DIABETIC KETOACIDOSIS

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DIAGNOSIS

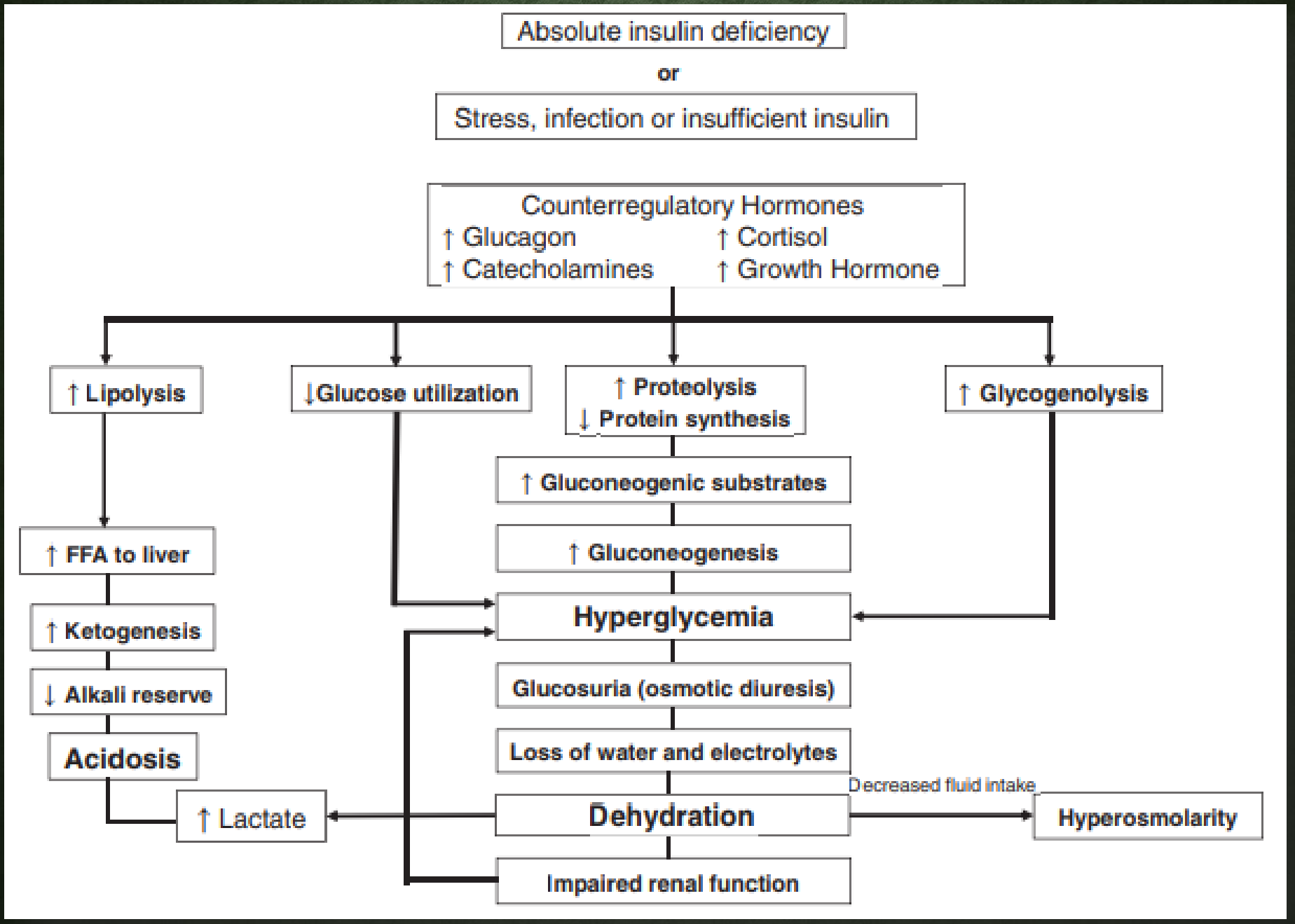
- Biochemical Criteria:
  - Blood sugar > 200mg/dL
  - pH < 7.3 or Serum bicarbonate < 15 mmol/L
  - Ketonemia (blood ß-hydroxybuyrate ≥3 mmol/L) or moderate or large ketonuria ≥2+

RISK FACTORS

- New cases
  - Younger age
  - Delayed diagnosis
  - Lower socioeconomic status
  - Low prevalence of T1DM in the country
- Known cases
  - Omitted insulin dose
  - Limited access to medical services
  - Unrecognized interruption of insulin delivery (insulin pump)
  - During illness, infection or stress
- Counter-regulatory hormones:
  - Glucagon
  - Growth hormone
  - Cortisol
  - Cathecholamines

