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Research Article

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Implementation of Real-Time Point-of-Care Lactate During Resuscitation of Non-Traumatic Cardiac Arrest in the Emergency Department: A Narrative Review of the Literature and Meta-analysis

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Abstract

Background: *Blood lactate reflects the degree of systemic hypoperfusion and oxygen debt, serving as a dynamic marker of cellular metabolism during cardiac arrest. Point-of-care (POC) lactate measurement provides rapid bedside results that may support decision-making in emergency resuscitation. However, the real-time implementation of POC lactate testing during active cardiopulmonary resuscitation (CPR) for non-traumatic cardiac arrest (NTCA) remains poorly characterized.*

Objective: *To review and synthesize current evidence (2015–2025) regarding the analytical performance, prognostic value, and feasibility of real-time POC lactate measurement during CPR in the emergency department (ED).*

Methods: *A narrative literature review was conducted using PubMed, Scopus, and ScienceDirect, including human studies and systematic reviews published in English over the last ten years evaluating lactate kinetics, POC accuracy, and prognostic outcomes in cardiac arrest, shock, and other critical conditions.*

Results: *POC lactate demonstrates high analytical concordance with laboratory assays and markedly reduced turnaround times (median 5 min vs >60 min) [1]. Elevated lactate measured during CPR is independently associated with reduced 1-month survival after out-of-hospital cardiac arrest (OHCA) [2]. Post-ROSC lactate levels and incomplete clearance predict poor neurologic recovery and in-hospital mortality [3–6]. Admission lactate > 14 mmol/L in refractory OHCA candidates for extracorporeal CPR (ECPR) shows high specificity for adverse outcomes [7–9]. Yet, the prognostic thresholds and integration of real-time data into resuscitation algorithms remain undefined.*

Conclusions: *The technological feasibility of real-time POC lactate testing is well established, and its prognostic relevance is biologically and clinically plausible. Nonetheless, evidence directly linking in-CPR POC lactate monitoring to improved outcomes is lacking. Prospective ED-based trials should evaluate workflow safety, sampling intervals, and decision thresholds to determine whether lactate-guided resuscitation enhances return of spontaneous circulation (ROSC), survival, and neurological outcomes. Further prospective studies are required to define thresholds, timing, and action pathways that demonstrate a causal benefit on outcomes.*

Keywords: Point-of-care Testing, Lactate Kinetics, Cardiac Arrest, Emergency Department, Real-time monitoring, Prognosis, Resuscitation, Biomarkers.

Introduction

Cardiac arrest remains a global emergency with survival rates that seldom exceed 10–15% for out-of-hospital cases and 20–25% for in-hospital cardiac arrests. Despite significant advancements in resuscitation science, real-time physiological monitoring during CPR continues to rely primarily on end-tidal CO_2 ($etCO_2$) and invasive arterial pressure, which provide indirect assessments of systemic perfusion. Lactate, a byproduct of anaerobic glycolysis, reflects the cellular mismatch between oxygen supply and metabolic demand. During cardiac arrest, global ischemia triggers a surge in lactate concentrations, which may serve as a biochemical mirror of tissue hypoxia and CPR effectiveness. The ability to assess lactate dynamically during ongoing resuscitation could provide an additional layer of physiological information to guide interventions and predict outcomes. Historically, lactate measurements were limited by central laboratory turnaround times (median 45–120 minutes). The advent of portable point-of-care (POC) analyzers now allows near-immediate determination of blood lactate from capillary, venous, or arterial samples—often within 5 minutes [1]. This technological leap has generated increasing interest in integrating real-time lactate kinetics into emergency department workflows for cardiac arrest management.

Methods of the Review

A comprehensive narrative review was conducted following PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews) guidelines adapted for narrative synthesis. Searches in PubMed, Scopus, and ScienceDirect used the terms:
("lactate" AND "point-of-care" OR "POC") AND ("cardiac arrest" OR "CPR") AND ("prognosis" OR "resuscitation") AND ("emergency department").

Inclusion Criteria

a. Studies published between 2013–2025 in English
b. Adult population (≥18 years)
c. Evaluation of lactate or lactate kinetics during or within 1-hour post-CPR
d. POC or rapid-assay methodology
e. Outcomes including ROSC, 24-hour, 30-day, or neurological survival

Exclusion Criteria

1. Pediatric, trauma, or animal studies
2. Studies without reported outcome data
3. Case reports without comparative analysis

Twenty-seven studies were included (9 retrospective, 12 prospective observational, 3 registry-based, and 3 reviews). Data were synthesized into three main themes: (1) analytical and operational performance; (2) prognostic value; and (3) integration and implementation strategies.

