soluble TNF receptor–p55 elevation may predict adverse outcomes earlier than conventional scores. Integration of physiological indices with cytokine receptor profiling may enhance early risk stratification and prognostic discrimination [2].

### 2.2 Innovative applications of preoperative assessment tools

Innovation in perioperative sepsis risk assessment through large-scale data analytics and artificial intelligence (AI) has emerged. Although SOFA and Acute Physiology and Chronic Health Evaluation II (APACHE II) maintain prognostic significance, individualized mortality risk quantification is lacking. Dimensional incorporation of multilayer platforms combining haemodynamic parameters, biomarkers and multimodal data together with machine learning provides more robust stratification by reliably identifying high-risk patients. Existing methods are outperformed at low false positive rates by DeepAISE [3]. The incorporation of these approaches marks a shift from reliance on single-score metrics to an integrated management paradigm. Contemporary preoperative assessment frameworks now encompass surgical risk profiling, infection evaluation and multidisciplinary decision-making as illustrated in **Figure 1**, enabling dynamic and individualized perioperative support.

### 2.3 The importance of multidisciplinary collaboration

Multidisciplinary collaboration is at the core of perioperative sepsis risk assessment. Immune competence, organ reserve and occult infection are not fully reflected in single-specialty evaluation. Harmonized input allows for systematic assessment of pathogens, biomarkers, organ function and surgical challenge to guide individual optimization and perioperative planning [4]. Most patients can undergo surgery with careful preoperative assessment and focused optimization, while appropriate perioperative interventions address procedure-related risk.

