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Closing the Loop: Multi-Disciplinary Strategies for Reducing Diagnostic Error in Acute Care

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Abstract

Background: Metabolic crises, specifically diabetic ketoacidosis (DKA), hyperosmolar hyperglycemic state (HHS), and refeeding syndrome (RFS), represent critical, often interlinked emergencies encountered from the prehospital setting through intensive care. Their management demands a coordinated, multi-professional approach to correct acute life-threatening disturbances while safely instituting metabolic support. **Aim:** This narrative review synthesizes current evidence on the integrated management of hyperglycemic emergencies and RFS prevention, analyzing the distinct but interdependent roles of emergency medical services (EMS), nursing, pharmacy, and clinical nutrition across the care continuum. **Methods:** A comprehensive literature search was conducted using PubMed, Scopus, and CINAHL databases (2010-2024). Relevant studies, guidelines, and protocols were reviewed to construct a narrative synthesis of best practices and evolving concepts. **Results:** Effective management hinges on prehospital recognition with point-of-care testing, protocol-driven fluid/insulin therapy, vigilant ICU monitoring for electrolyte shifts, and a meticulously calculated, gradual nutritional strategy to avert RFS. System-wide standardization and interprofessional communication are critical success factors. **Conclusion:** Transitioning a patient from street stabilization to ICU recovery requires seamless integration of discrete professional protocols into a unified care pathway to mitigate mortality and morbidity from metabolic crises.

Keywords: Diabetic Ketoacidosis; Hyperosmolar Hyperglycemic State; Refeeding Syndrome; Prehospital Emergency Care; Critical Care Nutrition.

Introduction

Metabolic decompensation represents one of the most acute and physiologically disruptive crises in emergency and critical care medicine. Diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS) are the quintessential hyperglycemic emergencies, characterized by profound insulin deficiency, hyperglycemia, and, in DKA, ketonemia and metabolic acidosis (Aldhaeefi et al., 2022). Concurrently, the initiation of nutritional support in the chronically malnourished or severely catabolic patient—a common scenario post-stabilization of such crises—introduces the peril of refeeding syndrome (RFS), a potentially lethal shift in fluids and electrolytes, particularly phosphate, potassium, and

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magnesium, driven by the reintroduction of carbohydrates (Huang et al., 2015).

The journey of a patient experiencing or at risk for these intertwined metabolic disasters begins at the street level, extends through the emergency department (ED), and culminates in the intensive care unit (ICU). This continuum demands a sophisticated, interprofessional response where the discrete expertise of emergency medical services (EMS), emergency and critical care nursing, pharmacy, and clinical nutrition must coalesce into a seamless therapeutic strategy (Hurtado et al., 2021). Figure 1 illustrates the integrated continuum of care for patients experiencing metabolic crises, tracing clinical management from prehospital emergency medical services through the emergency department, intensive care unit, and finally structured ICU nutritional support.

Figure 1. Continuum of Care in Metabolic Crisis: From Prehospital Assessment to ICU Nutrition

This narrative review synthesizes contemporary evidence (2010-2024) to analyze the integrated management of hyperglycemic emergencies and the prevention of RFS, mapping the critical interventions from prehospital stabilization to the calculated delivery of ICU nutrition, thereby highlighting the essential protocols and collaborative frameworks necessary to optimize patient outcomes.

Prehospital Recognition and Stabilization

The management of metabolic crisis is irrevocably time-sensitive. EMS personnel are the first medical responders to encounter patients in DKA, HHS, or in a state of malnutrition predisposing to RFS (Alter, 2021). Their initial assessment, point-of-care (POC) testing, and interventions set the trajectory for in-hospital care. Recognition begins with a high index of suspicion based on history and presentation: polyuria, polydipsia, altered mental status (more common in HHS), and Kussmaul respirations in DKA. However, atypical presentations are frequent, underscoring the critical importance of POC blood glucose (BG) measurement, a universal standard in EMS protocols (Benabbas et al., 2017). Severe hyperglycemia (often >350 mg/dL in DKA and >600 mg/dL in HHS) is the initial red flag. The evolving role of POC beta-hydroxybutyrate (β-OHB) testing in the prehospital environment represents a significant advancement. While not yet ubiquitous, evidence supports its utility in differentiating DKA from other causes of acidosis and hyperglycemia, and in expediting diagnosis upon ED arrival (Villani et al., 2017; Tremblay et al., 2021). Capillary or venous ketone meters provide results in seconds, allowing paramedics to identify ketosis early. EMS protocols are increasingly incorporating ketone testing for patients with hyperglycemia and altered mental status or nausea/vomiting (Care, 2023).

