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Practices in the Management of Patients with Multiple Organ Failure in the Intensive Care Unit

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Abstract

This article examines practices in the management of patients with multiple organ failure in the intensive care unit based on a comprehensive analysis of current clinical guidelines, epidemiological studies, and results of randomized controlled trials. This work aims to systematize and integrate epidemiological, pathophysiological, and clinical recommendation data into a unified decision-making algorithm for treating patients with multiple organ failure, as well as to assess the effectiveness of organ-targeted protocols and modern prognostic biomarkers. The relevance of the study is justified by the high prevalence of multiple organ failure among intensive care patients, elevated in-hospital mortality, and significant economic burden, all of which demand standardization of clinical practice and the search for new solutions for timely detection and correction of the syndrome. The novelty of the work lies in the inclusion of early ultrasound stratification of hemodynamics and volume status in the management algorithm, the use of dynamic markers such as lactate clearance and bedside ultrasound, and the integration of artificial intelligence algorithms to predict the risk of MOF development 24 hours before clinical manifestation. The main conclusions of the work are as follows: the primary stage of treatment remains volume-limited hemodynamic resuscitation with monitoring of lactate clearance and dynamic preload indices; subsequently, targeted vasopressors and inotropes are applied according to the Surviving Sepsis Campaign recommendations; organ-targeted support includes ultrasound stratification of congestion, lung-protective ventilation with early prone positioning, and clear criteria for ECMO initiation; optimal timing for CRRT initiation is determined on a personalized basis with a preference for regional citrate anticoagulation and the use of biomarkers. This article will be useful for intensivists as well as specialists in critical care medicine, anesthesiology, nephrology, and clinical engineering.

Keywords: *Multiple Organ Failure; Intensive Care; Hemodynamic Resuscitation; Extracorporeal Support; Ultrasound Stratification.*

INTRODUCTION

Multiple organ failure (MOF) is currently defined as altered function of at least two organ systems in an acutely ill patient for which homeostasis cannot be maintained without intervention, a definition enshrined in modern clinical sepsis and critical care guidelines (Al-Khafaji, 2019). Primary MOF develops shortly after direct severe injury (trauma, burn, massive ischemia), whereas secondary MOF results from dysregulated systemic inflammation, most often in sepsis. Common pathogenic links include endothelial dysfunction, microcirculatory impairment, and mitochondrial energetic failure, which trigger a cascade of progressive organ damage that mutually exacerbates and is difficult to reverse without comprehensive support.

The epidemiological picture is heterogeneous because studies employ different scoring systems (SOFA, LODS, Marshall) and diagnostic thresholds. Nevertheless, in an extensive population study in 2022, more than half of adult patients admitted to general intensive care units already met MOF criteria upon admission, with a reported prevalence of 56.2% (Karami et al., 2025). Individual cohorts demonstrate in-hospital mortality of 40–55% among patients with confirmed dysfunction of two or more organs (Sánchez-Casado et al., 2016); when five systems are involved, mortality approaches 100%.

Clinical and economic consequences extend far beyond the acute episode: survivors of MOF spend three times longer in the ICU, require prolonged respiratory and dialysis support, and treatment costs increase exponentially with each failed organ. The high incidence, severity of outcomes, and resource burden explain the international community's drive for early syndrome detection, standardization of organ-targeted protocols, and the search for new prognostic

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biomarkers. The present work focuses on practical aspects of managing such patients in a modern intensive care unit, integrating epidemiological, pathophysiological, and clinical recommendation data into a cohesive decision-making algorithm.