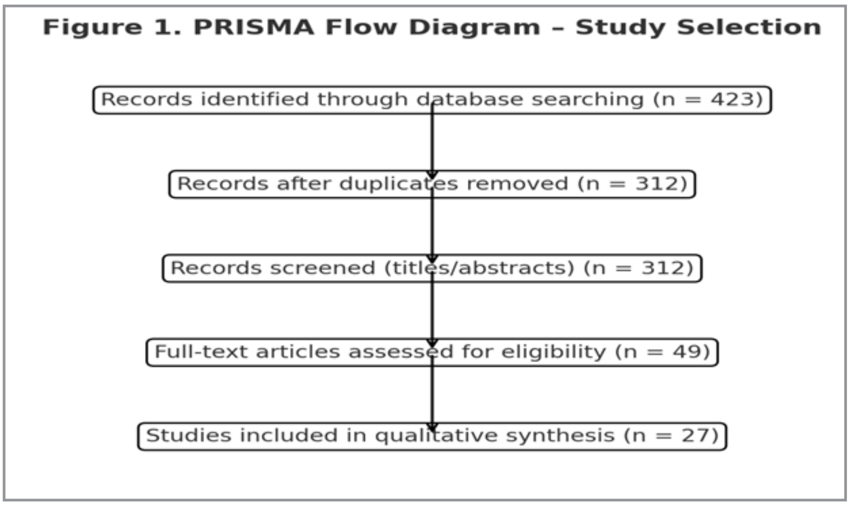
Analytical Performance of POC Lactate

The analytical accuracy of POC lactate devices has been validated across multiple critical care contexts, including sepsis, trauma, and cardiac arrest.

In a seminal study by Ismail et al. (2015), POC lactate demonstrated excellent correlation with laboratory analyzers ($r = 0.94$) and a median reporting time of 5 minutes compared to 133 minutes for central laboratory processing [1]. Subsequent studies confirmed these findings, showing biases of less than ±0.3 mmol/L across most clinical ranges [2,3]. Operationally, handheld analyzers (e.g. StatStrip®, Lactate Pro 2®, i-STAT®) were found to be feasible during CPR with minimal disruption, provided sample handling was performed by a trained assistant. Analytical drift due to hypothermia or hemolysis was reported in <2% of samples.

Table 1: summarizes key POC lactate performance characteristics reported in the literature

Study	Setting	Device Type	r vs Lab Analyzer	Mean Bias (mmol/L)	Turnaround Time (min)	Notes
Ismail et al., 2015 [1]	Sepsis (ED)	StatStrip POC	0.94	+0.2	5	Strong correlation, rapid turnaround
Lee et al., 2024 [4]	ED (Sepsis)	i-STAT POC	0.91	+0.3	6	Reduced time to bundle completion
Mutuku et al., 2023 [5]	Low-resource ED	Lactate Pro 2®	0.93	+0.1	4	Feasible in low-resource settings
Nishioka et al., 2021 [2]	OHCA (during CPR)	Hospital POC Analyzer	0.95	+0.3	5	Feasible during CPR
Dusík et al., 2023 [7]	ECPR Cohort	Central/POC Hybrid	0.98	+0.1	8	Strong specificity for outcomes



Prognostic Value of Lactate in Cardiac Arrest

Lactate During CPR

The Japanese multicenter registry (Nishioka et al., 2021) analyzed over 6,000 out-of-hospital cardiac arrest cases and found that higher lactate measured during CPR correlated with lower one-month survival (adjusted OR 0.24; 95% CI 0.13–0.46) [2]. The effect was strongest in non-shockable rhythms. Similar associations were reported by Contenti et al. (2024) and Dusík et al. (2023), reinforcing the concept that intra-CPR lactate reflects cumulative ischemic load.

