



Lactic Acidosis: Pathophysiology, Diagnosis, and Nursing Management

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Abstract

Background: Lactic acidosis is a critical metabolic condition characterized by the systemic accumulation of lactate, resulting from an imbalance between its production and clearance. It is commonly classified into Type A, caused by tissue hypoperfusion and hypoxia (e.g., shock), and Type B, associated with underlying diseases, toxins, or mitochondrial dysfunction. It is a frequent finding in critically ill patients and is strongly linked to high mortality rates.

Aim: This article aims to comprehensively review the pathophysiology, diagnosis, and management of lactic acidosis, with a specific focus on the integral role of nursing in early recognition, monitoring, and coordinating interdisciplinary care to improve patient outcomes.

Methods: The article synthesizes current medical knowledge on lactic acidosis, detailing its physiological mechanisms, risk factors, and diagnostic criteria. It outlines systematic approaches for assessment, evaluation (including arterial blood gas and anion gap analysis), and evidence-based medical and nursing interventions.

Results: Effective management hinges on rapid identification and treatment of the underlying cause, such as infection source control in sepsis. Medical management involves goal-directed fluid resuscitation, vasopressor support, and optimizing oxygen delivery. Serial lactate monitoring and clinical assessment of perfusion are crucial for evaluating treatment efficacy. Nursing management is pivotal in executing these interventions, providing continuous monitoring, and ensuring coordinated, patient-centered care.

Conclusion: Lactic acidosis is a life-threatening condition requiring a prompt, systematic, and interdisciplinary approach. Successful outcomes depend on correcting the underlying cause, restoring tissue perfusion, and meticulous supportive care, with nurses playing a central role in monitoring, intervention, and care coordination.

Keywords: Lactic acidosis, lactate, sepsis, shock, nursing management, critical care, hemodynamic monitoring, metabolic acidosis..

1. Introduction

Lactic acid is generated continuously as a product of anaerobic glycolysis and, at low concentrations, plays a vital role in normal cellular metabolism and interorgan shuttle pathways [1]. In critical illness, however, lactate accumulation reflects an imbalance between production and clearance, most commonly due to tissue hypoperfusion, mitochondrial dysfunction, or impaired hepatic and renal elimination [2]. Clinically, this dysregulation is captured in the construct of type A lactic acidosis, driven by hypoxia or shock states, and type B lactic acidosis, associated with sepsis-related metabolic derangements, medications, malignancy, and underlying organ failure [3]. The hemodynamic consequences of severe hyperlactatemia include vasoplegia, myocardial depression, and worsening microcirculatory flow,

creating a self-reinforcing cycle of hypoperfusion and cellular energy failure that is strongly linked to mortality [1][2]. Accordingly, serum lactate serves dually as a prognostic biomarker and a therapeutic target, with higher peak values and delayed normalization portending adverse outcomes across diverse cohorts, including sepsis, trauma, and postoperative populations [3]. From a nursing perspective, early recognition and serial assessment of lactate are integral to time-critical resuscitation bundles and bedside decision-making [1]. Point-of-care lactate testing facilitates rapid risk stratification, while trends in lactate—particularly lactate clearance within the first 2–6 hours—provide actionable feedback on the adequacy of interventions such as fluid resuscitation, vasoactive support, oxygen delivery optimization, and source control in sepsis

[2][3]. Nursing responsibilities extend to meticulous hemodynamic monitoring, ensuring timely sample acquisition, minimizing preanalytical errors, and coordinating multidisciplinary responses when lactate fails to decline as expected [1]. Equally important is the identification of non-hypoperfusion etiologies—drug exposures, thiamine deficiency, hepatic dysfunction—so that therapy can be individualized beyond fluids and pressors [2]. By integrating lactate kinetics with bedside signs of perfusion and organ function, nurses help translate biochemical signals into targeted care plans, shorten the time to effective therapy, and ultimately improve survival in patients vulnerable to the systemic consequences of lactic acidosis [3].

Nursing Diagnosis

In patients with lactic acidosis, a comprehensive nursing diagnosis encompasses the multifactorial conditions contributing to elevated lactate levels and impaired cellular metabolism. Shock is one of the most critical underlying conditions, as it leads to systemic hypoperfusion and oxygen deprivation at the tissue level. The nurse's primary focus in this context is to maintain adequate circulation through hemodynamic support, fluid resuscitation, and continuous monitoring of mean arterial pressure and urine output. In sepsis, the pathophysiological mechanisms include profound vasodilation, capillary leak, and mitochondrial dysfunction, all contributing to lactic acid accumulation. Nursing care emphasizes