MATERIALS AND METHODOLOGY

The investigation of practices in managing patients with multiple organ failure in the intensive care unit is based on a comprehensive analysis of 26 sources, encompassing clinical guidelines, epidemiological cohorts, pathophysiological reviews, randomized controlled trials, and meta-analyses. PubMed and Google Scholar databases were searched using the keywords "multiple organ failure," "intensive care," "resuscitation," "extracorporeal support," and "prognostication," encompassing publications in English and Russian from 1996 to 2025. The theoretical foundation comprised works on MOF pathogenesis, analysis of endothelial dysfunction, and mitochondrial energetic failure (Wang et al., 2024; Hu et al., 2024), as well as studies of prognostic models: comparative analysis of SOFA (Le Gall, 1996), LODS, and Marshall scores, evaluation of APACHE IV (Rayhandika et al., 2023) and SAPS III (Aldabbour et al., 2025), considering AUROC metrics and calibration. Methodologically, a systematic content analysis was conducted on international recommendations for hemodynamic resuscitation and ventilatory support, including the Surviving Sepsis Campaign 2021 (Evans et al., 2021), the ESICM ARDS guidelines (Pesenti et al., 2023), and recent data on neuromuscular blockade in ARDS (Rathi et al., 2024). A comparative analysis examined early lactate clearance indicators (Nguyen et al., 2004) and bedside ultrasound monitoring (Noor et al., 2025) as dynamic markers of therapeutic efficacy. To assess extracorporeal methods, RCTs and meta-analyses were reviewed: optimal timing for CRRT initiation (Bagshaw et al., 2020; Zarbock et al., 2016), anticoagulation choices (Boldt et al., 2023), outcomes of ECMO application (Rabah & Rabah, 2022) and hybrid platforms (Stub et al., 2025), as well as effects of liver-detoxification devices (Gadour et al., 2024).

RESULTS AND DISCUSSION

Multiple organ failure develops when an initial hit — most often sepsis, severe trauma, burn, or pancreatitis-induced shock — initiates a cascade of endothelial injury and DAMP mediator release; a subsequent second hit (reinfection, surgical revision, hypoperfusion) amplifies injury and recruits additional organs. The number of affected systems correlates directly with outcome: in trauma ICUs, syndrome incidence ranges from 28% to 88%, and mortality with five or more dysfunctions approaches 100% (Asim et al., 2020).

Systemic inflammation rapidly transitions from a hypercytokinemic phase to immunoparalysis, characterized by functional leukocyte anergy, PD-1 expression, and a sharp decline in monocyte HLA-DR expression. This combination of hyperinflammation and immunosuppression renders the patient vulnerable to late opportunistic infections. Simultaneously, the vascular glycocalyx in the microcirculation is disrupted, and leukocyte aggregates and microthrombi form, depriving tissues of oxygen even under normal macrocirculatory pressures (Wang et al., 2024). Figure 1 illustrates the stepwise assessment and correction of hemodynamics in septic shock — from prioritized perfusion examination (heart rate, blood pressure, capillary refill time, mottling) through echocardiography and laboratory markers to optimization of circulating volume and vascular tone for restoration of tissue perfusion.

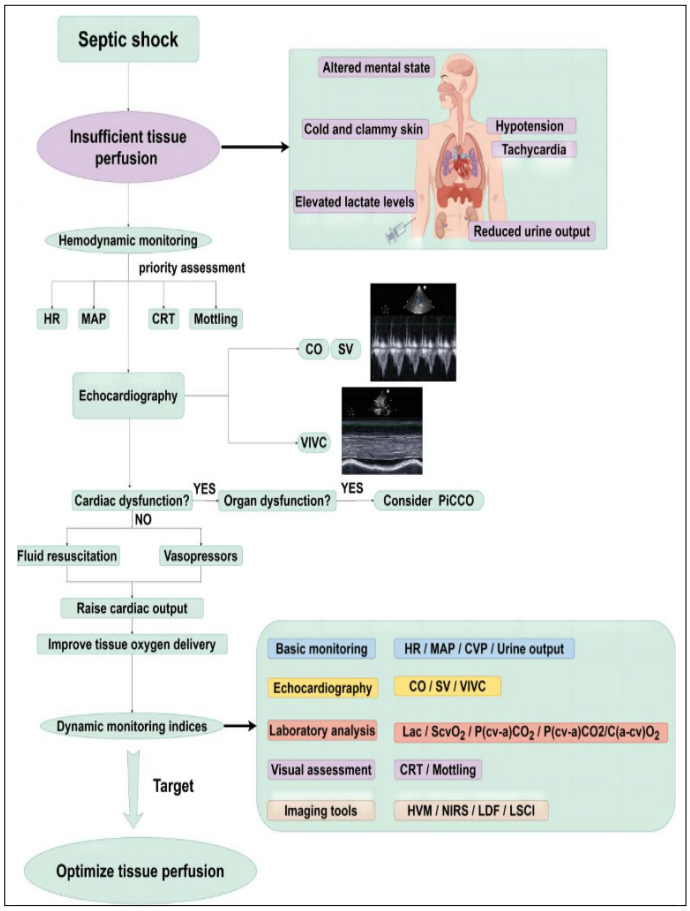

Fig. 1. Hemodynamic Optimization in Septic Shock (Wang et al., 2024)

At the cellular level, the key link is recognized as mitochondrial energetic failure: reduced biogenesis, electron leak, and a shift toward glycolysis lead to functional rather than structural organ failure, explaining the minimal necrosis observed in biopsies of severe MOF (Hu et al., 2024).