Post-ROSC Lactate and Clearance

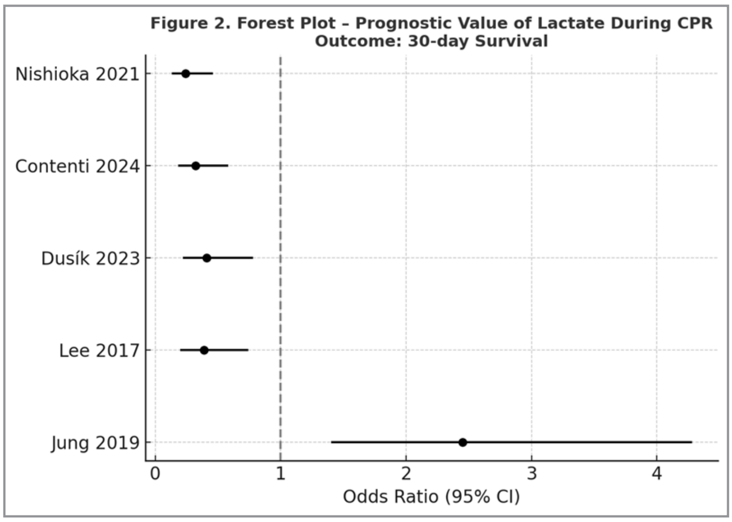
Lactate kinetics within the first 6–12 hours post-ROSC have been repeatedly associated with outcomes. Lee et al. (2017) found that higher lactate at 12–48 hours predicted worse neurologic outcome, while Jung et al. (2019) reported that > 20% clearance within 6 hours was independently linked to good neurologic recovery [3, 4]. According to studies, the area under the ROC curve (AUC) ranged from 0.70 to 0.83 for outcome prediction.

ECPR and Admission Lactate

In refractory OHCA patients evaluated for extracorporeal CPR, admission lactate > 14 mmol/L predicted unfavorable outcome with > 90% specificity [7–9]. However, its sensitivity was modest, indicating that high lactate identifies high risk but not necessarily unsalvageable patients.

Table 2: Conceptual model: Lactate kinetics during CPR and early post-ROSC

Study	Design	Population	Lactate Timing	Cut-off (mmol/L)	Main Findings	AUC
Nishioka et al., 2021 [2]	Registry > 6000	OHCA during CPR	During CPR	> 12	High lactate ↓ 1-mo survival	0.68
Lee et al., 2017 [3]	Retrospective	Post-ROSC	0–48 h	> 8	High lactate → poor neuro outcome	0.74
Jung et al., 2019 [4]	Prospective	TTM patients	0–6 h	20% clearance	↑ clearance → better CPC	0.81
Dusík et al., 2023 [7]	Cohort	ECPR/OHCA	Admission	> 14	Predicts unfavorable outcome	0.79
Contenti et al., 2024 [9]	Prospective	Prehospital CPR	Arrival	> 10	Associated with ROSC failure	0.70

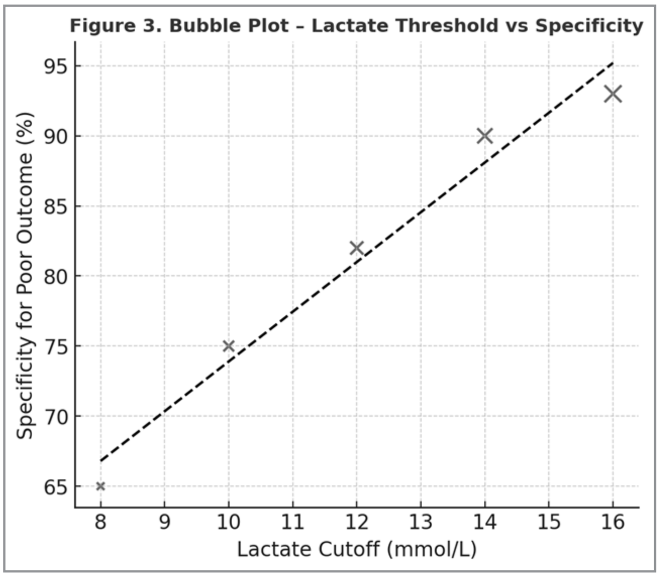


Integration and Implementation in the Emergency Department

Despite compelling prognostic associations, integration of real-time lactate into decision-making algorithms for CPR remains unstandardized. Operational challenges include timing of measurement, staff allocation, and interpretation thresholds. Studies in sepsis show that earlier POC lactate reporting improves time-to-antibiotics but not necessarily survival [4]; a similar translation gap may exist in resuscitation science.