early detection using sepsis protocols, administration of antibiotics, and titration of vasopressors while assessing for improving tissue perfusion and decreasing lactate trends. For patients with metformin-associated lactic acidosis, particularly those with diabetes mellitus, the nurse must monitor metabolic parameters, including serum lactate, glucose, and renal function. Diabetes predisposes patients to both metabolic derangements and microvascular disease, increasing the risk of inadequate tissue perfusion and delayed wound healing. When heart failure coexists, decreased cardiac output further compromises tissue oxygenation. Nurses play a vital role in monitoring signs of fluid overload, implementing oxygen therapy, and adjusting positioning to optimize respiratory and circulatory efficiency. Renal failure compounds the condition by reducing lactate clearance, necessitating close observation of fluid balance, creatinine levels, and potential need for renal replacement therapy. Psychological manifestations such as anxiety and confusion often arise from hypoxia and metabolic imbalance. Nursing interventions should include reassurance, environmental control, and early identification of neurological changes indicating worsening tissue ischemia. In totality, the nursing diagnosis must integrate physiological stabilization with psychosocial support, emphasizing continuous assessment and timely intervention to prevent progression to multiple organ dysfunction and improve patient outcomes in lactic acidosis [3].

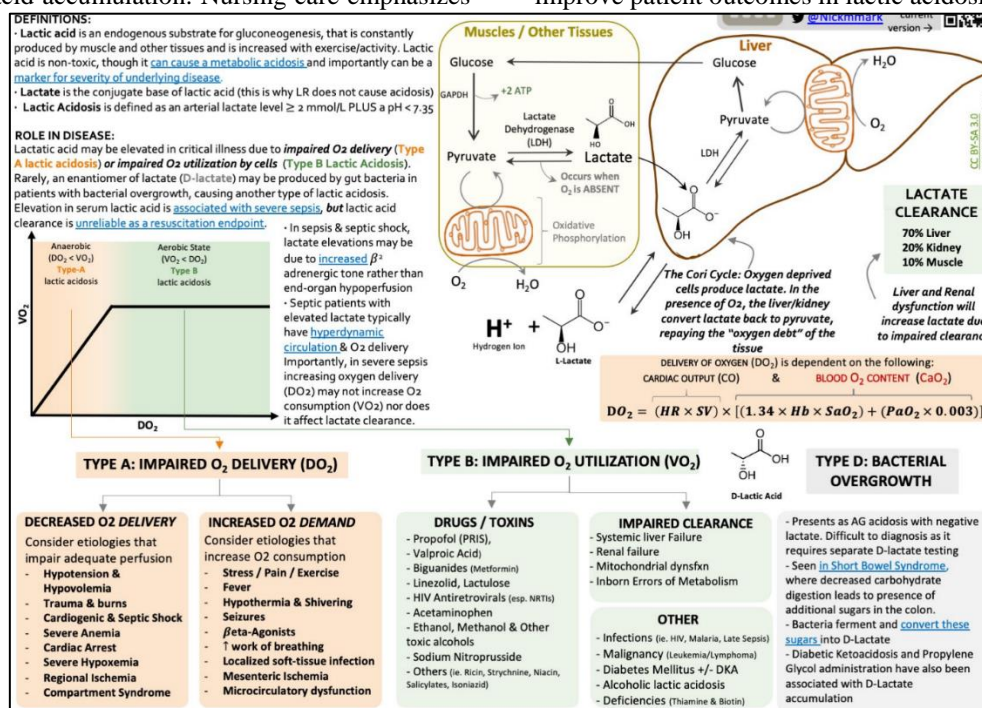


Figure-1: Overview of Lactic Acidosis.

Causes

Lactic acid is a normal intermediary metabolite produced during glycolysis, with an estimated generation of about 20 mmol/kg/day under physiological conditions. It enters the bloodstream and

is subsequently cleared primarily by the liver and, to a lesser extent, the kidneys, which together account for nearly 70–80% of lactate metabolism through the process of gluconeogenesis [4]. While several tissues—including the skin, erythrocytes, brain tissue,

skeletal muscle, and the gastrointestinal tract—produce lactate, only the liver and kidney possess the enzymatic machinery, specifically lactate dehydrogenase and pyruvate carboxylase, required to convert lactate back to glucose [5]. Thus, the maintenance of normal lactate levels relies on a delicate equilibrium between production and clearance. Any disruption of this balance, whether through enhanced generation or impaired utilization, results in elevated serum lactate and, if sustained, leads to lactic acidosis. Under normal aerobic conditions, pyruvate, the end product of glycolysis, is converted into acetyl-CoA by pyruvate dehydrogenase, entering the citric acid (Krebs) cycle to produce ATP efficiently via oxidative phosphorylation. However, in anaerobic states, such as oxygen deprivation or mitochondrial dysfunction, pyruvate is instead reduced to lactate through the lactic acid cycle (Cori cycle). This reaction regenerates NAD^+ from NADH, allowing glycolysis to continue and produce limited energy—only two ATP molecules per glucose molecule—critical for cell survival during hypoxic conditions [4][6]. The accumulated lactate is transported to the liver, where it undergoes gluconeogenesis, converting back into glucose that can be reused by peripheral tissues. Pathological and persistent lactic acidosis emerges when lactate production outpaces hepatic and renal clearance capacity. This commonly occurs in clinical conditions characterized by tissue hypoxia, circulatory failure, or impaired metabolic function. Examples include severe sepsis, where inflammatory mediators impair oxygen utilization; shock states, marked by decreased perfusion; severe hypovolemia or hypotension, reducing oxygen delivery; and hepatic dysfunction, limiting lactate clearance [5]. Additionally, convulsions, hypothermia, cardiac arrest, and certain drug toxicities—notably metformin or ethanol—can heighten lactate accumulation by increasing anaerobic glycolysis or inhibiting mitochondrial respiration. The coexistence of excessive lactate generation and impaired hepatic metabolism amplifies the acidosis, often resulting in profound metabolic derangement and life-threatening systemic effects [6]. Therefore, understanding these mechanisms is essential for targeted therapeutic strategies aimed at restoring tissue oxygenation, enhancing lactate clearance, and correcting the underlying pathophysiology driving lactic acidosis [4][5][6].