Prehospital treatment focuses on stabilization, not definitive management. The cornerstone is intravenous (IV) fluid resuscitation with normal saline (0.9% NaCl) to address hypovolemic shock and begin correcting hyperosmolarity. Aggressive fluid replacement is paramount in HHS, where fluid deficits are substantially larger (average 8-12 L) than in DKA (4-6 L) (Gosmanov et al., 2021). However, caution is required to avoid overly rapid correction, which may precipitate cerebral edema, particularly in younger patients. The administration of insulin is generally deferred to the in-hospital setting due to the risks of precipitous drops in potassium and glucose and the complexity of titration without continuous monitoring (Hess et al., 2022). EMS's critical role is establishing IV access, initiating volume resuscitation, and providing vital information to the receiving facility, including initial BG, ketone levels if available, and mental status trends. This data cascade directly informs the ED's readiness and initial treatment pathway, effectively bridging the gap between community and hospital care (Gerhardt et al., 2023).

Emergency Department and ICU: Nursing and Pharmacy-Driven Protocolization

Upon ED arrival, the management of DKA and HHS transitions into a highly protocol-driven phase, led by nursing and pharmacy teams executing evidence-based order sets. The immediate goals are to correct volume depletion, reverse hyperglycemia and ketosis (in DKA), correct electrolyte imbalances, and identify and treat precipitating causes (e.g., infection, non-adherence to medication). Standardized protocols significantly reduce time to insulin administration, ICU admission rates, and hospital length of stay (Bull et al., 2007; Wu et al., 2020). Understanding the distinct yet overlapping pathophysiology and management priorities for DKA and HHS is critical for appropriate therapy, as summarized in Table 1. Figure 2 contrasts the core pathophysiology, biochemical features, clinical presentation, and complications of diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS).

Table 1: Key Differences and Similarities in the Management of DKA and HHS

Parameter	Diabetic Ketoacidosis (DKA)	Hyperosmolar Hyperglycemic State (HHS)

Pathophysiology	Insulin deficiency, **ketosis**, metabolic acidosis.	Insulin insufficiency (relative), **severe dehydration & hyperosmolality**, minimal ketosis.
Typical Glucose	>250 mg/dL	>600 mg/dL
pH / Serum Bicarbonate	<7.3 / <18 mEq/L	>7.3 / >18 mEq/L
Serum Osmolality	Variable	**>320 mOsm/kg**
Fluid Deficit	Moderate (~4-6 L)	**Severe (~8-12 L)**
Initial Fluid of Choice	0.9% NaCl	0.9% NaCl (volume resuscitation is **paramount**)
Insulin Therapy	**Essential** for closing anion gap; bolus + infusion.	Required for hyperglycemia; often **less urgent** than fluids; may be sensitive.
Potassium Deficit	Severe	Severe
Mental Status	Alert to obtunded	**Stupor/Coma more common**
Mortality	<5% in centers	**~10-20%** (often due to comorbidities/age)

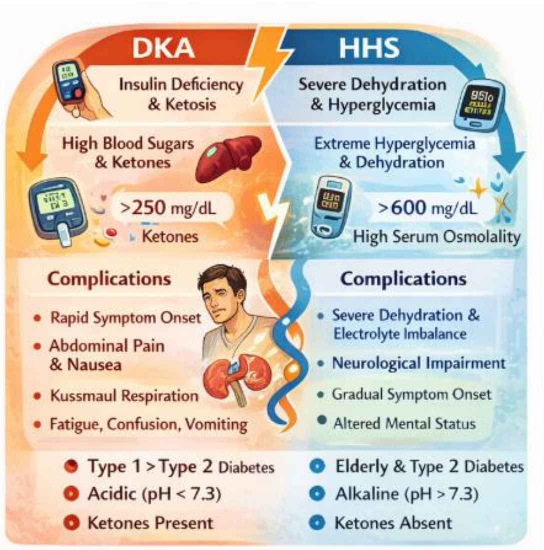

Figure 2. Metabolic Crises in Diabetes: Comparison of Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State

Fluid Resuscitation

The choice and rate of fluids remain nuanced. Isotonic saline (0.9% NaCl) is initiated. Recent guidelines suggest a more cautious approach than historical aggressive bolusing, with consideration for balanced crystalloids (e.g., Lactated Ringer's) to avoid hyperchloremic metabolic acidosis, which can prolong the time to acidosis resolution in DKA (Self et al., 2020; Ghosh, 2022). Once hemodynamic stability is achieved and serum sodium trends are monitored, fluid may be switched to 0.45% NaCl to replace free water deficits, especially in HHS.