Since the clinical presentation depends not only on the number of organs involved but also on the rapidity of their involvement, diagnosis is based on serial scoring systems. The classic SOFA score records an increase of ≥2 points as a marker of organ dysfunction, while the simplified qSOFA is used outside the ICU. LODS evaluates six organ systems and maintains good calibration across its 0–22 point range (Le Gall, 1996). For outcome prediction, general risk models are preferred: APACHE IV in recent samples of COVID-19-positive patients demonstrated an AUROC of 0.782 (Rayhandika et al., 2023) but consistently overestimated mortality, necessitating

local recalibration; SAPS III in multidisciplinary European ICUs preserved both discrimination and calibration with an AUROC of 0.81 (Aldabbour et al., 2025).

Laboratory and dynamic markers allow refinement of prognosis between score calculations. The most validated marker is lactate clearance. In a prospective study, a decrease in lactate of ≥ 10% over the first six hours was associated with a 11% reduction in the risk of death for each additional 10% decrease (Nguyen et al., 2004). Point-of-care ultrasound has become the standard for bedside assessment. The combination of echocardiography, Doppler measurements of stroke volume, and venous congestion indices (Fig. 2) enables real-time evaluation of fluid responsiveness and prevention of hypervolemia, as demonstrated in a 2025 review (Noor et al., 2025).

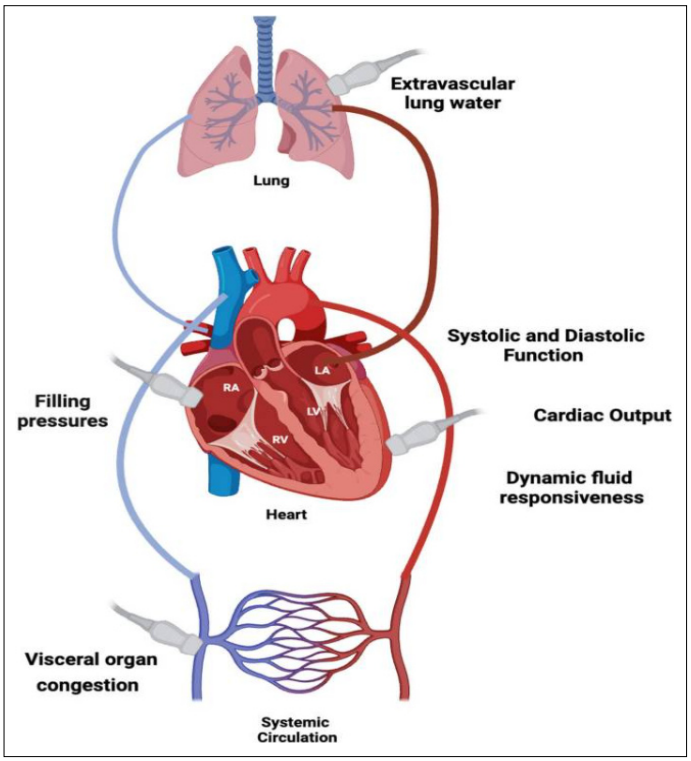

Fig. 2. Ultrasound integration in hemodynamic assessment evaluating cardiac output, fluid responsiveness, filling pressures, extravascular lung water, and visceral congestion (Noor et al., 2025)

Limitations of traditional scores have driven the adoption of artificial intelligence. Algorithms trained on the MIMIC-IV database predict the likelihood of MOF in trauma-induced sepsis patients 24 hours before clinical manifestation and outperform both SOFA and APACHE II in AUROC; a web-based calculator of the model is already available for clinical testing (Peng et al., 2025). A 2024 systematic review confirms that integrating routine laboratory data with gradient boosting raises sepsis mortality prediction accuracy to 0.88 without sacrificing interpretability, thanks to SHAP visualization methods (Mușat et al., 2024). The integration of such tools into the daily prognostic cycle not only enables earlier therapy escalation but also rational allocation of ICU resources, which becomes critical amid the increasing burden of patients with severe comorbidities. The integration of AI tools into the daily prognostic cycle not only enables earlier therapy escalation but also facilitates the rational allocation of intensive care unit resources, which is particularly relevant given the shortage of beds and medical staff. In the global economy, this is reflected in the rapid growth of the artificial intelligence in healthcare market: the AI in healthcare market, encompassing predictive and decision-support algorithms, was valued at USD 26.57 billion in 2024 and may grow to USD 187.69 billion by 2030 at a CAGR of 38.62%, as shown in Figure 3 (Grand View Research, 2025).