Risk Factors

Lactic acidosis represents one of the most significant metabolic derangements encountered in critically ill patients, often serving as both a marker of disease severity and an indicator of poor prognosis. It reflects a complex interplay between tissue hypoxia, impaired oxidative metabolism, and organ dysfunction, particularly of the liver and kidneys. Despite its clinical importance, studies on lactic acidosis remain limited in scale and design, with most

investigations being retrospective or based on small patient cohorts [4]. One of the most comprehensive efforts to elucidate its epidemiology and outcomes was conducted by Jung and colleagues (2011) in a multicenter, prospective study involving 2,550 patients, which remains a cornerstone in understanding its risk profile [5]. The findings from Jung et al. revealed that severe lactic acidosis occurred in approximately 6% of critically ill patients, underscoring its prevalence in intensive care settings. Notably, 83% of these individuals required vasopressor therapy, reflecting the close association between lactic acidosis and circulatory shock. The study demonstrated a 57% mortality rate in this group, with an average pH of 7.09 ± 0.11 and markedly elevated lactate concentrations. Importantly, both the magnitude of lactatemia and the duration required for its correction were independently associated with survival outcomes, emphasizing that prolonged hyperlactatemia is a strong predictor of death [6]. These findings reinforce lactate clearance as a critical therapeutic goal in the management of critically ill patients [6].

Shock, particularly septic, cardiogenic, or hypovolemic shock, remains the predominant risk factor for lactic acidosis. In these states, impaired tissue perfusion leads to anaerobic metabolism and accelerated lactate generation. When severe lactic acidosis (defined by $\text{pH} < 7.2$) accompanies shock, mortality can approach 50%, and when the pH drops below 7.0, survival becomes exceedingly rare [5][6]. This is attributed to the detrimental effects of profound acidemia on myocardial contractility, vascular tone, and cellular enzymatic activity. Interestingly, outcomes differ in non-shock-related lactic acidosis, such as metformin-associated cases, where despite comparable pH reductions (~ 7.0), mortality rates are significantly lower (around 25%) due to preserved perfusion and absence of global hypoxia. Other risk factors include renal or hepatic failure, which impair lactate clearance, and conditions such as sepsis, respiratory failure, and multi-organ dysfunction, all of which amplify susceptibility to lactate accumulation. Ultimately, the risk of lactic acidosis—and its associated mortality—depends not only on the underlying etiology but also on the timeliness and effectiveness of interventions aimed at restoring perfusion, reversing shock, and supporting metabolic recovery. Therefore, early recognition, aggressive hemodynamic resuscitation, and close monitoring of lactate dynamics remain essential nursing and clinical priorities in mitigating the risks associated with this critical condition [4][6].

Assessment

The assessment of lactic acidosis demands a systematic and comprehensive approach, as the condition may present either acutely or as a progressive metabolic deterioration over several days. Early identification of precipitating factors is essential