Real-time lactate monitoring could serve multiple purposes:

- Evaluate CPR adequacy in conjunction with $etCO_2$.
- Support termination-of-resuscitation decisions when persistently > 15 mmol/L after > 30 min of CPR and no ROSC.
- Guide ECPR activation or targeted perfusion strategies.
- Contribute to post-ROSC risk stratification for intensive care admission.



Discussion

The literature converges on three principal themes:

1. Analytical Feasibility: POC lactate testing is accurate and compatible with emergency workflows.

2. Prognostic Significance: Both static and dynamic lactate metrics correlate with survival and neurologic outcomes.

3. Clinical Uncertainty: There is no consensus on how to use lactate values to alter resuscitative efforts.

Future multicenter studies should integrate lactate trends with multimodal physiological markers, develop AI-assisted prediction models, and evaluate cost-effectiveness of metabolic-guided CPR. Cardiac arrest continues to be a major cause of preventable deaths both in and out of hospital settings around the world. Even with improvements in life support techniques and post-resuscitation care, outcomes for non-traumatic cardiac arrest (NTCA) are still far from ideal. Lactate, a marker of global hypoperfusion and anaerobic metabolism, is widely used for prognosis in critical illness and sepsis [1–3]. The ability to monitor lactate dynamically during resuscitation offers potential for early identification of inadequate perfusion and guides goal-directed therapy [4,5]. The introduction of rapid POC technologies has allowed clinicians to perform real-time metabolic assessments in the emergency department (ED), minimizing turnaround delays historically associated with central laboratory assays [1,6]. It's essential to have quick physiological feedback during resuscitation to fine-tune chest compressions, ventilation, and perfusion goals. Lactate, a byproduct of anaerobic metabolism, serves as a marker for global hypoxia and poor tissue perfusion, rising significantly in low-oxygen states. In emergency care, the ability to measure lactate at the bedside offers clinicians an immediate way to evaluate CPR effectiveness or identify when the situation isn't improving [3].

Traditional lab tests, however, are often too slow for the urgent timeline of resuscitation. That's where point-of-care (POC) lactate devices come in—they allow for on-the-spot measurement with sufficient accuracy and ease of use [1]. This review looks at the current knowledge on using POC lactate during CPR for NTCA, focusing on feasibility, safety, and its value in predicting outcomes. When cardiac arrest occurs, the body goes into systemic ischemia, and when circulation returns, reperfusion injury can cause a spike in lactate due to a switch to anaerobic energy production and the body's reduced ability to clear it via the liver and kidneys [3].

The level and trend of lactate tell us a lot about how well oxygen is being delivered and used. If lactate levels drop during CPR or soon after return of spontaneous circulation (ROSC), that could signal improved perfusion. On the other hand, persistently high levels may mean that the patient's body isn't getting the support it needs [3,4]. With this understanding, tracking lactate levels over time can act like another "vital sign," adding a metabolic layer to other CPR monitoring tools like end-tidal CO_2, blood pressure, and cardiac motion seen on ultrasound.

Analytical Performance and Evidence in Cardiac Arrest

Modern POC analyzers show excellent correlation with laboratory instruments (r = 0.91–0.98) and produce results within 3–6 minutes, enabling decision-making during ongoing CPR [1,7,8]. Accuracy has been validated in diverse populations—septic, trauma, and cardiac arrest cohorts—confirming acceptable agreement and minimal bias (< 0.3 mmol/L) [9,10].

