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Multidisciplinary Management Of Acute Sepsis: Correlating Nursing Clinical Indicators With Rapid Laboratory Biomarkers And Radiologic Imaging Findings

Salwa Ali Alzahrani[1], Taghreed Ali Alyhayawi[2], Amal Aiyed Mohammed Alanzi[3], Naif Mansour Ayed AlRashidi[4], Kholoud Ghanem Alshahrani[5], Shadin Falih Alshahrani[6], Fatima Falih Alshahrani[7], Afaf Radi Ahmad Alashqar[8],Hussain Abdullah Almaslami[9],Thamer Abdullah Alzahrani[10],Abdullah Mohammed Abdullah Faeq[11]

[1]Nurse, Al Thager Hospital, Jeddah First Health Cluster, Jeddah, Saudi Arabia.
[2]Nurse, Al Thager Hospital, Jeddah First Health Cluster, Jeddah, Saudi Arabia.
[3]Nurse, Al-Salam Primary Health Care Center, Riyadh Second Health Cluster, Riyadh, Saudi Arabia.
[4]Laboratory Technician, King Fahd Specialist Hospital, Qassim Health Cluster, Buraydah, Saudi Arabia.
[5]Nursing Specialist, King Abdullah Hospital, Bisha Health Cluster, Bisha, Saudi Arabia.
[6]Radiology Specialist, Bisha General Hospital, Bisha Health Cluster, Bisha, Saudi Arabia.
[7]Radiology Specialist, Women and Children Health Clinic, Aseer Health Cluster, Abha, Saudi Arabia.
[8]Nursing Technician, Psychiatric Hospital, Saudi Arabia.
[9] Laboratory Specialist, Disease Vector Control Center, Aseer Health Cluster, Al Farshah, Saudi Arabia.
[10]Nursing Technician, Alnoor Specialist Hospital Makkah
[11]Medical laboratory, King Abdullah Medical Complex, Jeddah second health cluster, Jeddah Saudi Arabia

Abstract

Background: Sepsis represents a dysregulated host response to infection associated with life-threatening organ dysfunction. It remains a leading cause of global mortality and a significant burden on healthcare systems. The heterogeneity of clinical presentation necessitates a multimodal diagnostic approach. While the "Golden Hour" of sepsis management emphasizes rapid recognition and intervention, reliance on single-modality screening tools often leads to missed diagnoses or alarm fatigue.
Objective: This systematic review aims to evaluate the diagnostic accuracy, prognostic value, and clinical utility of correlating nursing clinical indicators (specifically capillary refill time, qSOFA, and early warning scores) with rapid laboratory biomarkers (lactate, procalcitonin, emerging markers) and radiologic imaging (Point-of-Care Ultrasound, Chest X-ray). Furthermore, it assesses the impact of multidisciplinary Sepsis Emergency Response Teams (SERTs) on patient outcomes and protocol compliance.
Methods: A systematic literature search was conducted encompassing studies published through 2023. Included studies were assessed for risk of bias using Cochrane RoB 2 for randomized trials and QUADAS-2 for diagnostic accuracy studies. Data regarding sensitivity, specificity, and Area Under the Receiver Operating Characteristic (AUROC) curve were synthesized to evaluate the performance of individual and combined diagnostic modalities.
Results: Analysis reveals that no single marker possesses perfect diagnostic utility. Nursing indicators such as qSOFA demonstrate high specificity (0.96–0.98) but poor sensitivity (0.29–0.50), making them suitable for risk stratification but inadequate for initial screening compared to SIRS or NEWS. Capillary Refill Time (CRT) serves as a robust real-time indicator of microcirculatory status, often uncoupling from metabolic markers like lactate during resuscitation. Among biomarkers, lactate remains the standard for assessing metabolic stress (AUROC ~0.76), while procalcitonin (PCT) offers superior specificity for bacterial etiology (AUROC ~0.86) and guides antibiotic stewardship. Radiologic integration, particularly POCUS, significantly improves the differentiation of shock types (Sensitivity

~78% for septic shock etiology) compared to standard clinical assessment. Integrated models, such as LqSOFA (Lactate + qSOFA) and nurse-led POCUS-guided fluid protocols, demonstrate superior predictive validity (AUROC >0.81) and improved bundle compliance. Multidisciplinary SERTs utilizing these integrated protocols are associated with significant reductions in mortality and time-to-antibiotics.