for targeted intervention. The first step in evaluation involves obtaining a thorough medical and clinical history, focusing on potential causes of shock or hypoperfusion, which are the primary drivers of lactate accumulation. History-taking should include recent illnesses, fluid losses, cardiovascular events, and any history of sepsis, diabetes, renal disease, or hepatic dysfunction [7]. Additionally, a detailed review of medication use and toxin exposure—including agents such as metformin, ethanol, cyanide, or antiretroviral drugs—is vital, as these may precipitate lactic acidosis by interfering with mitochondrial oxidative phosphorylation or hepatic lactate metabolism. When the patient is unable to provide this information due to altered mental status, consulting family members or caregivers becomes indispensable in identifying potential etiologies [8]. Clinically, lactic acidosis lacks pathognomonic features, and its presentation is largely determined by the underlying etiology. Patients are often critically ill, with manifestations of systemic hypoperfusion or multiorgan dysfunction. Common accompanying conditions include septic shock, hypovolemic shock, or cardiogenic shock, all of which impair oxygen delivery and exacerbate anaerobic metabolism [9]. On physical examination, several cardinal signs suggest inadequate tissue perfusion: severe hypotension, tachycardia, altered mental status, oliguria or anuria, and tachypnea. The latter reflects a compensatory response to metabolic acidosis, as the body attempts to reduce carbon dioxide levels through hyperventilation. A characteristic respiratory pattern, known as Kussmaul respirations, may be observed, especially when acidosis is pronounced [10]. In cases where sepsis is the precipitating factor, additional findings may include fever exceeding 38.5°C, warm or cold extremities depending on the shock phase, and cutaneous mottling indicative of peripheral hypoperfusion. Laboratory evaluation remains central to assessment, with arterial blood gas analysis revealing low pH and bicarbonate depletion, while serum lactate measurement quantifies the metabolic burden. Complementary investigations should include renal and hepatic panels, blood cultures, electrolyte monitoring, and hemodynamic measurements to evaluate organ function and guide therapy [7][8][10]. Ultimately, a nurse's role in assessment extends beyond physical observation to include continuous monitoring of vital signs, fluid status, and mental state, ensuring early detection of clinical deterioration. Prompt recognition of lactic acidosis—coupled with identification of its underlying cause—allows for immediate intervention, prevents progression to multiorgan failure, and improves survival outcomes in critically ill patients [9][10].

Evaluation

The evaluation of lactic acidosis requires an integrated diagnostic approach that combines clinical assessment, laboratory investigations, and interpretation of acid–base balance parameters. In any

patient presenting with signs suggestive of metabolic acidosis, such as tachypnea, confusion, or hemodynamic instability, immediate laboratory testing should include serum electrolytes and arterial blood gas (ABG) analysis to assess the degree of acidemia and the underlying metabolic disturbance [7]. The ABG typically demonstrates a low pH, reduced bicarbonate (HCO_3^-), and a compensatory decline in partial pressure of carbon dioxide (PaCO_2) due to hyperventilation. Once metabolic acidosis is confirmed, further evaluation hinges on calculating the anion gap (AG), which serves as a crucial diagnostic tool in identifying the etiology of acidosis.

The anion gap represents the difference between measured cations and measured anions and is calculated as:

$$\text{AG} = \text{Sodium} - (\text{Chloride} + \text{Bicarbonate}).$$

Under normal physiological conditions, the anion gap ranges from 4 to 12 mEq/L, reflecting the presence of naturally occurring unmeasured anions such as phosphate, sulfate, and albumin [8]. When unmeasured anions—notably lactate—accumulate in the plasma, the anion gap widens, indicating a high anion gap metabolic acidosis (HAGMA). Therefore, in any case where the anion gap exceeds 12 mEq/L, serum lactate should be measured to confirm or exclude lactic acidosis. Elevated plasma lactate almost invariably contributes to a high anion gap, serving as a biochemical hallmark of the condition [9]. However, interpretation of the anion gap must be contextualized, especially in critically ill patients, where hypoalbuminemia can confound diagnostic accuracy. Since albumin constitutes the largest pool of unmeasured anions, its reduction—common in sepsis, liver failure, or malnutrition—can mask a true elevation in the anion gap. For this reason, clinicians often apply a correction formula: for every 1 g/dL decrease in serum albumin below the normal value of 4 g/dL, the anion gap should be increased by approximately 2.5 mEq/L to adjust for this effect [10]. Failure to correct for hypoalbuminemia may lead to underdiagnosis of lactic acidosis or misinterpretation of mixed acid–base disorders. Furthermore, not all lactic acid elevations manifest with an elevated anion gap. Mild-to-moderate hyperlactatemia or concurrent non-anion gap acidosis—as seen with renal tubular acidosis or diarrhea—may produce a normal anion gap despite metabolic derangements [7][9]. Therefore, measurement of serum lactate concentration remains indispensable, even when the anion gap appears normal. In summary, evaluation of lactic acidosis requires careful synthesis of ABG results, electrolyte analysis, and serum lactate measurement, accompanied by interpretation of the anion gap within the clinical context. This diagnostic vigilance ensures accurate identification of metabolic acidosis, facilitates prompt treatment, and improves outcomes in critically ill patients [8][10].

