

HYPERGLYCEMIA HYPEROSMOLAR SYNDROME CLINICAL PATHWAY

EXECUTIVE SUMMARY

Physician Owner(s): Andrew MacFadyen, MD



Primary Objective

Hyperglycemic Hyperosmolar Syndrome (HHS) is an acute diabetic emergency that is on a spectrum with diabetic ketoacidosis.^{5,6,7,9} It occurs primarily in older teens, often in the setting of Type 2 diabetes and can be missed, leading to increased end organ damage and prolonged hospital stay.^{1,2,7,10} Sometimes it can be the initial manifestation of Type 1 diabetes and can also occur along with DKA.^{3,4} The potential morbidities of HHS are different from DKA and are easy to overlook.^{5,7} The objective of this pathway is to recognize HHS and standardize its treatment.

Recommendations

Patients with HHS who are managed on the DKA pathway do not do as well.⁴ The main difference between DKA and HHS is the large degree of dehydration in HHS. Patients who present with HHS are at least 10-15% dehydrated and have on-going fluid losses.¹⁷ In HHS, the patient is given more fluid, initially, plus the urine losses are replaced. In addition, insulin is not started in HHS until the glucose plateaus, which can be 2-3 hours after treatment commences. The severe dehydration leads to a hyperosmolar state which increases the patient's risk for thrombotic complications as well as rhabdomyolysis.^{11,12,15,17}

- **HHS versus DKA¹⁷**
 - **Fluid management**
 - **Basic Principle:** Patients with HHS have high fluid needs with on-going fluid losses. Fluid boluses should be titrated to the degree of hypovolemic shock the patient is experiencing. While 20ml/kg of isotonic fluid is a good place to start, the patient may need more than that to begin with. Urine output will need to be carefully monitored and accounted for or hypovolemic shock can return.
 - Initial bolus is 20ml/kg of LR.
 - Maintenance is set at 2x calculated.
 - Urine output is measured and replaced every 30 minutes.
 - **Insulin**
 - **Basic Principle:** Ketosis is not the main problem in HHS and rehydration will often drop the glucose concentration. Dropping the glucose concentration rapidly can lead to hypovolemia and venous thrombosis if the patient is not adequately hydrated.
 - Do not immediately start insulin drip.
 - Expect glucose drop with rehydration. Once glucose stops dropping more than 50 mg/dL in an hour, start insulin at the normal 0.1units/kg/hr.
 - **Electrolytes**
 - **Basic Principle:** the massive fluid shifts in HHS and its treatment can make electrolyte management challenging.
 - Sodium is most important. Adjust fluids to achieve a gradual decline of 0.5mmol/L/hr.
 - Potassium losses can be significant and can cause cardiac dysrhythmias. May need higher than normal potassium replacement, especially after insulin is started.
 - Hypophosphatemia can increase risk of rhabdomyolysis.
 - BUN/creatinine can reflect acute kidney injury.
 - Follow electrolytes every 2 hours initially then every 4 hours.

CLINICAL



EFFECTIVENESS

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- Also follow serum osmolality and creatinine kinase every 4 hours
- **Anticoagulation**
 - **Basic Principle:** the dehydration and hyperosmolality of the blood create the right conditions for venous thrombosis in any location in the body. Also, dropping the serum osmolality too quickly increase the risk for venous thrombosis if the patient isn't well hydrated.
 - Start prophylactic enoxaparin along with mechanical anti-coagulation, especially if patient is over 12 years of age. Use therapeutic dosing if thrombus is confirmed.
- **Complications** ^{4,5,8,11,12,13,14,15,16}
 - Electrolytes
 - Sodium, potassium, calcium, and phosphate should all be closely managed.
 - Renal failure secondary to severe dehydration and/or rhabdomyolysis
 - Neurology
 - If altered mental status, consider continued dehydration vs cerebral thrombosis. Cerebral edema in HHS is rare.
 - Rhabdomyolysis
 - Suspect if myalgia, weakness, and dark urine. Monitor CK every 2-3 hours.
 - There is not a clear understanding of how rhabdomyolysis relates to HHS, however, it has been noted that there is a relation. Hypophosphatemia increases risk of rhabdomyolysis.
 - Venous thrombosis
 - Can occur anywhere. Have high index of suspicion. Place on prophylactic anti-coagulation.
 - Malignant hyperthermia
 - Consider dantrolene if conventional therapies don't work.
 - There is not a clear understanding of how malignant hyperthermia relates to HHS, however, it has been noted that there is a relation.
- **Monitoring Labs** ^{17, 18}
 - Glucose every hour
 - Rhabdomyolysis
 - CK every 2-4 hours
 - Creatinine every 2-4 hours
 - Electrolytes, serum osmolality every 2-4 hours

Rationale

This pathway will impact quality of care and workflow/efficiency. We expect to have improvements similar to those of the DKA pathway. There are two major barriers to the pathway: providers not recognizing HHS and very few instances of HHS so that people do not get familiar with the pathway. We will try to minimize the impact of both barriers with widespread education including case reviews with feedback. We anticipate approximately 1 case per year.

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Metrics

Process Metric

1. Increase the proportion of patients that have ALL of the following labs (CK, serum osm, urine Ketones) obtained during admission to 80% by June 2028.
2. Increase proportion of patients the HHS order set is used to 80% by June 2028. (once completed)

Outcome Metric

1. Increase the proportion of patients that have anticoagulation started during admission to 50% by June 2028.

Balancing Metric

1. Monitor number of patients who are transferred out of the PICU <12 hours from time of last fluid bolus).

Team Members

- Champion: Dr. Andrew MacFadyen
- Drew Sankey, PharmD (Pharmacy)
- Paige Hillman, PharmD (Pharmacy)
- Jason Burrows, MD (Pediatric Hospital Medicine)
- Monina Cabrera, MD (Endocrine)
- Chelsea Majerus, MD (Emergency Medicine)
- Krisi Kult, MSN, RN, CPEN, CPN (Emergency Medicine)
- Meghan Spencer, MSN, RN, CPEN, TCRN (Emergency Medicine)

Evidence

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