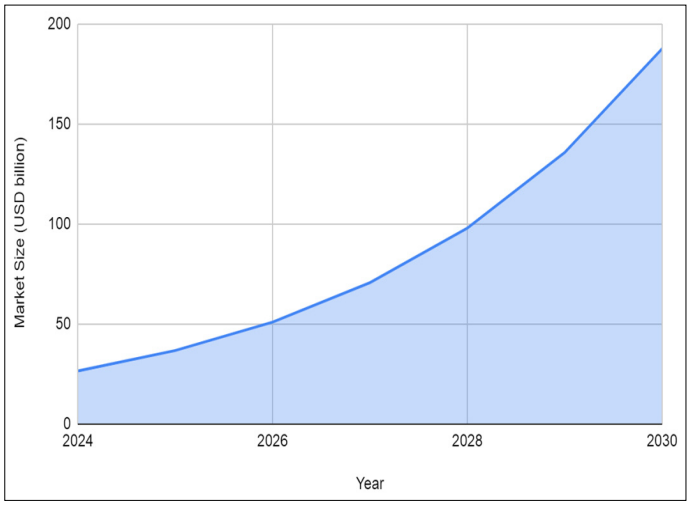

Fig. 3. Global AI in Healthcare Market (Grand View Research, 2025)

The earliest and most critical step in multiple organ failure remains the rapid correction of macro-hemodynamics. The 2021 international sepsis guidelines recommend administering at least 30 mL/kg of balanced crystalloids within the first three hours, thereafter guiding therapy based on dynamic preload indices and lactate clearance to avoid both under-resuscitation and congestive overload (SCCM, 2021). Even during the initial assessment, a de-resuscitation strategy must be anticipated, with diuretics or ultrafiltration initiated as soon as venous congestion indices begin to rise.

If hypotension persists, norepinephrine remains the first-line vasopressor; it should be added whenever maintenance of a MAP ≥ 65 mm Hg is required, and combination with vasopressin becomes appropriate when the norepinephrine dose exceeds approximately 0.3 μg/kg/min, thereby reducing total catecholamine burden. Dobutamine is used to treat low cardiac output in the presence of an adequate circulating volume. This strategy is endorsed as a strong recommendation in the Surviving Sepsis Campaign (Evans et al., 2021).

To further characterize the hemodynamic profile and predict response to fluid therapy, routine use of advanced ultrasound assessment is advisable: evaluation of left ventricular ejection fraction and cardiac output from apical views, measurement of stroke volume by VTI in the outflow tract, dynamic VTI changes during passive leg raising, and application of the VExUS score for early detection of venous congestion and

target-organ injury (Kanitkar et al., 2024). Such an approach synchronizes macro- and microcirculatory resuscitation goals, reducing the incidence of positional oliguria-induced renal injury.

Respiratory support is based on strict lung protection: tidal volume 4–6 mL/kg of ideal body weight, plateau pressure < 30 cm H_2O, and preferably driving pressure limited to 14–15 cm H_2O. When PaO_2/FiO_2 falls below 150 mmHg after stabilization, early and prolonged (≥ 16 h) prone positioning is implemented, which has been shown to reduce mortality (Pesenti et al., 2023).

Controversies regarding continuous cisatracurium infusion have been resolved through compromise: short-term (<48 h) neuromuscular blockade retains value in severe ARDS with pronounced asynchrony and high respiratory drive, whereas routine prolonged use under deep sedation does not improve 90-day survival and increases the risk of neuromuscular weakness. Thus, contemporary guidelines permit paralytic agents only when PaO_2/FiO_2 < 150 mm Hg or uncontrolled air-hunger occurs, favoring light sedation in other situations (Rathi et al., 2024).