Medical Management

Effective medical management of lactic acidosis begins with rapid identification and treatment of the precipitating cause, because lactate accumulation is a consequence rather than a primary disease. Thus, mesenteric ischemia demands urgent surgical consultation, persistent convulsions require immediate seizure control, hypoxemia mandates airway/ventilatory optimization, and drug- or toxin-mediated mitochondrial inhibition (e.g., metformin, cyanide, ethanol) calls for antidotes or extracorporeal removal as indicated [7][8]. While this etiologic focus is universal, supportive care must be individualized and initiated in parallel: secure the airway when needed, deliver supplemental oxygen, obtain reliable vascular access, monitor serial lactate, and correct hemodynamic instability while minimizing iatrogenic harm [9]. Given its frequency and lethality, type-A lactic acidosis from septic shock is a central framework for management. Septic shock is operationally defined by sepsis with tissue hypoperfusion, vasopressor-requiring hypotension, and elevated lactate despite adequate fluid resuscitation, and it is a leading cause of profound hyperlactatemia in the ICU [7][10]. The early care bundle rests on three pillars: rapid infection management, prompt hemodynamic resuscitation, and continuous reassessment guided by lactate trends and perfusion endpoints. Infection control should begin immediately after obtaining blood cultures (and other appropriate cultures), followed by broad-spectrum antibiotics within the first hour of recognition, with timely de-escalation once pathogen data mature [7][8]. Anatomic source control—drainage of abscesses, removal of infected devices, biliary decompression, or debridement of necrotic tissue—should proceed as soon as it is logistically feasible and clinically safe, because persistent infectious sources perpetuate lactate generation and shock physiology [9][10]. Early coordination between nursing, critical care, surgery, and interventional services reduces time to source control and improves the likelihood of lactate clearance [8].

Initial intravascular volume repletion uses crystalloids, with a typical starting bolus of 30 mL/kg administered rapidly, followed by frequent reassessment to avoid fluid overload and its cardiopulmonary consequences [7]. Beyond the first bolus, further fluids should be titrated to dynamic indices of fluid responsiveness—for example, passive leg raise with stroke-volume surrogates, or small test boluses assessed against changes in pulse pressure or capillary refill—rather than static pressures alone [9]. Balanced crystalloids may be preferred once large volumes are anticipated to mitigate chloride load. The usual MAP target is ≥ 65 mmHg; this level balances global perfusion against vasopressor-related adverse effects, though higher thresholds can be considered in chronic hypertensives and lower thresholds in select patients to limit vasopressor exposure [7][10]. If

hypotension persists after adequate fluids, initiate vasopressors. Norepinephrine is first-line due to its potent α -adrenergic effect and favorable signal on survival and arrhythmia risk [7]. If the MAP goal is unmet, add vasopressin at a fixed 0.03 units/min (“shock dose”) to restore vascular tone and reduce norepinephrine requirements; refractory cases may benefit from epinephrine as an adjunct to raise MAP and cardiac output when myocardial depression coexists [8][9]. Phenylephrine is generally reserved as a salvage agent when tachyarrhythmias limit other catecholamines or when specific vasodilatory phenotypes persist; ongoing bedside nursing assessment of rhythm, extremity perfusion, and urine output is essential to titration [10]. In patients with persistent shock despite adequate vasopressors and fluids, stress-dose corticosteroids can be considered to hasten shock reversal; close glucose and infection surveillance are necessary once steroids are started [7][8]. Ventilatory management is guided by concomitant respiratory failure and, when present, sepsis-induced ARDS. Use low tidal volume ventilation with targets ≤ 6 mL/kg predicted body weight and plateau pressure <30 cm H₂O, apply appropriate PEEP, and employ prone positioning when severe hypoxemia persists (e.g., PaO₂/FiO₂ ≤ 150) [9][10]. Avoid severe alkalemia from excessive hyperventilation; although respiratory compensation helps buffer metabolic acidosis, overcorrection can impair oxygen delivery. Oxygenation should prevent hypoxemia without causing hyperoxia-related oxidative stress; titrate the FiO₂ to the lowest level achieving adequate saturation [7].

Because lactate is both a risk marker and a therapeutic target, trend serial lactate (e.g., every 2–6 hours early) to evaluate resuscitation effectiveness. Rising or stagnant lactate should trigger stepwise reevaluation: confirm source control adequacy, reassess volume status dynamically, audit vasopressor dosing and MAP target, optimize hemoglobin and oxygen delivery, and search for overlooked drivers such as occult ischemia or drug effects [8][10]. Bedside perfusion metrics—capillary refill, skin temperature, mental status, and urine output—must be integrated with biochemical data to avoid chasing numbers detached from physiology [9]. Adjunctive therapies require nuanced application. Thiamine supplementation (e.g., 200 mg IV every 12 hours) is reasonable in malnourished or alcohol-use patients to facilitate pyruvate dehydrogenase activity and support aerobic metabolism [7]. Sodium bicarbonate is not routinely indicated in lactic acidosis because it can worsen intracellular acidosis and CO₂ load; however, it may be considered when pH ≤ 7.1 with refractory hemodynamic instability or life-threatening hyperkalemia while definitive measures proceed [8]. Renal replacement therapy (RRT) is warranted for standard indications (severe AKI, volume overload, hyperkalemia, uremia) and can aid lactate and acid

removal when clearance is profoundly impaired; in metformin-associated lactic acidosis, hemodialysis is particularly effective because metformin is dialyzable and its removal can markedly accelerate recovery [9][10].