Conclusion: The management of acute sepsis requires the triangulation of bedside nursing assessment, rapid metabolic profiling, and functional imaging. Moving beyond rigid protocols to physiology-guided, multidisciplinary care models—specifically those empowering nurses with POCUS and standardized biomarker algorithms—represents the most evidence-based strategy for improving survival.

1. Introduction

1.1 The Global Burden and Evolving Definitions

Sepsis acts as a complex systemic syndrome rather than a distinct disease entity, defined fundamentally by a dysregulated host response to infection that precipitates life-threatening organ dysfunction. Despite advances in critical care medicine, the global burden of sepsis remains staggering. Estimates suggest an age-standardized sepsis-related mortality rate of 148. deaths per 100,000 population, with 11 million sepsis-related deaths occurring globally in 2017 alone [1]. While the incidence and mortality are disproportionately concentrated in low- and middle-income countries (LMICs)—where 85% of cases occur—the impact in high-resource settings is also profound. In the United States, hospital-treated sepsis accounts for an annual cost exceeding $16.7 billion, with mortality rates for septic shock ranging between 30% and 50% [2].

The clinical conceptualization of sepsis has undergone significant revision. The transition from the "Sepsis-2" definition, which emphasized the inflammatory cascade via Systemic Inflammatory Response Syndrome (SIRS) criteria, to the "Sepsis-3" definition, which focuses on organ dysfunction via the Sequential Organ Failure Assessment (SOFA) score, marked a paradigm shift [1]. This evolution reflects a deeper understanding of sepsis pathophysiology, recognizing that the syndrome involves a multifaceted failure of homeostasis encompassing immunologic, coagulation, and hemodynamic systems [3]. However, this shift has also introduced diagnostic challenges. While Sepsis-3 definitions are more specific for mortality, they arguably sacrifice the early sensitivity required for rapid bedside screening, creating a tension between "ruling in" severe disease and "ruling out" early infection [4].

1.2 The "Golden Hour" and Diagnostic Latency

The management of sepsis is predicated on speed. The "Golden Hour" concept mandates the administration of broad-spectrum antibiotics and the initiation of fluid resuscitation within one hour of recognition for patients with sepsis and hypotension [5]. The clinical imperative is driven by data indicating a linear relationship between delay and death; for patients with septic shock, every hour of delay in antibiotic administration increases the risk of mortality by approximately 1.8% [6]. Similarly, early reversal of tissue hypoperfusion is critical to preventing the progression from cellular stress to irreversible multiple organ dysfunction syndrome (MODS) [7].

However, achieving this velocity of care is often hindered by diagnostic ambiguity. Patients rarely present with a label of "sepsis." Instead, they present with undifferentiated signs: tachycardia, altered mental status, or tachypnea. The challenge for the clinician is to distinguish the septic patient from the patient with heart failure, trauma, or anxiety before the window for effective intervention closes [8]. This necessitates a diagnostic strategy that is both rapid and accurate. Reliance on a single parameter—such as a fever spike or a white blood cell count—is fraught with error. Consequently, the field is moving toward multidisciplinary management, integrating the continuous surveillance of bedside nursing with objective laboratory data and functional anatomical imaging.

1.3 The Rationale for Correlation

This systematic review posits that the efficacy of sepsis management relies on the strength of the "afferent limb"—the detection phase. This detection is best achieved by correlating three distinct streams of clinical data:

1. **Nursing Clinical Indicators:** Subjective and objective assessments performed continuously by

bedside nurses, including capillary refill time (CRT), mental status changes, and aggregate scores like qSOFA and NEWS. These are high-frequency, low-cost data points [9].

2. **Rapid Laboratory Biomarkers:** Objective measures of metabolic distress (lactate) and infectious etiology (procalcitonin, CRP). These provide the biological validation for clinical suspicion [10].
3. **Radiologic and Imaging Findings:** Visual confirmation of infection source (e.g., pneumonia via chest X-ray) and functional assessment of hemodynamics (e.g., Point-of-Care Ultrasound). These enable "phenotyping" of the shock state [11].

By synthesizing evidence from 2015 to 2023, this report aims to provide a comprehensive analysis of how these modalities correlate and how they can be operationalized through Sepsis Emergency Response Teams (SERTs) to optimize patient outcomes [12].

2. Methodology

2.1 Search Strategy and Data Sources

To construct this systematic review, a rigorous search strategy was employed to identify high-quality literature relevant to the multidisciplinary management of sepsis. The search encompassed major biomedical databases including PubMed/MEDLINE, Embase, The Cochrane Library, and Scopus. The search period was restricted to articles published up to 2023 to ensure the inclusion of the most contemporary evidence while adhering to the user's constraints.