Insulin Therapy

Continuous IV insulin infusion is the standard of care. A bolus dose (0.1 unit/kg) is often recommended, followed by a fixed-weight-based infusion (typically 0.1 unit/kg/hr). The primary goal is not normoglycemia, but the suppression of lipolysis and ketogenesis; therefore, the rate of BG decline should be steady (50-75 mg/dL/hr) to avoid cerebral edema (French et al., 2019). Pharmacy departments are instrumental in managing standardized drip concentrations, ensuring safe titration per protocol, and monitoring for medication errors. The use of subcutaneous rapid-acting insulin analogs for mild-to-moderate DKA in non-ICU settings is an emerging, protocol-dependent alternative (Galindo et al., 2022).

Electrolyte Management

Potassium replacement is universally required due to total body depletion exacerbated by insulin therapy and volume expansion. Protocols mandate frequent monitoring (every 2-4 hours initially) and replacement in IV fluids, often requiring concentrated potassium infusions under strict nursing and pharmacy supervision (Hassan et al., 2022). Phosphate and magnesium are also depleted, but routine replacement is not recommended unless levels are severely low or clinical symptoms (e.g., muscle weakness, cardiac arrhythmias) are present (Care, 2023). This careful, monitored depletion sets the stage for the later risk of RFS.

Monitoring and Transition

Nursing's role in vigilant, frequent monitoring of vital signs, neurologic status, BG (hourly), electrolytes, and anion gap is irreplaceable. Resolution of DKA is defined by a BG <200 mg/dL, serum bicarbonate ≥18 mEq/L, venous pH >7.3, and anion gap ≤12 (Kitabchi et al., 2009). Transition to subcutaneous insulin must overlap with the IV infusion for 1-2 hours to prevent rebound hyperglycemia. For HHS, the endpoint is resolution of hyperosmolarity and mental status improvement (Moazzami et al., 2023).

The Overlooked Threat: Refeeding Syndrome in the ICU

As the hyperglycemic crisis resolves, attention must pivot to the patient's nutritional status. Many patients presenting with DKA/HHS have antecedent malnutrition due to catabolic stress, poor intake, or substance use (Heuft et al., 2023). The sudden provision of carbohydrate calories—via enteral or parenteral nutrition—can trigger RFS, characterized by severe hypophosphatemia, hypokalemia, hypomagnesemia, fluid shifts, and thiamine deficiency, leading to respiratory failure, cardiac arrhythmias, and death (Bioletto et al., 2021). The pathophysiology involves a rapid shift from fat to carbohydrate metabolism, stimulating insulin release, which drives electrolytes into cells and increases cellular water uptake (Cioffi et al., 2021).

Risk assessment is the first and most crucial step. Validated tools like the National Institute for Health and Care Excellence (NICE) criteria identify high-risk patients based on factors such as BMI <16 kg/m^2, unintentional weight loss >15% in 3-6 months, little or no nutritional intake for >10 days, or low pre-feeding electrolyte levels (Marino et al., 2020). ICU patients post-DKA/HHS often meet multiple criteria.

Prevention and Management

Prevention is paramount and falls squarely within the domain of Clinical Nutrition, in close collaboration with the ICU team. The core principle is "start low and go slow." A structured approach based on risk stratification, as outlined in Table 2, is essential to mitigate this iatrogenic complication. Figure 3 depicts the metabolic cascade underlying refeeding syndrome following rapid carbohydrate reintroduction in malnourished or catabolic patients. Insulin-mediated intracellular shifts of phosphate, potassium, and magnesium lead to electrolyte depletion, fluid imbalance, and thiamine deficiency.

Table 2: Refeeding Syndrome (RFS) Risk Stratification and Prophylactic Management

Risk Category (NICE Criteria)	Prophylactic Management Protocol
HIGH RISK (≥1 of): BMI <16 kg/m^2; Unintentional weight loss >15% in 3-6 months; Little/no intake >10 days; Low K, Phos, Mg pre-feeding. OR 2+ MODERATE RISK factors.	**1. Nutrition:** Start at **10-20 kcal/kg/day** (max 50% requirements). Increase slowly over 3-7 days. **2. Electrolytes:** Replete low K, Phos, Mg **before** feeding. Monitor levels 12-hourly for first 72h, then daily. **3. Vitamins:** IV Thiamine 200-300 mg daily for 3-5 days, then oral. Multivitamin daily. **4. Fluid:** Monitor closely, avoid overload.
MODERATE RISK (≥1 of): BMI 16-18.5 kg/m^2; Unintentional weight loss 10-15% in 3-6 months; Little/no intake for 5-10 days. OR 2+ LOW RISK factors.	**1. Nutrition:** Start at **~50% requirements**. Increase to full over 3-4 days. **2. Electrolytes:** Check baseline & daily for first 3 days. Replete if low. **3. Vitamins:** Oral Thiamine 100-300 mg daily + multivitamin.
LOW RISK: BMI >18.5 kg/m^2; Weight loss <10% in 3-6 months; Recent intake.	Start at or near the estimated requirements. Monitor electrolytes baseline and at discretion. Provide a routine oral multivitamin.