Glycemic control (target 140–180 mg/dL), early enteral nutrition as tolerated, venous thromboembolism prophylaxis, and stress ulcer prevention form the scaffold of supportive ICU care. Meticulous nursing surveillance—timely antibiotic administration, strict intake/output accounting, daily weight and edema monitoring, vigilant line/catheter care, prevention of pressure injuries, and continuous assessment for delirium or agitation—directly influences perfusion, infection control, and readiness to wean vasopressors [7][8]. Importantly, care plans should be revisited at least hourly early in shock, because lactic acidosis can evolve rapidly; small course corrections (adjusting fluids, vasopressors, ventilator settings, or analgesia/sedation) often determine whether lactate clears or spirals higher [9]. In summary, medical management of lactic acidosis is cause-directed, time-critical, and iterative. For septic shock—the prototypical driver of type-A hyperlactatemia—swift antibiotics and source control, goal-directed fluids, judicious vasopressors (norepinephrine first-line, vasopressin as adjunct, epinephrine or phenylephrine selectively), lung-protective ventilation for ARDS, and vigilant reassessment anchored by lactate trends constitute best practice. Thoughtful use of thiamine, selective bicarbonate, and RRT completes a comprehensive strategy aimed at restoring aerobic metabolism, clearing lactate, and improving survival [7][8][9][10].

Nursing Management

Nursing management of lactic acidosis centers on rapid stabilization, meticulous monitoring, and targeted actions that address both the metabolic derangement and its precipitating cause. If lactic acidosis is suspected to be drug induced, the offending agent should be discontinued immediately while communicating the change to the interprofessional team and reconciling medications to prevent unintentional re-exposure. Two large-bore peripheral IV lines should be established without delay to facilitate prompt fluid resuscitation, blood sampling, and potential vasoactive infusions. Supplemental oxygen is indicated when the saturation falls below 94%, with escalation to advanced airway support as needed to maintain adequate oxygen delivery. Continuous cardiac monitoring is essential to detect dysrhythmias or ischemic changes that may worsen perfusion, while strict intake and output documentation guides ongoing fluid strategy and helps identify early signs of renal hypoperfusion or fluid overload. Frequent laboratory reassessment is a cornerstone of care: serial lactate levels should be trended to confirm that values are declining with resuscitation, and basic metabolic panels should be reviewed for evolving acid–base or electrolyte

disturbances that influence myocardial function and perfusion. A chest radiograph should be reviewed to evaluate for cardiomegaly, pulmonary congestion, or interstitial edema consistent with heart failure, findings that would necessitate careful titration of fluids and possible diuretic or vasodilator therapy as directed by the treating clinician. In patients with diabetes mellitus, bedside glucose monitoring and correction with sliding-scale regular insulin help mitigate hyperglycemia-driven osmotic diuresis and metabolic stress; hypoglycemia should be vigilantly avoided. Peripheral pulses must be checked regularly to assess macrovascular perfusion, capillary refill, and skin temperature, with any asymmetry or deterioration prompting immediate escalation. The abdomen should be palpated and examined serially for tenderness, guarding, distention, or pain out of proportion to examination—features concerning for mesenteric ischemia that warrant urgent provider notification and expedited imaging or surgical consultation. Throughout care, nurses should anticipate complications, prevent line and pressure injuries, ensure early communication of trends that deviate from expected recovery (such as stagnant or rising lactate), and coordinate timely interventions across disciplines. Precise documentation, patient and family education, and readiness to adapt the plan in response to dynamic hemodynamics and laboratory data are integral to restoring perfusion, promoting lactate clearance, and improving outcomes [9][10].

Monitoring

Monitoring in lactic acidosis must be proactive, continuous, and explicitly tied to the suspected etiology to prevent progression to organ failure. The first objective is to determine the primary cause through a focused history, medication reconciliation, and targeted diagnostics, because timely reversal of the precipitating insult is the single most effective means of clearing lactate. Pharmacists play a key role in reviewing current and recently discontinued medications to ensure that no agents known to precipitate lactic acidosis are being administered—examples include biguanides, linezolid, nucleoside analogs, and toxic alcohols. Once drug-induced causes are excluded or addressed, clinicians should recognize that most remaining cases reflect inadequate perfusion; therefore, early resuscitation with crystalloids, vasoactive support as needed, and oxygen therapy are essential. Patients with respiratory fatigue or refractory hypoxemia may require noninvasive or invasive mechanical ventilation to optimize oxygen delivery and reduce the work of breathing, thereby limiting further lactate generation from respiratory muscles. Nursing surveillance is the axis on which effective monitoring turns. This includes strict intake and output charting to evaluate renal perfusion, frequent vital signs with an emphasis on mean arterial pressure and respiratory rate, and serial bedside assessments of mental status, skin temperature, capillary refill, and peripheral pulses.