When protective ventilation, proning, and optimized hemodynamics fail to achieve PaO_2/FiO_2 > 80 mm Hg for ≥ 6 h (or < 50 mm Hg for > 3 h) on FiO_2 100% and PEEP ≥ 10 cm H_2O, the patient should be transferred to a center experienced in venovenous ECMO. Analysis of EOLIA and subsequent meta-analyses demonstrate that, with such candidate selection, ECMO reduces 60-day mortality by approximately 11% and preserves organ function compared to continued conventional ventilation (Rabah & Rabah, 2022).

Thus, organ-targeted support in MOF is founded on an early, volume-limited resuscitation cycle, targeted vasopressor therapy, and ultrasound-guided decongestion. At the same time, respiratory management relies on maximizing lung protection, dynamic control of ventilation–perfusion mismatch, and the timely initiation of ECMO in refractory hypoxemia. This integrated approach minimizes secondary organ injury and enhances the likelihood of reversing multi-organ dysfunction.

The decision to initiate renal replacement therapy in multiple organ failure represents a balance between the risks of delaying treatment—hyperkalemia, acidosis, and fatal fluid overload—and the futility of prophylactic filtration. Following a series of conflicting RCTs, consensus has shifted toward personalized timing: in the multicenter STARRT-AKI trial, accelerated initiation (≈ 6 h after KDIGO stage 2 criteria) did not improve 90-day survival compared with standard initiation upon severe oliguria, azotemia, or hemodynamic instability—43% versus 43.9% mortality (Bagshaw et al., 2020). However, the single-center ELAIN study, which commenced RRT immediately upon KDIGO stage 2 and NGAL > 150 ng/mL, demonstrated a 15% absolute reduction in 90-day mortality and faster renal recovery (Zarbock et al., 2016). Current algorithms recommend initiating CRRT at KDIGO stage 3, refractory hyperkalemia, or positive fluid balance, with an earlier start permitted in centers using biomarker screening for patients at high risk of progression.

After circuit initiation, not only the presence but the intensity of support matters. To preserve filter life and minimize bleeding, regional citrate remains the first-line anticoagulant; systematic reviews confirm a more than two-fold increase in membrane lifespan without rising complication rates compared with systemic heparin (Boldt et al., 2023). Contraindications to citrate (severe hepatic failure, significant hypocalcemia) warrant a switch to unfractionated or low-molecular-weight heparin under anti-Xa monitoring.

The increasing frequency of combined severe pulmonary and renal dysfunction has driven the development of hybrid platforms. The simplest configuration is an in-line filter added to an ongoing VV-ECMO circuit; this reduces thrombogenic surface and conserves cannulae but increases circuit resistance and complicates ultrafiltration balance. Nevertheless, a single circuit remains preferable when vascular access is limited or coagulopathy is severe.

Lung–kidney modules are often supplemented by artificial liver detoxification. Meta-analysis data on SPAD/MARS/Prometheus devices show comparable bilirubin and aromatic acid removal capabilities, but no convincing 28-day mortality benefit. However, in acute-on-chronic liver failure, albumin dialysis courses improve the ammonia-to-amino acid ratio and reduce encephalopathy severity (Gadour et al., 2024). For individual patients with hyperbilirubinemia and hepatorenal syndrome, combining MARS with CVVHDF allows simultaneous control of ammonia and fluid removal, creating a chain of extracorporeal support without surgical intervention.

Cardiac support in shock increasingly extends beyond VA-ECMO. The latest 2025 systematic review of five matched cohorts found that in patients with ongoing hypoperfusion on vasopressors, the use of percutaneous Impella pumps reduced in-hospital mortality to 39.6% versus 53.8% with VA-ECMO and required fewer transfusions (Stub et al., 2025). In biventricular failure or severe pulmonary hypertension, TandemHeart or classic VA-ECMO remains preferred. In contrast, Impella is more often chosen for isolated left ventricular dysfunction and early ventricular unloading in tandem with ECMO.

Thus, renal, hepatic, cardiac, and antimicrobial supports form an intertwined extracorporeal–pharmacological network, in which timing, dosing, and circuit interactions are inseparable from dynamic monitoring of efficacy and safety. Skillful integration of these elements not only replaces individual organ function but also creates conditions for recovery, continuing the logical sequence initiated by hemodynamic stabilization and lung protection.