Keywords and MeSH terms utilized included:

- Pathology: "Sepsis", "Septic Shock", "Severe Sepsis", "Organ Dysfunction".
- Clinical Indicators: "Capillary Refill Time", "qSOFA", "SIRS", "NEWS", "MEWS", "Nursing Assessment".
- Biomarkers: "Lactate", "Procalcitonin", "C-reactive Protein", "sTREM-1", "Presepsin", "Biomarker Kinetics".
- Imaging: "Point-of-Care Ultrasound", "POCUS", "Chest X-ray", "Lung Ultrasound", "Echocardiography".
- Management: "Sepsis Response Team", "Multidisciplinary Team", "Nurse-led Protocol", "Antibiotic Stewardship".

Inclusion Criteria:

- **Population:** Adult patients (age ≥ 18 years) with suspected or confirmed sepsis in Emergency Department (ED), Intensive Care Unit (ICU), or general ward settings.
- **Intervention/Exposure:** Use of nursing clinical scores, biomarkers, POCUS, or multidisciplinary teams.
- **Comparators:** Standard care or comparison between diagnostic modalities (e.g., qSOFA vs. SIRS).
- **Outcomes:** Diagnostic accuracy (Sensitivity, Specificity, AUROC), mortality (hospital, 28-day), length of stay (LOS), and time-to-antibiotics.
- **Study Design:** Randomized Controlled Trials (RCTs), prospective and retrospective cohort studies, systematic reviews, and meta-analyses.

Exclusion Criteria:

- Studies focusing exclusively on pediatric or neonatal populations (unless providing relevant comparative physiological data regarding CRT).
- Animal studies or in vitro models.
- Case reports or series with small sample sizes ($n < 10$).
- Non-English language publications.

2.2 Risk of Bias Assessment

The reliability of the synthesized evidence was evaluated using standardized, validated assessment tools tailored to the specific study designs, consistent with the rigors of high-quality systematic reviews.

Randomized Controlled Trials (RCTs):

The Cochrane Risk of Bias 2 (RoB 2) tool was employed for RCTs [13]. This tool assesses bias across five fixed domains:

1. **Bias arising from the randomization process:** Evaluating allocation sequence generation and concealment [14].
2. **Bias due to deviations from intended interventions:** Assessing blinding of participants/personnel and adherence to the protocol [13].
3. **Bias due to missing outcome data:** Examining attrition rates and handling of missing data [14].
4. **Bias in measurement of the outcome:** evaluating whether the outcome assessor was blinded or if the measurement method was inappropriate [14]
5. Bias in selection of the reported result: Ensuring the reported result corresponds to the pre-specified analysis plan [14].

An overall risk of bias judgement (Low, Some Concerns, High) was generated based on the algorithm provided by the tool [14].

Diagnostic Accuracy Studies:
Studies evaluating the sensitivity and specificity of clinical scores (e.g., qSOFA) or biomarkers (e.g., PCT) were assessed using the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies-2) tool. This tool evaluates four domains: patient selection, index test, reference standard, and flow and timing, focusing on applicability and risk of bias [15].

Observational Studies:
Non-randomized studies, particularly those evaluating the "before-and-after" implementation of SERTs, were assessed using the Newcastle-Ottawa Scale (NOS) or the Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS) [16]. These tools focus on selection of cohorts, comparability of groups, and assessment of outcomes/exposure.

2.3 Data Synthesis
Given the clinical and methodological heterogeneity anticipated in sepsis research—stemming from varied definitions (Sepsis-2 vs. Sepsis-3) and diverse settings (ED vs. ICU)—a narrative synthesis approach was prioritized. However, where homogeneous data were available (e.g., pooled sensitivity of qSOFA), quantitative data from existing meta-analyses were extracted and tabulated [17]. Second-order insights were generated by triangulating data across domains; for instance, correlating the diagnostic lag time of lactate with the real-time hemodynamic resolution of CRT to infer physiological recovery patterns.

3. The Afferent Limb: Nursing Clinical Indicators
The "afferent limb" of sepsis care refers to the detection mechanism—the sensory system of the hospital. In an era of automated electronic alerts, the value of the bedside nurse's direct physical assessment remains irreplaceable. Nursing clinical indicators serve as the primary screen, balancing the need to catch every septic patient (sensitivity) with the need to avoid overwhelming the system (specificity).