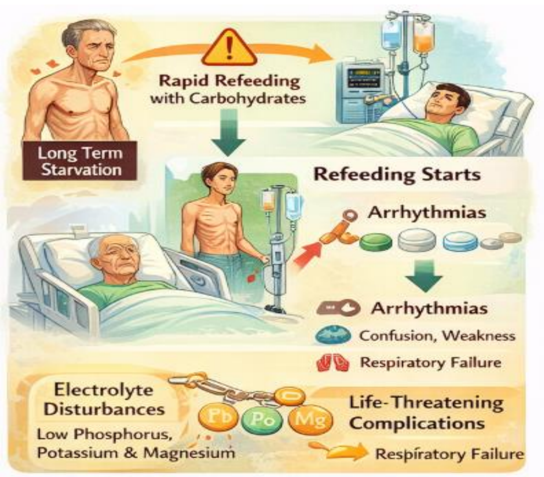

Figure 3. Pathophysiology and Clinical Consequences of Refeeding Syndrome in Critically Ill Patients

As the patient transitions from acute resuscitation to the recovery and reparative phase, the nutritional strategy must pivot to a paradigm of calculated caution to avert iatrogenic harm. The foundational principle is a meticulously low and gradual energy prescription, typically initiating at 10-20 kcal/kg/day (approximately 50% of calculated requirements), with incremental increases over 3-7 days contingent upon demonstrated tolerance and, most critically, stable electrolyte levels (da Silva et al., 2020). This careful caloric advancement is underpinned by aggressive and preemptive electrolyte management. Proactive repletion of phosphate, potassium, and magnesium is essential before feeding if levels are low or low-normal, followed by intensive monitoring (every 12-24 hours initially) and aggressive intravenous replacement during the first 72 hours of nutritional support to counteract the intracellular shifts driven by insulin release (Friedli et al., 2018).

Concomitantly, high-dose intravenous thiamine (200-300 mg daily) must be administered before and during the initial days of feeding in high-risk patients to prevent Wernicke's encephalopathy, a devastating neurological complication of refeeding (Maiorana et al., 2014). Furthermore, vigilant attention to fluid balance is required to avoid circulatory overload exacerbated by the antinatriuretic effect of insulin. This deliberate, restrained approach stands in stark contrast to the aggressive fluid and electrolyte replacement of the initial hyperglycemic crisis but is equally vital for survival, representing a critical shift from emergency correction to controlled metabolic reconstruction (Olsen et al., 2021).

Interprofessional Integration

The successful navigation from street to ICU requires more than individual expertise; it demands system-level integration. Interprofessional rounds, shared electronic medical record order sets, and clear communication handoffs are critical. EMS must relay POC data effectively (Edholm et al., 2020). ED and ICU nurses must be empowered to titrate insulin and electrolytes per protocol. Pharmacists must audit drips and educate on transitions. Dietitians must be consulted early for risk assessment and must drive the nutritional plan. Studies show that implementing such integrated care pathways reduces hypoglycemia events, hypokalemia, length of stay, and healthcare costs (Mendez et al., 2017; Kelepouris et al., 2023).

Conclusion

The management of metabolic crises exemplifies the continuum of critical care. From the EMS technician obtaining a POC ketone reading to the dietitian meticulously calculating day-one caloric needs, each professional executes a discrete yet interdependent protocol. Hyperglycemic emergencies demand rapid, aggressive intervention to correct shock, acidosis, and hyperosmolarity, while the subsequent phase demands exquisite restraint and calculation to prevent iatrogenic RFS. This narrative review underscores that optimal outcomes are achieved not in siloes but through the deliberate integration of prehospital alert systems, protocol-driven medical management, and a proactive, staged nutritional strategy. Future efforts should focus on expanding POC diagnostic capabilities in the field, refining standardized order sets to include RFS prevention bundles, and fostering a culture of shared mental models among all professions involved in this high-stakes metabolic journey.

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