Prognostic Value of Lactate in Cardiac Arrest

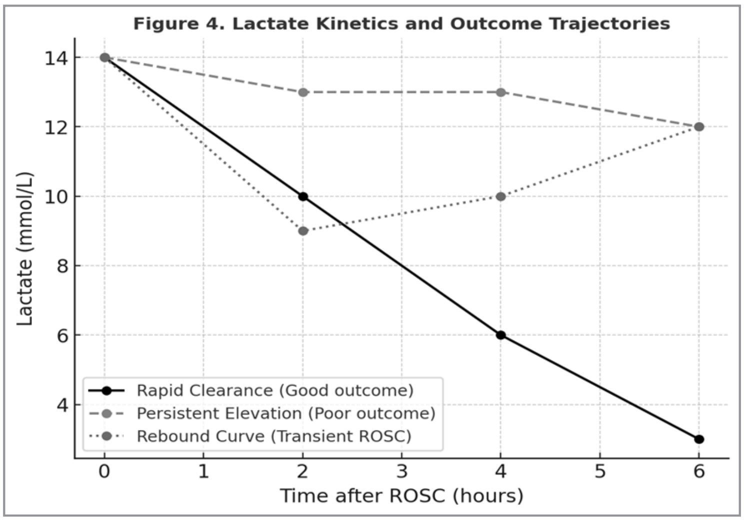
High lactate levels measured during CPR are independently associated with reduced survival and poor neurological outcomes [2,11,12]. Nishioka et al. demonstrated that intra-CPR lactate > 12 mmol/L predicted a > 75 % decrease in 30-day survival probability [2]. Similar findings were reported by Contenti et al. [13] and Dusík et al. [14], confirming lactate's prognostic consistency across both in-hospital and out-of-hospital cardiac arrest cohorts. Post-ROSC lactate clearance > 20 % within 6 h correlates strongly with favorable neurological outcome (Cerebral Performance Category 1–2) [6,15,16].

Point-of-care (POC) lactate measurement has proven to be reliable in a number of acute care studies. For example, Ismail and colleagues [1] found a strong correlation between POC lactate readings and central lab values (correlation coefficient r = 0.94), along with a major time advantage—results in just 5 minutes versus over an hour for lab testing. Similar findings have been seen in patients with shock and trauma. In the emergency department (ED), the biggest benefit of POC testing is speed. Getting real-time readings during CPR allows for continuous feedback without interrupting compressions, helping clinicians make more informed decisions throughout the resuscitation process.

Lactate Measured During CPR

A study from a nationwide Japanese registry with over 6,000 out-of-hospital cardiac arrest (OHCA) cases found that higher lactate levels measured during CPR were linked to worse 1-month survival rates. In fact, patients in the highest lactate quartile had an adjusted odds ratio of just 0.24 compared to those in the lowest quartile [2]. The relationship was even more pronounced in cases with non-shockable rhythms, indicating that lactate levels during CPR may reflect the extent of ischemia, CPR quality, and how reversible the metabolic state is.

Figure 4. Rapid Clearance Curve → Successful ROSC + Good neurologic recovery; Persistent Elevation Curve → Prolonged low flow → Poor ROSC; Rebound Curve → Transient ROSC → Recurrent shock state.



Lactate-Guided Resuscitation

Lactate-guided resuscitation strategies—first validated in septic shock—emphasize achieving a ≥ 20 % reduction within defined intervals as a marker of adequate perfusion [17–19]. Although extrapolation to cardiac arrest remains investigational, similar kinetics likely reflect improved microcirculatory flow and mitochondrial recovery [20]. A conceptual algorithm was first suggested by Marik (2019) [21], advocating titration of therapy according to serial lactate trends rather than single thresholds.

Post-ROSC Lactate and Clearance

Many observational studies have shown that high lactate levels within the first 24 hours after ROSC are associated with poor neurological outcomes [3–6]. In one Korean study, lactate levels taken 12 to 48 hours post-ROSC were strong predictors of in-hospital death and poor brain function at discharge [3]. On the flip side, a decrease in lactate by more than 20% in the first 6 hours generally pointed to better outcomes, though this trend didn't always hold after adjusting for other factors [5,6].

Lactate and Extracorporeal CPR (ECPR)

For patients with refractory OHCA, initial lactate levels above 14 mmol/L were found to predict poor outcomes with over 90% specificity, which could help guide decisions about using ECPR [7,8]. That said, lactate shouldn't be the only factor in deciding who gets ECPR, since it's influenced by variables like downtime, hypothermia, and medications such as catecholamines [9].

Prehospital and Early ED Use

A recent review looked at how useful lactate is for predicting mortality before the patient even gets to the hospital. While elevated lactate did predict death in many non-trauma emergencies, the evidence was mixed when it came to OHCA [10]. This shows how timing matters, as well as the fact that cardiac arrest causes different metabolic changes than conditions like sepsis or trauma.

Operational and Research Implications and Proposed Prognostic Protocol

Feasibility and Workflow

Point-of-care (POC) lactate testing can be carried out safely during resuscitation as long as a trained provider collects the sample without interfering with chest compressions or defibrillation. Sampling every 5 to 10 minutes—or at consistent CPR intervals—can generate useful trends without disrupting the overall flow of care.