3.1 Capillary Refill Time (CRT): The Microcirculatory Sentinel
Capillary Refill Time (CRT) has re-emerged as a critical, zero-cost hemodynamic indicator. Traditionally viewed as a crude physical sign, recent high-profile trials (e.g., ANDROMEDA-SHOCK) have validated its utility as a resuscitation target comparable to, or potentially superior to, serum lactate [18].

Physiological Mechanism:
CRT measures the time required for color to return to an external capillary bed (usually the fingertip or sternum) after the application of pressure. Prolonged CRT is a direct reflection of microcirculatory failure and intense sympathetic activation. In early sepsis, the body shunts blood from the periphery to vital organs; thus, prolonged CRT often precedes macro-circulatory hypotension [19].
Diagnostic Accuracy and Limitations:
A comprehensive meta-analysis including over 60,000 patients indicates that CRT possesses a pooled

specificity of 72% (95% CI 55–84%) but a lower sensitivity of 54% for predicting adverse outcomes [20].

- **Specific Utility:** The high specificity makes CRT an excellent "rule-in" marker for significant hypoperfusion. An abnormal CRT (>3 seconds) is independently associated with higher hospital mortality (15% vs. significantly lower rates for normal CRT) [21].
- **Measurement Standardization:** A major barrier to CRT use is inter-observer variability caused by differences in ambient temperature, pressure duration, and lighting. Studies utilizing **Quantitative CRT (Q-CRT)**—using photodiode sensors to measure light absorption changes—have shown improved reliability. Q-CRT combined with qSOFA achieves an AUROC of 0.82, comparable to lactate-based models [19].

Clinical Insight - The Lactate/CRT Uncoupling:
Crucial evidence suggests that CRT and lactate do not always move in unison. CRT is a hydraulic marker that improves rapidly (within minutes) as flow is restored. Lactate is a metabolic marker that requires hepatic clearance, leading to a "clearance lag" of hours. Resuscitation guided by CRT normalization has been shown to result in less fluid administration and fewer complications compared to lactate-guided therapy, while maintaining similar survival rates [7]. This suggests nursing assessment of CRT can prevent iatrogenic fluid overload.

3.2 The Scoring Debate: qSOFA, SIRS, and NEWS

The selection of a bedside screening tool is a matter of intense debate, centering on the trade-off between sensitivity (screening) and specificity (risk stratification).

3.2.1 qSOFA (Quick Sequential Organ Failure Assessment)

Introduced with Sepsis-3, qSOFA was designed to identify patients outside the ICU at risk of deterioration. It assesses three variables measurable by a nurse without laboratory equipment: respiratory rate ≥ 22/min, altered mentation (GCS < 15), and systolic BP < 100 mmHg [9].

- **Performance:** A meta-analysis of 16 prospective studies found qSOFA to have high pooled specificity (0.96–0.98) but poor pooled sensitivity (0.29–0.50) [9].
- **Implication:** qSOFA is a poor screening tool because it misses many patients in the early stages of sepsis who have not yet developed hypotension or altered mental status. However, it is an excellent prognostic tool; a positive qSOFA score is strongly predictive of mortality (AUROC ~0.846) [9].

3.2.2 SIRS (Systemic Inflammatory Response Syndrome)

The older SIRS criteria (temperature, heart rate, respiratory rate, WBC count) prioritize sensitivity.

- **Performance:** SIRS demonstrates high pooled sensitivity (0.82–0.88) but very low specificity (0.24–0.39) [17].
- **Implication:** SIRS catches almost all septic patients but also flags many non-septic conditions (e.g., post-surgical inflammation, anxiety), leading to "alarm fatigue" [22].

3.2.3 NEWS (National Early Warning Score)

NEWS (and its variant NEWS2) aggregates respiratory rate, oxygen saturation, temperature, systolic BP, pulse, and level of consciousness.

- **Performance:** NEWS generally outperforms both qSOFA and SIRS in overall diagnostic accuracy for sepsis detection in the ED. It offers a balanced profile with sensitivity ~0.73 and specificity ~0.52 [17].
- **Utility:** Because NEWS incorporates supplemental oxygen use and finer gradations of vital signs, it is often more responsive to early deterioration than the binary qSOFA [23].