Laboratory monitoring should be scheduled and consistent: repeat lactate measurements to establish the rate of clearance, arterial or venous blood gases to track acid–base trends, and metabolic panels to follow bicarbonate, potassium, and creatinine. Any plateau or rise in lactate should prompt an immediate “resuscitation huddle” to re-evaluate intravascular volume, vasopressor dosing, oxygenation, hemoglobin level, and adequacy of source control. Diagnostic adjuncts refine monitoring further. Bedside ultrasound can rapidly assess fluid responsiveness, ventricular function, and signs of pulmonary edema that might alter fluid strategy; chest radiography can reveal interstitial congestion or cardiomegaly suggesting decompensated heart failure; and serial abdominal examinations can identify evolving peritonitis or pain out of proportion to findings that warrant urgent imaging for mesenteric ischemia. For patients with diabetes taking metformin, pharmacists should deliver targeted education on warning symptoms—progressive malaise, dyspnea, and somnolence—and coordinate alternative glycemic therapies when renal function declines. Across all phases, documentation must be precise, handoffs structured, and contingency plans clear, as almost every organ system can be affected and clinical status can change within minutes [9][10].

Coordination of Care

Optimal outcomes in lactic acidosis depend on deliberate coordination among disciplines from the moment of recognition through stabilization and recovery. Because the differential diagnosis spans shock syndromes, sepsis, cardiopulmonary failure, mesenteric ischemia, toxic ingestions, and endocrine and renal disorders, the care team should include an intensivist for hemodynamic strategy, an internist or hospitalist for diagnostic synthesis, an endocrinologist for glycemic and mitochondrial considerations, a nephrologist for renal replacement decisions, a surgeon for suspected ischemic or infectious sources requiring procedural intervention, ICU nurses for continuous monitoring and bundle adherence, and a clinical pharmacist for medication causality analysis and therapeutic optimization. A structured early case conference—or at minimum, a brief interprofessional huddle—aligns priorities: rapid cultures and antibiotics when infection is suspected, fluid and vasopressor targets, oxygenation and ventilation plans, imaging and laboratory sequencing, and criteria for escalating to the operating room or initiating dialysis. Communication loops are the backbone of coordination. Nurses should escalate predefined triggers such as failure of lactate to decrease by expected intervals, sustained hypotension despite stepwise vasopressor titration, new arrhythmias, declining urine output, or worsening mental status. Pharmacists provide real-time input on antibiotic dosing in the context of changing renal function, drug–drug interactions with vasoactive agents, and the

safety of bicarbonate therapy or thiamine supplementation. Respiratory therapists collaborate on ventilator setting adjustments, especially in patients with evolving acute respiratory distress syndrome, where lung-protective strategies must be balanced against the need for adequate minute ventilation to compensate for metabolic acidosis. Surgeons and interventionalists must be engaged early when source control is likely to determine survival, as delays translate into persistent lactate generation and organ dysfunction. Disposition decisions—ICU versus step-down—should be revisited frequently because patients may improve rapidly with effective resuscitation or deteriorate quickly if the underlying driver is not controlled. Finally, family communication is integral: setting expectations, clarifying goals of care in refractory shock, and aligning treatment intensity with patient values ensures ethically sound, patient-centered care while the team continues aggressive, time-sensitive management [10][11][12].

Risk Management

Risk management in lactic acidosis focuses on preventing avoidable deterioration while building systems that surface etiologies and treatment gaps early. At the unit level, standardized sepsis and shock pathways reduce variability, ensuring prompt measurement of lactate, timely antibiotics when infection is suspected, and early reassessment of hemodynamics and fluid responsiveness. Checklists embedded in electronic order sets can cue clinicians to stop potential offending medications, obtain cultures before antibiotic administration, schedule repeat lactate measurements, and order renal and hepatic panels at defined intervals. Nursing-driven protocols empower bedside staff to initiate oxygen therapy, obtain immediate labs for new mental status changes, and escalate care when predefined thresholds are crossed, such as a sustained mean arterial pressure below target or a failure of lactate to decline within a set time window. From a medication safety perspective, pharmacists should lead periodic reviews of high-risk agents associated with lactic acidosis, maintain automated alerts for metformin in the context of declining eGFR or iodinated contrast exposure, and recommend dose adjustments of antimicrobials and vasoactive agents as organ function evolves. Education initiatives aimed at clinicians and patients alike mitigate risk: diabetes education programs can teach those on metformin to recognize early symptoms and understand when to hold the medication during intercurrent illness or dehydration; critical care education can emphasize dynamic fluid assessment tools to avoid both under-resuscitation and fluid overload. Diagnostic risk is addressed through pathways for suspected mesenteric ischemia, including rapid access to CT angiography and surgical consults, and protocols for toxicology screening when history suggests ingestion. Finally, system-level debriefs after severe lactic acidosis cases—especially

those with adverse outcomes—should analyze timelines for antibiotics, source control, vasopressor escalation, ventilatory support, and renal replacement therapy, with concrete action items and feedback loops. In aggregate, these interprofessional strategies reduce the likelihood of missed diagnoses, delayed interventions, medication-induced exacerbations, and communication failures that can worsen morbidity and mortality [12].