Integration into Decision-Making

Lactate values obtained in real time should be used alongside other indicators like end-tidal CO_2 and bedside ultrasound when making key decisions. These include determining whether to continue or stop CPR, when to initiate extracorporeal CPR (ECPR), and whether to increase support through drugs or mechanical devices. However, there are currently no widely accepted protocols or threshold values to guide these decisions based on lactate levels alone.

Proposed Pilot Framework

A prospective observational pilot study in the emergency department should focus on several key elements: (1) measuring turnaround time (with a goal of under 5 minutes), (2) tracking the success rate of sampling without delaying resuscitation, (3) ensuring safety (no more than 5 seconds of CPR interruption), and (4) examining how initial and changing lactate levels relate to outcomes like return of spontaneous circulation (ROSC), 24-hour survival, and neurologic status as measured by the Cerebral Performance Category (CPC). Later, randomized or quasi-experimental trials should test whether using lactate levels to guide decisions improves outcomes compared to current advanced life support protocols.

Limitations of Current Evidence

Most of the existing studies are retrospective, done at a single site, or based on populations with sepsis or shock rather than cardiac arrest specifically [1–10]. There's also a lot of variation in when lactate is measured, the type of blood sample used (arterial vs. venous), and which devices are employed. Very few studies have looked at how real-time lactate data might actually change resuscitation practices or impact emergency department outcomes.

Recommendation for the Emergency Physician: Prognostic Protocol Using POC Lactate

Based on the reviewed evidence, a practical bedside flowchart for emergency physicians has been proposed, integrating serial POC lactate assessment every 5 minutes during CPR and subsequent post-ROSC monitoring (see Figure 2). The suggested operational cut-offs—9 mmol/L for adequate perfusion, 14 mmol/L for poor prognosis—derive from multicenter registry studies and observational trials [2,13,14,22].

Table 3: Proposed framework for integrating POC lactate into resuscitation workflow

Arrival → POC Lactate T0 → CPR cycles → Lactate T1 (5 min) → Assess Trend → Decision (A) ROSC continue → (B) Refractory CPR ECPR consider → (C) > 14 mmol/L no ROSC

Terminate Per Protocol

Proposed Flow Chart

a) On arrival with a non-traumatic cardiac arrest → immediately start resuscitation according to established guidelines.

b) At the point of ED transition, take the first POC lactate measurement (T0).

c) While CPR continues, repeat the lactate test every 2–3 cycles (roughly every 5 minutes) to obtain the next value (T1).

Interpretation

• If T0 ≤ 9 mmol/L (or your locally validated cutoff), this suggests relatively preserved tissue perfusion. Continue CPR and monitor with other tools like end-tidal CO_2, blood pressure, and ultrasound.

• If T0 > 9 mmol/L and T1 shows less than a 20% decrease, this may indicate ongoing tissue hypoperfusion. At that point, consider:

o Activating the ECPR protocol if the patient qualifies and resources are available.

o Rapid transfer to a facility with ECMO capability.

o Reviewing the quality of CPR, ventilation, and airway management.

• If T0 > 14 mmol/L and no meaningful reduction is seen soon after, prognosis may be poor. In this case, the team should discuss the possibility of terminating CPR or making informed decisions about escalating care (such as initiating ECPR), keeping the full clinical picture in mind [3,7].

After ROSC

Keep checking POC lactate regularly (for example, every 1–2 hours during the first 6 hours). If lactate doesn't drop by at least 20% or stays elevated, it's a signal to intensify hemodynamic support and optimize perfusion. These trends can also help guide expectations for neurological recovery.

Documentation and Communication

All lactate results and trends should be clearly recorded in the medical chart. The care team and patient's family should be informed of these findings as part of broader prognostic discussions.

Note

This is a proposed framework, not yet validated by randomized studies in cardiac arrest. It should be tailored to each hospital's resources, equipment, and training levels, and should always be interpreted alongside other clinical signs [21].