PATHOPHYSIOLOGY

- Decreased insulin secretion → partial hepatic oxidation of fatty acids to ketone bodies
- Hyperglycemia → osmotic diuresis & polydypsea
- Worsening hyperglycemia & diuresis → dehydration
- Acidosis → vomiting → dehydration
- Tachypnea → increased insensible water loss → dehydration
- Electrolyte abnormalities


Absolute insulin deficiency
or
Stress, infection or insufficient insulin
Counterregulatory Hormones
↑ Glucagon
↑ Catecholamines
↑ Cortisol
↑ Growth Hormone
↑ Lipolysis
↓Glucose utilization
↑ Proteolysis
↓ Protein synthesis
↑ Glycogenolysis
↑ Gluconeogenic substrates
↑ FFA to liver
↑ Gluconeogenesis
↑ Ketogenesis
Hyperglycemia
↓ Alkali reserve
Glucosuria (osmotic diuresis)
Acidosis
Loss of water and electrolytes
Decreased fluid intake
↑ Lactate
Dehydration
Hyperosmolarity
Impaired renal function

PRESENTATION

- Polyurea (+ Dehydration)
- Polydypsea
- Tachycardia
- Tachypnea, deep sighing (Kussmaul) respiration
- Breath smells of acetone
- Nausea and/or vomiting
- Abdominal pain
- Blurry vision
- Confusion, drowsiness, progressive decrease in level of consciousness and, eventually, loss of consciousness (coma)

EMERGENCY ASSESSMENT

- Immediate measurement of blood glucose
- Blood or urine ketones
- Serum electrolytes
- Blood gas
- Assessment of severity of dehydration and LOC
- Second peripheral intravenous (IV) line

Unless absolutely necessary, **avoid** placing a central venous catheter (high risk of thrombosis, esp in very young child)

LABORATORY STUDIES

- Blood sugar > 200mg/dL
- pH < 7.3
- HCo3 < 15
- Na is depressed (due to hyperglycemia)
  - Na corrected = $\left\{ \dfrac{\text{blood sugar} - 100 \times 1.6}{100} + \text{Na pt} \right\}$
- BUN
- WBC, diff
- Finding etiology of Fever (B/C, U/C,…)
- ECG

CLASSIFICATION OF DKA

	MILD	MODERATE	SEVERE
Serum bicarbonate	10-15	5-10	<5
pH (venous)	7.2-7.3	7.1-7.2	<7.1
Clinical	Orient, alert but fatigued	Kussmaul respirations; orient but sleepy; arousable	Kussmaul or depressed respirations; sleepy to depressed sensorium to coma

EUGLYCEMIC KETOACIDOSIS

Patients with modestly elevated blood glucose < 250 mg/dL

- Partially treated
- Consumption of little/no carbohydrate, Low carb/high fat diet
- Starvation (anorexia or religious fasting)
- Pregnancy
- Pancreatitis
- Use of insulin pump
- Off-label use of SGLT2-inhibitors
- Cocaine intoxication
- Prolonged vomiting or diarrhea

INDICATIONS FOR INTENSIVE CARE UNIT ADMISSION

- Severe DKA
  - Long duration of symptoms
  - Compromised circulation
  - Depressed level of consciousness
- Increased risk for cerebral edema
  - <5 years of age
  - Severe acidosis
  - High BUN

FLOW CHART

Meticulous monitoring

Timely adjustments in treatment

- Vital signs (heart rate, respiratory rate, BP): Hourly
- Neurological observations (GCS): Hourly
- Fluid intake and output : Hourly
- Blood Glucose : Hourly
- Elect, BUN, ca, mg, ph, and blood gas : 2 to 4 hourly
- Body weight : each morning

TREATMENT

1. Dehydration
   - Severe → 10% dehydration
   - 10cc/kg Bolus normal saline IV if severe
   - 20cc/kg Bolus normal saline if in shock
   - Deficit + Maintenance fluid during 36-48 hrs
   - If Blood Sugar <300, Sugar can be added to the IV fluid
   - In obese patients, calculations based on **ideal body weight**
2. Hyperglycemia
   - Regular insulin IV infusion : 0.1 U/kg/hr
   - BS should decrease not faster than 100mg/dl/hr
   - If Blood Sugar falls < 300, decrease insulin infusion rate