Discharge Planning

Discharge planning for patients recovering from lactic acidosis begins as soon as clinical stabilization is achieved and should be individualized to the underlying etiology. The transition from ICU to ward, and ultimately home or rehabilitation, requires clear criteria: hemodynamic stability without escalating vasoactive support, normalization or consistent downward trend of lactate, resolution or control of the precipitating cause, and an oxygenation and ventilation plan that is sustainable outside the ICU. A comprehensive medication review is essential to reconcile changes made during critical illness, discontinue agents implicated in lactic acidosis, and reintroduce chronic therapies safely. For patients with diabetes, metformin use requires special attention; renal function and recent episodes of hypoxia or sepsis should guide decisions about resumption, dose changes, or substitution with alternative agents, with explicit instructions on “sick day” rules to pause therapy during dehydration or acute illness. Education is the centerpiece of discharge. Patients and caregivers should understand warning signs of recurrent hypoperfusion or infection—worsening shortness of breath, chest or abdominal pain, confusion, decreased urine output, fever, and profound fatigue—and have a clear plan for immediate medical contact if these occur. Follow-up appointments must be scheduled prior to discharge: primary care for coordination; specialty clinics such as cardiology for heart failure optimization, nephrology for renal recovery and dialysis access care if applicable, endocrinology for glucose management, surgery or interventional services for post-source control evaluation, and infectious diseases if prolonged antibiotics are required. Laboratory surveillance plans should be explicit, detailing when to recheck lactate, renal and hepatic function, and glucose. Nutrition and physical therapy consultations can address deconditioning, guide protein and caloric goals to support recovery, and structure a safe mobilization program that respects residual cardiopulmonary limitations. Finally, a written care plan—plain language, culturally sensitive, and aligned with patient preferences—should summarize the hospitalization, the cause of lactic acidosis, medications to continue, discontinue, or monitor, equipment needs such as home oxygen if indicated, and emergency contact pathways. Thorough discharge planning reduces readmissions, prevents medication-related harm, and supports durable recovery after a high-risk metabolic crisis [12].

Other Issues

Lactic acidosis is not a singular disease but a biochemical signal reflecting mismatches between oxygen delivery and demand, mitochondrial function, and clearance capacity; effective care starts by asking “why is lactate high in this patient now?” rather than treating lactate in isolation. Serial lactate serves best as a trajectory marker; the direction and speed of change often matter more than any single value. Integrating biochemical data with bedside perfusion signs—capillary refill, skin temperature, mental status, and urine output—prevents overreliance on numbers that can lag physiology. When fluids are required, dynamic assessments outperform static pressures in predicting benefit and reduce iatrogenic fluid overload that can frustrate attempts to wean from oxygen or vasopressors. Source control is time-sensitive; unresolved infection continuously drives lactate production, so early procedural consultation is a life-saving intervention, not an afterthought. Medications matter: always search for iatrogenic contributors and apply “sick day” rules to drugs like metformin during intercurrent illness or dehydration. Be cautious with bicarbonate; reserve it for severe acidemia with specific indications while definitive therapy proceeds. Thiamine is low-risk and may meaningfully help selected patients. Above all, clinicians should maintain humility and curiosity—reassess frequently, invite second looks from colleagues, and be willing to pivot when the patient’s course diverges from expectations. In summary, lactic acidosis is common, clinically heterogeneous, and consequential; mastery lies in disciplined etiologic thinking, timely coordinated action, and relentless bedside reassessment to restore aerobic metabolism and improve survival [11][12].

Conclusion:

In summary, lactic acidosis is a common and perilous metabolic derangement that serves as a critical marker of illness severity and poor prognosis. Its successful management is entirely dependent on a rapid, systematic, and interdisciplinary approach. The cornerstone of treatment is the prompt identification and reversal of the underlying cause, whether it is septic shock requiring source control and antibiotics, correction of hypovolemia, or discontinuation of an offending drug. Medical management focuses on restoring adequate tissue perfusion through goal-directed fluid resuscitation and vasopressor support, while continuously monitoring the response through serial lactate measurements and clinical signs of perfusion. Ultimately, nurses are central to achieving positive outcomes. Their role extends from initial suspicion and assessment to the meticulous execution of complex care plans, including hemodynamic monitoring, medication titration, and vigilant surveillance for complications. Effective coordination among intensivists, pharmacists, respiratory therapists, and surgeons, facilitated by clear nursing communication, is essential. By integrating

biochemical data with bedside clinical judgment and maintaining a relentless focus on the etiology, the healthcare team can break the cycle of cellular energy failure, promote lactate clearance, and significantly improve the chances of patient survival.

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