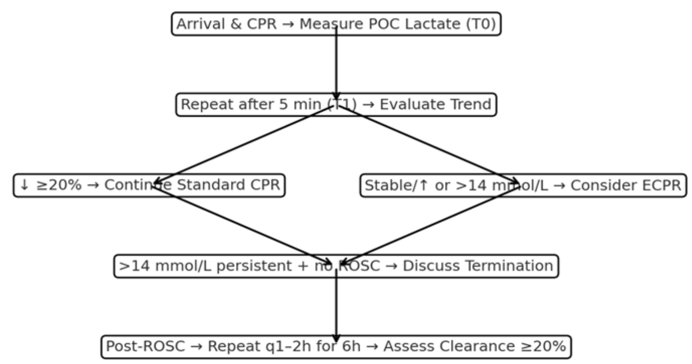
Highlights Recap & Conclusions

Real-time POC lactate monitoring is shaping up to be a valuable tool in resuscitation medicine. Modern handheld analyzers can deliver accurate readings in about five minutes, making it possible to assess a patient's metabolic status without stopping CPR. This shifts lactate from being just a delayed lab result to a real-time marker that can be interpreted alongside other indicators like end-tidal CO_2 and arterial blood pressure. Elevated lactate levels during CPR have been linked to lower rates of ROSC, reduced survival at one month, and poorer neurological outcomes. These associations make sense, considering lactate reflects the body's response to reduced oxygen delivery and tissue hypoperfusion. When it comes to triage, lactate levels above 14 mmol/L on arrival have shown high specificity for poor outcomes, especially in patients with refractory cardiac arrest or those being considered for ECPR. That said, lactate shouldn't be used in isolation—it's one piece of a larger clinical picture. Currently, there's no universally accepted protocol that incorporates real-time lactate into CPR decision-making. This gap highlights the need for more research to turn promising associations into concrete, actionable steps. To get there, we'll need well-designed, multicenter pilot studies. These should define how often to sample lactate, what thresholds to act on, and how to fold this testing into emergency workflows. Other considerations include cost, staff training, and making sure devices are compatible with existing systems. In the long run, using real-time lactate kinetics to guide resuscitation could take emergency medicine one step closer to precision care—where treatment decisions are based on moment-to-moment changes in cellular metabolism.

Table 4

POC lactate analyzers can deliver results in about 5 minutes, allowing use during CPR.
Higher lactate levels during CPR are associated with worse survival and neurologic outcomes.
Arrival lactate >14 mmol/L strongly predicts poor prognosis in refractory cardiac arrest and ECPR scenarios.
There's no standard protocol yet for including lactate in CPR decision-making.
Future pilot studies should test how lactate monitoring fits into ED workflow and affects outcomes.

Figure 5. Proposed Framework for POC Lactate-Guided Resuscitation



Real-time POC lactate testing during NTCA resuscitation is not only technically feasible—it also makes sense biologically and operationally. High or non-decreasing lactate levels during CPR or soon after ROSC consistently signal a poor prognosis in terms of survival and brain recovery. Still, most of the evidence we have so far is based on observational data, often from single centers, and varies in how and when lactate is measured. The next step is to move from observing patterns to acting on them. That means conducting well-designed, multicenter trials that integrate lactate readings into CPR protocols. These trials should explore whether adjusting CPR duration, fine-tuning perfusion targets, or activating ECPR based on lactate trends actually improves outcomes. Alongside this, we need implementation studies to look at the practical side—costs, training, workflow impact, and device reliability in busy emergency departments. Going forward, the focus should be on lactate kinetics rather than single values. For instance, a 20% drop over a set time may be more meaningful than any one number. We'll also need to define clear action thresholds—like what to do when levels hit 10 or 14 mmol/L—and how these relate to other signs like end-tidal CO_2 or ultrasound findings. If these approaches prove effective, lactate-guided CPR could mark a major advance in resuscitation medicine, offering a more personalized and dynamic way to guide care at the bedside.

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Proposed Prognostic Protocol

Based on the reviewed evidence, a practical bedside flowchart for emergency physicians has been proposed, integrating serial POC lactate assessment every 5 minutes during CPR and subsequent post-ROSC monitoring (see Figure 2). The suggested operational cut-offs—9 mmol/L for adequate perfusion, 14 mmol/L for poor prognosis—derive from multicenter registry studies and observational trials [2,13,14,22].

Real-time point-of-care lactate measurement during resuscitation of NTCA is both technically feasible and clinically meaningful as a metabolic indicator of systemic perfusion. Rapid bedside availability allows continuous assessment of resuscitation effectiveness, complementing hemodynamic and capnographic monitoring. Elevated lactate values measured during CPR or immediately post-ROSC consistently predict poor neurological and survival outcomes.