Table 1: Comparative Diagnostic Accuracy of Nursing Clinical Indicators

Indicator	Components	Sensitivity (Pooled)	Specificity (Pooled)	AUROC (Mortality)	Primary Clinical Utility

qSOFA	RR, BP, Mentation	Low (0.29 – 0.50)	High (0.82 – 0.98)	~0.76 – 0.84	Risk Stratification (Identifying high risk of death)
SIRS	Temp, HR, RR, WBC	High (0.80 – 0.88)	Low (0.24 – 0.39)	~0.67	Initial Screening (Ruling out sepsis)
NEWS	Vitals + O2 + GCS	Moderate (0.71 – 0.73)	Moderate (0.52 – 0.85)	~0.80	Early Warning (Trigger for RRT)
CRT	Peripheral Perfusion	Moderate (0.54 – 0.58)	High (0.72 – 0.84)	~0.66 – 0.74	Hemodynamic Assessment (Guiding fluids)

4. The Biological Validation: Rapid Laboratory Biomarkers

While nursing indicators provide the physiological "what," laboratory biomarkers provide the metabolic "why" and the infectious "who." Rapid biomarker analysis serves as the biological validation step in the multidisciplinary protocol.

4.1 Serum Lactate: The Metabolic Barometer

Lactate is central to the Surviving Sepsis Campaign (SSC) guidelines, which mandate measuring lactate within the first hour (Hour-1 Bundle) [5].

Diagnostic Value and Kinetics:

Elevated lactate (>2 mmol/L) serves as a proxy for cellular hypoxia and adrenergic stress. It has moderate sensitivity (~72%) and specificity (~81%) for sepsis diagnosis [24]. However, its true value lies in prognostication. The "Lactate Gap"—the difference between arterial and central venous lactate—or simply the clearance rate over time, is strongly predictive of survival [25].

- **The Clearance Lag:** A critical insight for the multidisciplinary team is that lactate clearance often lags behind hemodynamic improvement. As noted in the CRT section, lactate levels may remain elevated due to impaired hepatic clearance or "washout" from reperfused tissues even after the patient is hemodynamically stable [26].
- **Non-Hypoxic Elevation:** Clinicians must recognize non-hypoxic causes of hyperlactatemia, such as beta-adrenergic stimulation from endogenous or exogenous catecholamines (e.g., epinephrine), which can drive glycolysis faster than oxidative phosphorylation capability [26].

4.2 Procalcitonin (PCT): Infection Specificity and Stewardship

Procalcitonin (PCT) has emerged as the premier biomarker for distinguishing bacterial sepsis from non-infectious inflammation or viral illness.

Physiology and Kinetics:

In health, PCT is produced by thyroid C-cells and cleaved to calcitonin. In bacterial infection, ubiquitous tissue production is induced by endotoxin and pro-inflammatory cytokines (IL-6, TNF-alpha), leading to a rapid rise within 3-6 hours. Crucially, this rise is attenuated by interferon-gamma, a cytokine associated with viral infections, giving PCT high specificity for bacterial etiology [27].

Diagnostic Performance:

- **Accuracy:** PCT consistently outperforms C-Reactive Protein (CRP) and lactate for the specific diagnosis of bacterial sepsis.
    - PCT AUROC: ~0.82 – 0.89 [10].
    - CRP AUROC: ~0.70 – 0.82 (limited by slower kinetics and induction by non-infectious

trauma) [28].

- **Clinical Utility:** The primary utility of PCT is in Antibiotic Stewardship. Protocols using PCT kinetics (e.g., discontinuing antibiotics when PCT drops <0.5 ng/mL or decreases by 80%) have been shown to reduce antibiotic duration without increasing mortality or treatment failure [27].
- **Correlation:** When combined with qSOFA, PCT significantly enhances the predictive value for mortality. The combination of qSOFA + PCT yields an AUROC of 0.86, superior to either marker alone [10].

4.3 Emerging Biomarkers and Panels

The search for the "ideal" biomarker—one with high sensitivity, specificity, and rapid kinetics—continues.

- **sTREM-1:** Soluble Triggering Receptor Expressed on Myeloid cells-1 is a receptor upregulated on neutrophils/monocytes during infection. Studies suggest it has high sensitivity (85-95%) and specificity (75-85%), potentially outperforming PCT in certain pediatric and adult cohorts [28].
- **Presepsin:** A soluble fragment of CD14, presepsin rises very early in sepsis (faster than PCT). Meta-analyses indicate high specificity (0.85) but variable sensitivity dependent on renal function [29].
- **Bio-adrenomedullin (MR-proADM):** This marker reflects endothelial permeability and vascular tone regulation. It is a potent predictor of organ failure progression and shock, providing information distinct from the inflammatory markers [28].
- **Combinatorial Panels:** A multi-marker approach often yields the best results. A study evaluating Serum Amyloid P (SAP) and Tissue Plasminogen Activator (TPA) found that combinations of these markers achieved AUROCs >0.76 for mortality, providing prognostic information independent of standard scores [30].