EXAMPLE

7 y/o boy with DKA , BWt: 20 kg , severely dehydrated , BS: 400

- **NPO**
- IV Normal saline 200cc in 1 hour bolus

Fluid calculation:

- Deficit: 100cc/kg = 1000 cc
- Maintenance: 1500 cc
- [Deficit + 2* Maintenance] / 48 hrs = 4000/48 ~ 83 cc/hr

- IV normal saline 83 cc/hr (until BS>300)

- BS: 200-300 → change IV to ½ , ½ with D5W %
- BS: 100-200 → change IV to ½ , ½ with D7.5W %
- BS: 100-200 → change IV to ½ , ½ with D10W %

EXAMPLE

Regular Insulin with 0.1 unit/kg/hr

- 50 unit regular insulin in 50 cc normal saline start with :
- → 0.1 drop /kg/min = 0.1cc/kg/hr
- 2 drop/min (2 cc/hr)

1cc (1 unit) ~ 60 drop

1hr ~ 60 min

- BS > 300 → 0.1 drop /kg/min = 0.1cc/kg/hr
- BS: 200-300 → drops * 3/4 (1.5 drops/min)
- BS: 100-200 → drops * 1/2 (1 drop/min)

TREATMENT

3. Acidosis

- Insulin therapy:
  - Decreases the production of FFAs & prot catabolism
  - Increases tissue glucose usage
- Avoid bicarbonate therapy unless:
  - Severe acidosis (pH< 6.9) with evidence of compromised cardiac contractility
  - Life-threatening hyperkalemia
- Potential adverse effects of bicarb.:
  - Paradoxical CNS acidosis
  - Tissue hypoxia
  - Abrupt osmotic changes
  - Increased risk of cerebral edema

As acidosis is corrected, urnie ketone concentrations may appear to rise.

TREATMENT

4. Electrolyte Imbalance
   - Total body K depletion is likely.
   - When adequate urine output is shown & the ECG is normal, K should be added to the IV fluids (20-40 meq/L)

- If serum K is > 5.5 meq/L → No K in IV fluid
- K: 5 – 5.5 → 20 meq/L KCl
- K: 3.5 - 5 → 40 meq/L KCl
- K: 3 – 3.5 → 60 meq/L KCl with heart monitoring
- K < 3 → 80 meq/L KCl with heart monitoring

TREATMENT: FINAL STEP

- When acidosis has been corrected:
  - pH >7.3
  - HCO3 >15
  - No nausea or vomiting
  - Normal mental status

- Give 0.1 unit/kg regular insulin SQ stat
- Start PO feeding (after 30 min)
- Discontinue IV insulin infusion (after 1hr)
- Start maintenance insulin & check blood sugars accordingly

COMPLICATIONS

- Cerebral Edema
- Intracranial thrombosis or infarction
- Acute renal failure & acute tubular necrosis
- Pancreatitis
- Arrhythmias
- Pulmonary edema
- Bowel ischemia

WARNING SIGNS AND SYMPTOMS OF CEREBRAL EDEMA

- Onset of **headache** after treatment/progressively worsening/severe headache
- Slowing of heart rate not related to sleep or improved intravascular volume
- Change in neurological status / Specific neurological signs
  - Restlessness, Irritability, Increased drowsiness, Confusion, Incontinence, Cranial nerve palsies, Dilated pupils, Ophthalmoplegia, Seizures
- Rising blood pressure
- Vomiting
- Decreased oxygen saturation

CEREBRAL EDEMA

- Clinically apparent **cerebral edema** in 1-5%
- Most serious complication
- 20-80% mortality rate
- 6-12hrs after beginning therapy
- Often follows a period of clinical improvement
- Risk factors:
  - Higher initial BUN
  - Lower initial HCO3
  - Failure of increase in Na as BS decreases
  - Bicarbonate therapy
- Treatment:
  - IV mannitol, intubation, hyperventilation,….

PREVENTION OF DKA

- Management is not complete until an attempt has been made to identify and treat the cause.
- Known case of diabetes:
  - Preceding febrile illness / gastroenteritis
  - Psychosocial problems
  - Failure to appropriately administer insulin
- New onset diabetes:
  - Delay in diagnosis