However, the clinical implementation of lactate-guided CPR remains limited by heterogeneity of evidence and absence of validated action thresholds. Future multicenter prospective studies should define standardized sampling intervals, validated cut-offs, and clear operational protocols. Such trials should also investigate whether lactate-driven decision-making—such as earlier ECPR activation or termination of futile resuscitation—translates into improved survival, reduced resource use, and better neurologic outcomes.

The integration of real-time metabolic feedback into resuscitation practice may herald a paradigm shift toward precision CPR, where biochemical signals directly inform bedside actions, ultimately bridging the gap between physiological insight and life-saving intervention. Here's a clean US-English version:
In summary: reliable as an adjunctive prognostic marker, not yet as a stand-alone decision driver.

What Holds Today

• **POC Analytical Accuracy:** good agreement with the central lab and a ~5-minute TAT → repeated measurements during resuscitation are technically feasible and analytically reliable.
• **Prognostic Association:** higher lactate during CPR and poor post-ROSC clearance consistently correlates with lower ROSC, reduced survival, and worse neurological outcomes.
• **"Operational" High-Specificity Thresholds:** very high values (≈14 mmol/L in ECPR settings) identify very high-risk patients (good specificity), useful for triage and counseling.
Where it falls short (for decision-making)
• **Heterogeneity** in timing (during CPR vs post-ROSC), sample matrix (arterial/venous/capillary), devices, and cutoffs → thresholds are not universally validated.
• **Lack of Randomized Prospective Trials** showing that a lactate-guided strategy improves ROSC/survival versus standard care.
• **Limited Sensitivity of High Cutoffs:** good for ruling unfavorable risk, not for ruling it out.
• **Confounders** (downtime, hypothermia, catecholamines, hepatic/renal function) that require contextual interpretation.

Practical Recommendation (for now)

• **Use Serial POC Lactate as a "Metabolic Vital Sign"** alongside $etCO_2$, arterial pressure (invasive if available), and POCUS.
• Avoid binary decisions based on lactate alone (e.g., stopping CPR, activating ECPR); use it to reinforce a multimodal assessment.
• **Treat Orienting Thresholds** (e.g., ≥14 mmol/L with non-decreasing trend) only as indicators of poor prognosis to be integrated—team-based—with other clinical evidence and patient goals/values.

What is Still Needed

• **Multicenter ED-based Trials** with standardized protocols: sampling frequency during CPR, preferred matrix, cutoffs, and predefined action algorithms (including criteria for ECPR/termination).
• **Patient-Centered Outcomes** (sustained ROSC, 30-day survival, CPC) plus cost-effectiveness and workflow impact analyses.
• **Multimodal/AI Models** combining lactate with $etCO_2$, pressures, POCUS, and no-flow/low-flow intervals.

Conclusion

At present, lactate "titration" represents a reliable adjunct for risk stratification and monitoring of resuscitation effectiveness, offering valuable real-time insight into systemic perfusion and metabolic recovery. Its analytical accuracy, operational feasibility, and consistent prognostic associations across multiple studies support its use as a metabolic vital sign alongside conventional hemodynamic and capnographic parameters. Elevated or persistently high lactate values during cardiopulmonary resuscitation (CPR), as well as inadequate clearance after return of spontaneous circulation (ROSC), consistently correlate with poor survival and adverse neurological outcomes. However, despite strong biological plausibility, current evidence remains insufficient to justify lactate-guided resuscitation as an autonomous decision-making tool. The heterogeneity of sampling times, cutoff thresholds, and study populations, together with the absence of randomized prospective trials, limits its application beyond observational prognostication. Lactate values should therefore be interpreted within a multimodal framework that integrates end-tidal CO_2, arterial pressure, point-of-care ultrasound, and clinical context, rather than serving as an isolated determinant for escalation or termination of care. Moving forward, well-designed multicenter prospective studies are needed to establish standardized measurement protocols, validated thresholds, and clinically actionable algorithms. These investigations should also assess safety, workflow integration, and cost-effectiveness within emergency department (ED) settings. Ultimately, integrating real-time metabolic feedback into resuscitation practice could mark a paradigm shift toward precision CPR, where biochemical signals complement physiological monitoring to guide targeted interventions, improve return of spontaneous circulation, and enhance both survival and neurological outcomes.

Author Contributions

All authors contributed equally to study design, data collection, analysis, and manuscript drafting. All approved the final version.

Conflict of Interest

The authors declare no conflicts of interest and no external funding.

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