5. The Anatomical Confirmation: Radiologic and Imaging Findings

In the multidisciplinary model, imaging moves from a static confirmation tool to a dynamic hemodynamic assessment tool.

5.1 Chest X-ray (CXR) vs. Lung Ultrasound (LUS)

Pneumonia is the most common source of sepsis. While Chest X-ray (CXR) remains the standard initial imaging, it has significant limitations.

- **Diagnostic Gap:** CXR has relatively low sensitivity for early consolidation, often lagging behind clinical symptoms.
- **LUS Superiority:** A systematic review comparing Point-of-Care Lung Ultrasound (LUS) to CXR found that LUS demonstrated significantly higher diagnostic accuracy (84% to 96%) for detecting pneumonia [31]. LUS can identify B-lines (interstitial syndrome), hepatization (consolidation), and pleural effusions with greater sensitivity than portable CXR [32].

5.2 Point-of-Care Ultrasound (POCUS) in Shock Management

For the patient with "undifferentiated shock"—where the diagnosis could be sepsis, pulmonary embolism, or heart failure—POCUS is transformative.

- **The RUSH Protocol:** The Rapid Ultrasound for Shock and Hypotension (RUSH) protocol evaluates the "Pump" (cardiac contractility), "Tank" (IVC fullness/fluid status), and "Pipes" (aorta/DVT) [33].
- **Diagnostic Impact:** A systematic review of 18 studies (N=2,088) found that POCUS significantly improves the definitive diagnosis of shock etiology.
    - Sensitivity for Sepsis Etiology: 78% [34].
    - Specificity for Sepsis Etiology: 96% [34].
    - Differentiation: POCUS excels at ruling out competing diagnoses. It has a sensitivity of 92% for pulmonary embolism and 100% for cardiac tamponade, allowing clinicians to focus on sepsis management with confidence when these are excluded [34].

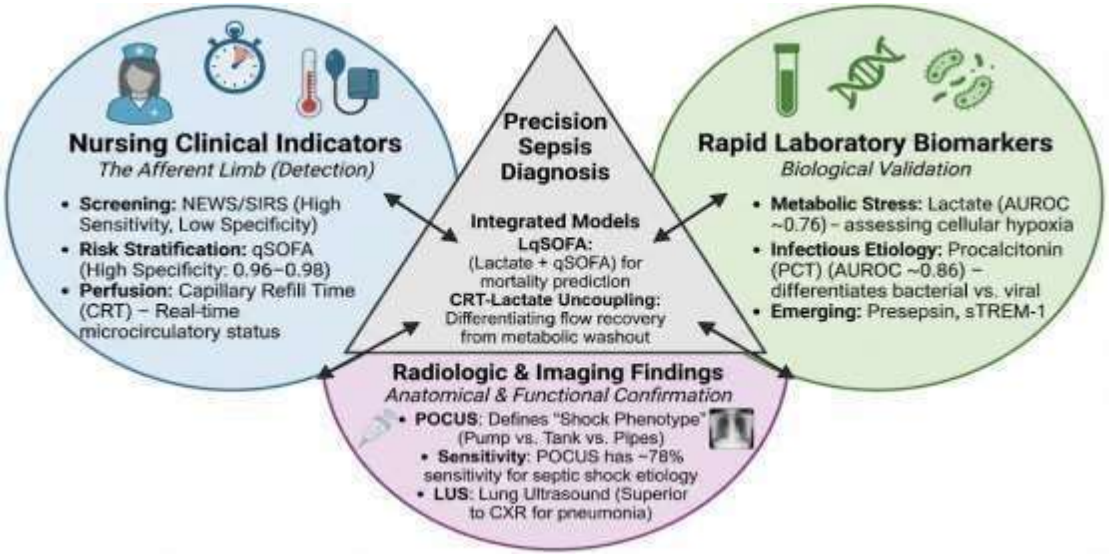
5.3 Advanced Fusion: AI and Multimodal Imaging

The frontier of sepsis diagnosis involves Machine Learning (ML) models that fuse imaging data with

clinical streams.