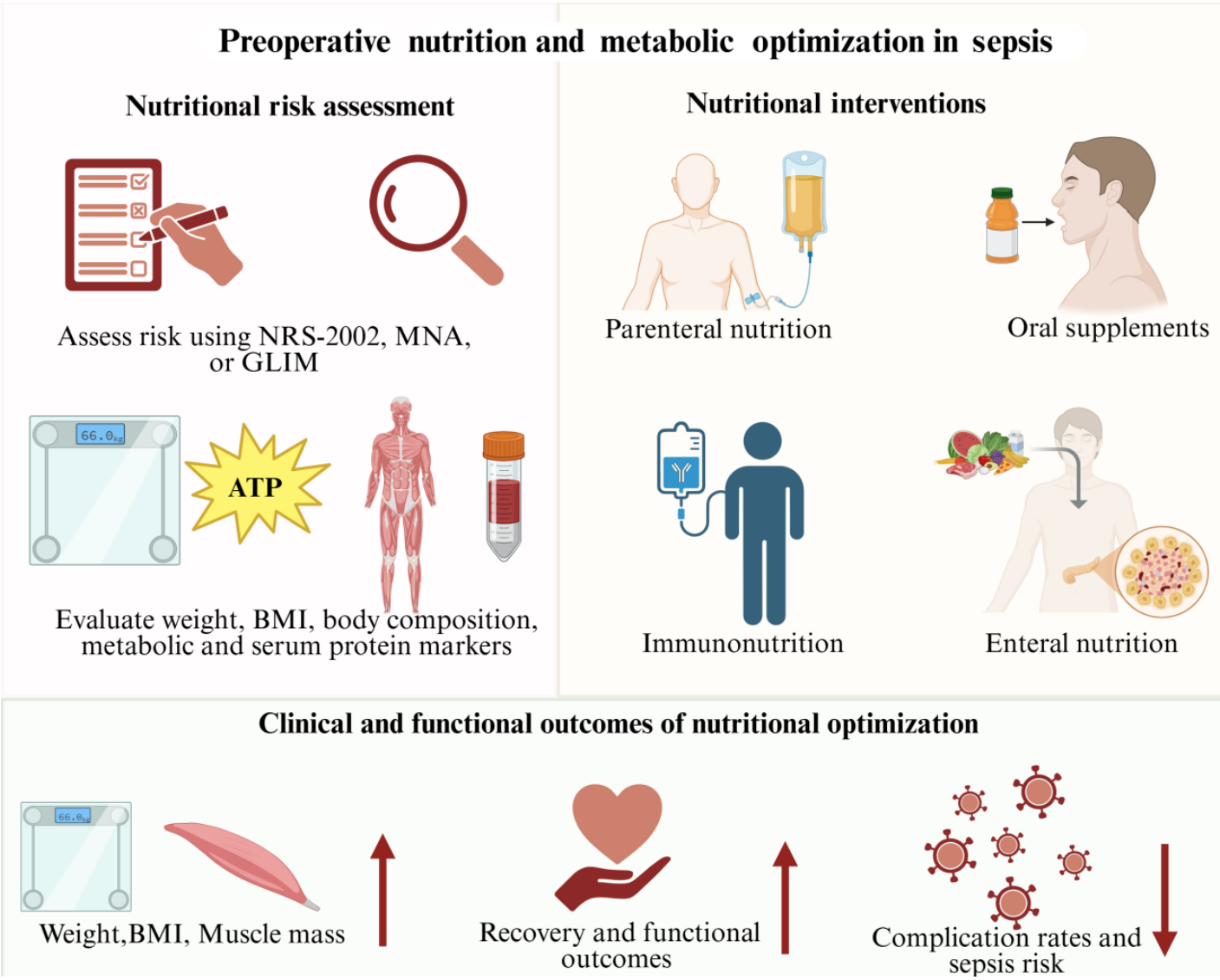



**Figure 2. Conceptual framework for preoperative nutritional and metabolic optimization in patients with sepsis.** The framework contains three primary domains: (1) Nutritional risk assessment, using validated tools such as the NRS-2002, MNA or the GLIM criteria to assess body weight, BMI, body composition and metabolic parameters, including serum protein biomarkers; (2) Nutritional interventions that can be performed via enteral nutrition, parenteral nutrition, oral nutritional supplementation and/or immunonutrition; (3) Clinical and functional outcome evaluation, covering changes in body weight, BMI, and muscle mass, the incidence of complications and sepsis risk, as well as recovery and functional outcomes. This figure was created with BioRender. NRS-2002, Nutritional Risk Screening 2002; MNA, Mini Nutritional Assessment; GLIM, Global Leadership Initiative on Malnutrition; BMI, body mass index.

## 3 SPECIFIC STRATEGIES FOR PREOPERATIVE OPTIMIZATION

### 3.1 Nutritional support and metabolic modulation

Perioperative care in septic surgical patients centers on preoperative nutritional and metabolic optimization. Sepsis causes intense inflammation and stress leading to proteolysis, immune dysfunction and metabolic derangement. Preoperative nutritional support replenishes stores and reduces the risk of infection. The modified Nutrition Risk in the Critically Ill (mNUTRIC) score is used to evaluate nutritional and inflammatory risk in sepsis. It may help guide individualized nutritional assessment and management in patients with sepsis [5]. In addition to supplementation, stringent glycemic and metabolic control improves energy availability, mitigates inflammation and maximizes surgical tolerance. This systematic, integrative framework covers the full lifecycle of care, including risk stratification, individualized intervention, and outcome assessment in **Figure 2**.

### 3.2 Preoperative interventions to optimise cardiovascular function

Preoperative optimisation of cardiovascular risk in sepsis reduces perioperative complications. In hypovolaemia or car-

diac dysfunction, haemodynamic-guided fluids are perfusion-preserving. Vasoactive agents stabilise pressure, and cardiac reserve assessment informs risk. Electrolyte and acid–base disturbances are corrected to optimise oxygen delivery. In coronary disease or hypertension, therapies are adjusted to minimise events. The aim is cardiovascular stability, but within safety limits.

### 3.3 Innovative strategies for precision management of comorbidities

Alongside concomitant risk factors, perioperative patients with sepsis have complex comorbidities requiring precision management for risk reduction and optimisation. AI-enabled individualised risk models allow for continuous monitoring of cardiopulmonary function, diabetes and renal insufficiency, and tiered management. Postoperative sepsis is predicted by the Hospital Frailty Risk Score (HFRS), which facilitates enhanced perioperative monitoring [6]. In a multidisciplinary context, this stratification allows a selective intervention—all complex and costly measures to optimise cardiac function, glycemic homeostasis and fluid balance while protecting renal perfusion—which should contribute to maximising preoperative reserve and improving perioperative safety and prognosis.