CRITERIA FOR DIAGNOSIS OF HHS

Hyperglycemic Hyperosmolar State

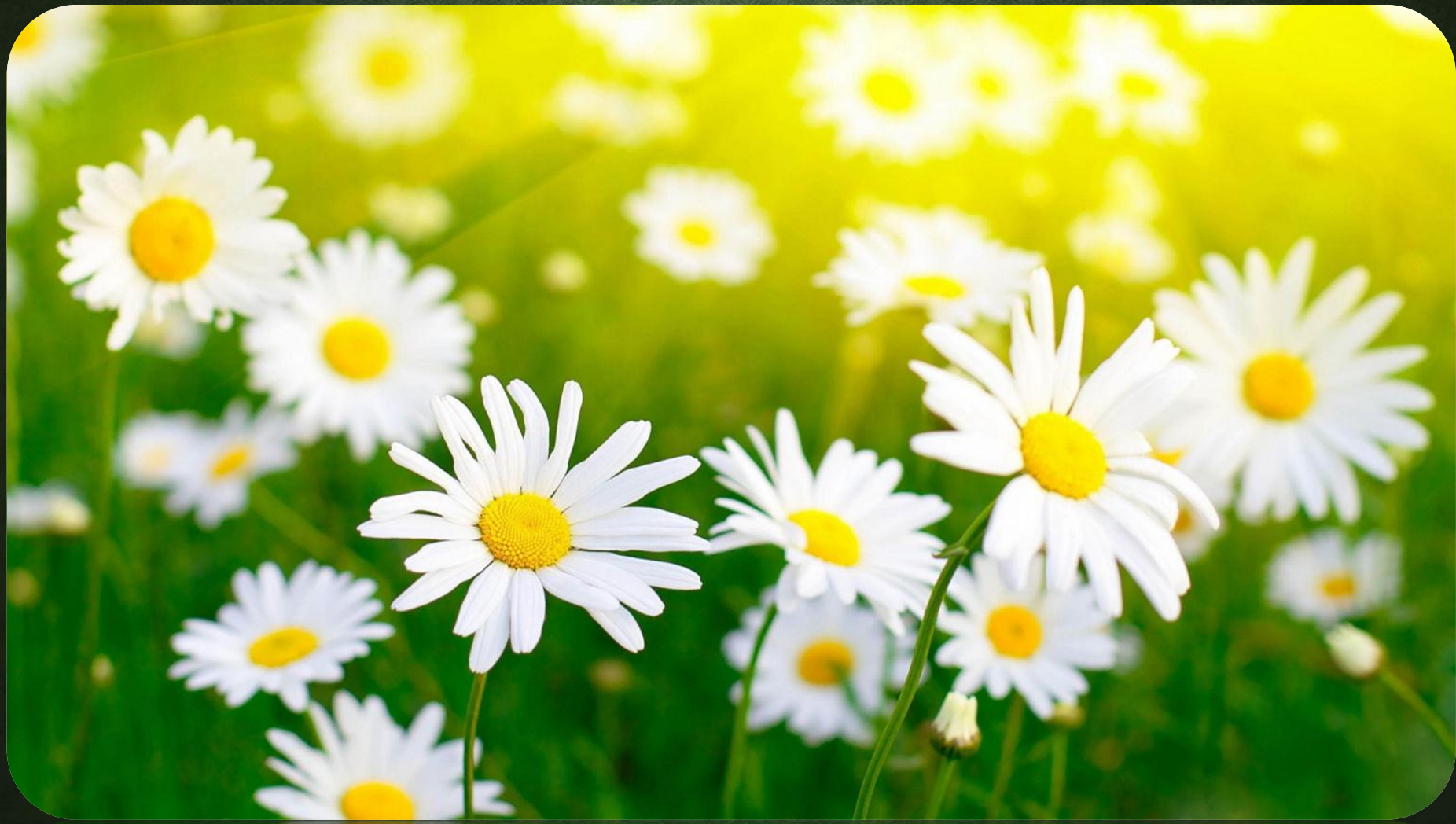
Formerly referred to as Hyperosmolar Non-Ketotic Coma

- Plasma glucose concentration > 600 mg/dL
- pH >7.30
- Serum bicarbonate >15 mmol/L
- Small ketonuria, absent to mild ketonemia
- Effective serum osmolality >320 mOsm/kg
- Altered consciousness (eg, obtundation, combativeness) or seizures (in approximately 50%)

Effective osmolality (mOsm/kg) = 2 × (plasma Na) + plasma glucose

TREATMENT OF HHS

- Initial bolus should be ≥20 mL/kg of isotonic saline
- Fluid deficit :12% to 15% of body weight over 24 to 48 hours
- Replacement of urinary losses is recommended
- Early insulin administration is unnecessary
- Insulin infusion : 0.025 to 0.05 units/kg/h
- Decrease in serum glucose concentration of 50-75 mg/dL/hour
- Bicarbonate therapy is contraindicated



INSULIN EFFECT