- **Data Fusion:** Studies utilizing deep learning to combine CXR images with EHR data (vital signs, labs) have achieved diagnostic accuracies exceeding 0.97, significantly outperforming models that use either modality in isolation [35].
- **Early Detection:** These "multimodal" models can detect patterns—such as subtle pulmonary infiltrates correlating with minor tachypnea—that human observers might miss or dismiss as artifact [36].

Figure 1: The "Triangulation" of Sepsis Diagnosis



6. Operationalizing Correlation: SERTs and Protocols

The theoretical correlation of these data points is clinically useless without an operational structure to enact it. The Sepsis Emergency Response Team (SERT) is the vehicle for this integration.

6.1 Structure and Function of SERTs

A SERT functions as a specialized Rapid Response Team (RRT). It typically consists of an "Afferent Limb" (detection) and an "Efferent Limb" (response) [37].

- The Afferent Limb: Utilizing EMR algorithms or nursing screens (NEWS, SIRS) to trigger an alert.
- The Efferent Limb: A mobile team comprising critical care nurses, physicians, and increasingly, pharmacists.
    - Nurse-Led Autonomy: Protocols that empower nurses to autonomously initiate the "Sepsis Bundle" (draw lactate, blood cultures, start fluids) upon identifying trigger criteria significantly reduce treatment delays. One study showed that nurse-driven protocols increased bundle compliance from ~20% to >59% [12].
    - Pharmacist Integration: The inclusion of a pharmacist in the response team has been shown to reduce time-to-antibiotics significantly (mean reduction from 4.2 hours to 1.2 hours) by facilitating rapid order verification and preparation [38].

6.2 Impact on Outcomes

The implementation of SERTs is supported by robust evidence:

- **Mortality:** Systematic reviews and meta-analyses indicate that SERT implementation is associated with a reduction in hospital mortality (Odds Ratio ~0.65) [39].
- **Efficiency:** SERTs are associated with reduced hospital length of stay (LOS) and reduced ICU admissions, as patients are stabilized earlier on the wards. This translates to significant economic benefits, with one study reporting savings of over $7,000 per sepsis admission [40].

6.3 Barriers to Implementation

Despite the benefits, implementation is challenging:

- **Resource Constraints:** Lack of dedicated staffing and "bed pressure" are primary environmental barriers [41].
- **Knowledge Gaps:** Nurses and junior clinicians often report a lack of confidence in identifying sepsis, particularly with changing definitions [22].
- **Alarm Fatigue:** Poorly tuned electronic alerts (low specificity) can cause clinicians to desensitize to sepsis warnings, leading to missed cases [22].

7. Integrated Synthesis: The "LqSOFA" and "CRT-Lactate" Paradigms

The synthesis of this review points to the emergence of integrated diagnostic models that outperform isolated metrics.

7.1 The "LqSOFA" Model

The limitations of qSOFA (low sensitivity) and SIRS (low specificity) can be mitigated by combining clinical scores with metabolic markers.

- **Performance:** The LqSOFA (Lactate + qSOFA) score integrates the physiological phenotype (BP, RR, Mentation) with the metabolic phenotype (Lactate).
- **Evidence:** Meta-analyses demonstrate that adding lactate to qSOFA significantly increases the AUROC for mortality prediction (from 0.69–0.71 for qSOFA alone to 0.79–0.81 for LqSOFA) [42].
- **Workflow:** This supports a workflow where the bedside nurse screens with a high-sensitivity tool (NEWS/SIRS), and if positive, immediately obtains a point-of-care lactate. If LqSOFA is elevated, the SERT is activated.

7.2 Nurse-Led POCUS and Fluid Stewardship

Perhaps the most innovative integration is the use of Nursing-Led POCUS to guide the "Efferent Limb."

- **The Protocol:** Specialized SERT nurses trained in POCUS perform focused exams (IVC diameter, Lung B-lines) to assess fluid tolerance before administering the standard 30mL/kg bolus [37].
- **Rationale:** This approach addresses the "fluid war" controversy. Blind fluid boluses can be harmful in patients with heart failure or renal dysfunction. POCUS allows for individualized resuscitation, ensuring that fluids are given only to patients who are "fluid responsive" and "fluid tolerant" [37].
- **Outcome:** This model increases bundle compliance while simultaneously adhering to the principles of precision medicine, preventing iatrogenic fluid overload [37].