The effectiveness of MOF management is determined not only by the sophistication of technical support but by the cohesion of the bedside team. A comprehensive clinical pathway must be delineated, from admission through rehabilitation transfer, with every procedure, laboratory checkpoint, and decision to escalate or de-escalate therapy documented in a unified protocol. This approach eliminates variability across shifts, minimizes diagnostic delays, and reduces the risk of duplicate orders. Checklists embedded in daily rounds help the team systematically track key care modules—from delirium prevention to timely adjustment of antibiotic dosages and extracorporeal circuit parameters—thus transforming a complex cascade of interventions into a controlled sequence of steps.

Within the multidisciplinary team, each member fulfils a critical function. The ICU pharmacist is responsible for pharmacokinetics in the setting of altered volume of distribution and filtration, assesses solution compatibility, conducts therapeutic drug monitoring, and alerts the physician at the first signs of drug-induced nephro- or hepatotoxicity. The physiotherapist initiates gentle mobilization, respiratory training, and passive movements even before the need for extracorporeal support has resolved, which has been shown to shorten the duration of mechanical ventilation and reduce the incidence of ICU-acquired weakness. The infection-control specialist organizes surveillance cultures, audits connector sterility, implements catheter-associated infection prevention measures, and coordinates the antimicrobial stewardship program, in which de-escalation decisions are made at least once daily.

To maintain high-quality care, every intensive care unit tracks a transparent set of indicators. Core metrics include mortality, length of stay, and readmission rate. Process metrics follow: completion of daily checklists, time to first antimicrobial dose, and proportion of successful early chair-seating attempts. These data are automatically extracted from electronic health records, visualized on dashboards, and discussed weekly at clinical conferences. This feedback cycle underpins continuous education, which includes bedside micro-lectures, simulation training, error reviews, and mandatory courses on updated guidelines. Such an ecosystem fosters a culture in which each team member sees a direct link between their contribution and patient outcomes, and where standardization, interprofessional collaboration, and ongoing learning become integral to successful management of multiple organ failure.

Thus, effective management of patients with multiple organ failure in the intensive care unit rests on three pillars: early detection and volume-limited hemodynamic correction; organ-targeted support via ultrasound stratification and extracorporeal modalities; and well-defined, interdisciplinary protocols with continuous quality monitoring. Integrating modern scoring systems, AI-based predictive algorithms, and flexible timing of replacement therapies not only reduces secondary organ injury but also enables rational allocation of ICU resources. A well-coordinated team approach, with a mandatory feedback cycle based on daily checklists, simulation training, and analysis of key indicators, transforms a complex cascade of interventions into a controlled pathway to recovery.

CONCLUSION

In conclusion, the management of patients with multiple organ failure in the intensive care unit requires a systematic, stepwise approach grounded in early recognition and timely correction of macro- and microcirculatory disturbances. The primary phase remains volume-limited hemodynamic resuscitation with targeted control of lactate clearance and dynamic preload indices, followed by goal-directed vasopressor and inotropic therapy by Surviving Sepsis Campaign recommendations. The integration of bedside ultrasound assessment of volume status, cardiac function, and venous congestion synchronizes macro- and microcirculatory goals, minimizes complications of hypervolemia, and improves the likelihood of reversing organ dysfunction.

At the next level of organ support, strict adherence to lung-protective ventilation and timely application of prolonged prone positioning in severe ARDS are essential, as is early referral to centers offering venovenous ECMO for refractory hypoxemia. For renal replacement therapy, personalized timing and regional citrate anticoagulation are preferred, as they extend filter life and reduce bleeding risk. Hybrid extracorporeal platforms—combining pulmonary-renal, hepatic detoxification, and cardiac support technologies—create a chain of replacement therapies in which each circuit is activated according to defined criteria and interacts within a unified algorithm.

The effectiveness of all these interventions depends on seamless interdisciplinary collaboration, including clear admission and rounding protocols, regular checklists, and the active involvement of pharmacists, physiotherapists, and infection-control specialists. Continuous monitoring of key indicators (mortality, duration of mechanical ventilation, readmission rates, adherence to antimicrobial and extracorporeal protocols) and systematic feedback via dashboards and simulation training establishes an environment of perpetual quality improvement.

Therefore, comprehensive management of multiple organ failure rests on three cornerstones: early volume-limited hemodynamic intervention using dynamic and ultrasound markers; organ-targeted support with extracorporeal technologies; and clearly defined, interdisciplinary protocols with ongoing quality assurance. Implementation of integrated algorithms—incorporating modern scoring systems and AI-based prognostication—ensures reduction of secondary organ injury and optimization of intensive care resources, ultimately enhancing survival and long-term outcomes for critically ill patients.

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