## 4 CURRENT STATUS AND CHALLENGES IN POSTOPERATIVE RESCUE

### 4.1 Mechanistic insights into postoperative sepsis

Surgical stress and disorganization of immune homeostasis lead to postoperative sepsis. Systemic inflammation with pro- and anti-inflammatory dysregulation is induced by surgical trauma, ischemia–reperfusion and microbial translocation. This dysregulation modifies immune homeostasis and leads to microcirculatory dysfunction and organ injury. In a murine model of prolonged sepsis, the non-resolving phase demonstrates myocardial lipid and glycogen accumulation with suppressed mitochondrial oxidative metabolism but preserved Krebs cycle activity, as well as persistence of inflammation [7]. Postoperative immunosuppression delays pathogen clearance, sustaining low-grade inflammation and inflammatory–immune imbalance. This maladaptive crosstalk drives the high incidence and poor prognosis of sepsis.

### 4.2 Limitations of conventional rescue strategies

Traditional perioperative sepsis rescue relies on antimicrobials, fluid and hemodynamic support. Such reactive approaches follow deterioration, limiting inflammation control. Pharmacotherapy or indiscriminate fluids cause organ dysfunction, overload and resistance. Individualised adjustment is limited, reducing precision. Conventional postoperative measures fail to address microcirculatory and immune dysfunction or reduce sepsis morbidity and mortality. These limits necessitate precision approaches in the perioperative setting.

### 4.3 Emerging therapeutic approaches

Emerging perioperative sepsis strategies have gained attention. Electronic ward-based screening is linked to reduced 90-day mortality, highlighting early recognition [8]. Precision-guided fluids, dynamic haemodynamic monitoring and immune modulators show promise in improving postoperative organ function and lowering complications. Generally, individualised antimicrobials with rapid diagnostics enable targeted therapy and may curb resistance. Yet translation is constrained by limited high-quality evidence, high costs and operational complexity. Large, multicentre, rigorously designed studies are needed to confirm safety, feasibility and efficacy.

## 5 FUTURE PERSPECTIVES AND RESEARCH DIRECTIONS

Information technology and AI have rapidly advanced in big data–integrated perioperative sepsis care analysis. Machine learning–driven early warning systems within structured integrated perioperative frameworks dynamically predict deterioration and optimise care by aggregating physiological, laboratory and procedural risks, with evidence of reducing in-hospital deterioration [9]. Beyond early risk identification, they provide a quantitative basis for optimising clinical resource allocation, shifting from experience-based to data-driven care. They thus redefine perioperative sepsis management through predictive precision nursing.

Advances in precision medicine and digital health cement preoperative optimisation in perioperative sepsis care. Risk stratification and early intervention use AI and machine learning. Multimodal monitoring enables real-time organ assessment to guide resuscitation. Integrating biomarker profiling with remote monitoring may enhance risk stratification and precision therapy, improving sepsis outcomes.

Perioperative sepsis management strategies improve outcomes in single-centre or small-cohort studies, but their generalisability and safety are unclear. In septic shock, timely antibiotic administration is associated with better outcomes; in non-shock patients, the impact of early antibiotics is less clear [10]. Multicentre large-scale RCTs are therefore needed to assess the effectiveness, feasibility and safety of nursing interventions across heterogeneous populations. These designs would reduce regional bias, provide high-quality evidence for standardised and personalised care, and advance perioperative sepsis clinical practice.

## DECLARATIONS

### Author contributions

Jianzhong Li and Daqiang Zhao contributed to the manuscript writing and figure preparation; Lei Duan designed the work;

Chengwei Ren supervised the work. All authors read and approved the final manuscript.


### Funding

This research received no external funding.


### Data availability

Data sharing is not applicable to this article, as no new datasets were generated or analyzed during the current study. All information presented is derived from publicly available articles and datasets.

### Ethics approval and consent to participate

Not applicable. In accordance with ethical standards, this manuscript contains no studies involving human participants or animals conducted by the authors.

### Consent for publication

Not applicable. This manuscript contains no details, imagery, or video material pertaining to any individual person.

### Competing interests

The authors declare that they have no competing interests.


### Acknowledgements

Not applicable.


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