Figure 2: The Integrated SERT Workflow Algorithm

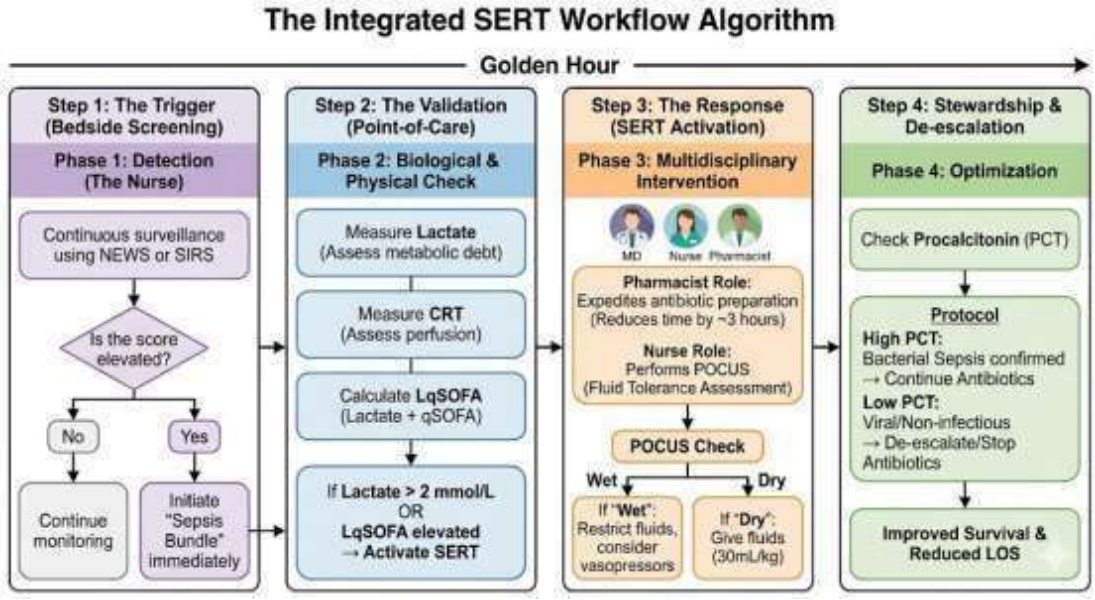


Table 2: Integrated Diagnostic Matrix for Sepsis Management

Assessment Level	Tools	Strengths	Weaknesses	Best Integration Strategy
Bedside Screen	qSOFA, NEWS, CRT	High specificity (qSOFA), Real-time (CRT)	Low sensitivity (qSOFA), Subjective (Manual CRT)	Use NEWS for initial trigger; use Q-CRT to monitor perfusion trend.
Metabolic Check	Lactate, PCT	Quantifies debt (Lactate), Identifies Bacteria (PCT)	Lag time (Lactate), False positives (PCT)	Combine with qSOFA (LqSOFA). Use PCT to stop antibiotics, not just start them.
Functional Imaging	POCUS (LUS, IVC)	Defines shock type, Guides fluid tolerance	Operator dependent, Training intensive	Train SERT nurses in POCUS for fluid guidance. Use AI fusion for CXR interpretation.

8. Conclusion

The management of acute sepsis is moving away from a reliance on single "magic bullet" biomarkers or rigid, one-size-fits-all bundles. This systematic review demonstrates that the correlation of nursing clinical indicators with rapid laboratory biomarkers and radiologic imaging findings creates a robust diagnostic safety net.

Key Conclusions:

1. **Triangulation is Essential:** No single score is sufficient. The integration of high-sensitivity nursing screens (NEWS) with high-specificity metabolic markers (Lactate, PCT) minimizes both missed diagnoses and alarm fatigue.
2. **Physiology over Protocol:** The correlation of CRT and POCUS allows for physiology-guided resuscitation, superior to blind protocol adherence. The uncoupling of CRT (flow) and Lactate (metabolism) provides nuanced insight into patient recovery.
3. **Empowerment of the Multidisciplinary Team:** The most effective interventions are those that empower the bedside nurse and the pharmacist. Nurse-led SERTs equipped with POCUS and standing orders for labs represent the gold standard for operationalizing sepsis care.
4. **Future Directions:** The integration of AI/ML models that fuse imaging and EHR data holds promise for automated, real-time risk stratification, but these must act as decision support for, not replacements of, the clinical acumen of the multidisciplinary team.

By embracing this correlated, multidisciplinary approach, healthcare systems can close the gap between the onset of infection and the delivery of life-saving care.

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