DIABETIC EMERGENCIES

DIABETIC KETOACIDOSIS (DKA)  
and  
HYPEROSMOLAR HYPERGLYCAEMIC STATE (HHS)

By  
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✓ To understand the brief pathophysiology and triggers of DKA
✓ To know the **diagnostic criteria** and step by step **management protocol** of DKA and HHS
✓ To be aware of the complications of DKA and HHS

**THINGS NOT COVERED:**
- Hypoglycemia
- Euglycemic DKA
- Mixed Picture: DKA and HHS
- Detailed Pathophysiology
- Controversial Issues
SURVEY
PRE-SESSION QUESTIONNAIRE
DIABETIC KETOACIDOSIS (DKA)

- It is an abnormal metabolic state and a life-threatening emergency - hyperglycaemia, ketonaemia, and acidosis
- Common in type 1, but about 1/3rd of cases in type 2.
- Epidemiology: UK Incidence: 8.0-51.3 cases/1000 patient years in T1 DM
- UK mortality rate: remains <1%, but still is the leading cause of death in people <58 years with T1DM)

**PRECIPITATING FACTORS:**
- Missed/wrong insulin dose, poor compliance, Failure of insulin pumps
- Intercurrent illness: Infection, MI, Pancreatitis
- Surgery, Trauma, Pregnancy
- Recreational drugs, Antipsychotics, Chemotherapy

**INSULIN**
- deficiency
- Relative or absolute
- Counter regulatory hormone excess
  - (Glucagon, cortisol, GH, catecholamines)

**Glycogenolysis** → Gluconeogenesis → Lipolysis → Ketoacids

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Glucose
SIGNS AND SYMPTOMS

- Feeling tired and sleepy
- Confusion, passing out
- Stomach pain, feeling or being sick
- Needing to pee more often, high ketones
- Blurred vision
- Being very thirsty, sweet smelling breath (like nail varnish or pear drop sweets)
- High blood sugar levels
DIAGNOSIS

all three of the following must be present:

D • blood glucose above **11** mmol/L or known diabetic *(Exception: Euglycemic DKA)*

K • blood ketones >/= **3** mmol/L or urine ketones >/= **2+**

A • venous **pH < 7.3** and/or bicarbonate < **15** mmol/L

**Differential Diagnosis:**
- HHS
- HHS/DKA mixed picture
  - Euglycemic DKA
- Alcoholic Ketoacidosis
- Starvational Ketoacidosis
MANAGEMENT

ABCDE Approach,
2 large bore iv cannulas

Tests: VBG for pH, bicarbonate;
bedside and lab glucose and ketones; U&ES, FBC, CRP;
CXR, ECG

Consider ITU referral if any of the following:
1. Young or elderly or pregnant
2. Heart or liver or kidney failure
3. Severe DKA judged by: blood ketones >6mmol/L or bicarbonate <5mmol/L or pH <7.1 or potassium <3.5 mmol/L or GCS <12 or persistent hypoxia or persistent brady/ tachycardia or anion gap >16
**Time since diagnosis of DKA**

- **0 min to 60 min**
  - **Restore circulatory volume**
    - Give 500ml of 0.9% sodium chloride stat doses until systolic BP>90 mmHg
    - Then give 1000ml 0.9% sodium chloride over 1 hr
  - **Start insulin therapy**
    - Start fixed rate insulin infusion at 0.1ml/kg/hr
    - Continue patient’s long-acting insulin

- **60 min to 6 hrs**
  - **Continue fluid replacement**
    - 1 litre of 0.9% sodium chloride with potassium*, over 2 hr
    - Then 1 litre of 0.9% sodium chloride with potassium*, over 2 hr
    - Then 1 litre of 0.9% sodium chloride with potassium*, over 4 hr
  - **Potassium replacement**
    - <3.5- senior review
    - 3.5-5.5- 40 mmol/l
    - >5.5- no replacement

- **6 hrs to 12 hrs**
  - **Continue fluid replacement**
    - 1 litre of 0.9% sodium chloride with potassium*, over 4 hr
    - Then 1 litre of 0.9% sodium chloride with potassium*, over 6 hr
    - Senior review if DKA persists beyond 12 hours
  - **Monitor for hypoglycaemia**
    - Start 500ml 10% glucose at 125ml/hr and reduce insulin infusion rate by 50% (0.05ml/kg/hr) *when glucose ≤ 14 mmol/L*
**ADDITIONAL MEASURES**

**Monitoring**
- Hourly glucose and **hourly ketones**
- Bicarbonate & potassium at 1 hr & 2 hr after diagnosis & 2 hourly thereafter
- **Check infusion rate if:**
  - Ketones not reducing by 0.5mmol/hr
  - Bicarbonate not increasing by 3mmol/hr
  - Glucose not reducing by 3mmol/hr
- If glucose ≤4 mmol/L, follow hypoglycaemia guidelines and ensure fixed rate insulin infusion is running at 0.05ml/kg/hr if DKA still persists

**RESOLUTION OF DKA** = **Ketones < 0.6 mmol/L and venous pH > 7.3**
- Diabetes referral for further management and until then VRII
- Expectation: Patient should be eating and drinking and back on normal insulin
- **Transfer to s.c insulin**: Give insulin infusion until 30 minutes after s.c short acting insulin has been given

- Consider catheter if not passed urine by 1h, aim for urine output 0.5mL/kg/h.
- Consider NG tube if vomiting or drowsy
- Start all patients on LMWH
  - *Find and treat infection/cause for DKA*

Bicarbonate may increase risk of cerebral oedema and is not recommended.
• Cerebral Edema (monitor GCS, any suspicion warrants urgent imaging and antiedema measures)
• Hyperkalemia and Hypokalemia
• Hypoglycemia
• Aspiration pneumonia
• Hypomagnesaemia, Hypophosphatemia
• Venous thromboembolism
• Other: pulmonary edema, cardiomyopathy, rhabdomyolysis
# HYPEROSMOLAR HYPERGLYCAEMIC STATE (HHS)

- **HHS** is a medical emergency which is different from **DKA** (Previously know as HONK)
- Typically occurring in T2 DM and elderly
- **Presentation**: over many days (unlike hours in DKA), and consequently the dehydration and metabolic disturbances are more extreme.
- HHS carries **higher mortality risk** than DKA and may be complicated by **vascular events**

### PRECIPITATING CAUSES

<table>
<thead>
<tr>
<th>Intercurrent or co-existing illness</th>
<th>Medication-induced</th>
<th>Diabetes-related</th>
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<tbody>
<tr>
<td>MI/Intestinal ischaemia/PE</td>
<td>Metformin during intercurrent illness.</td>
<td>First presentation of diabetes mellitus:</td>
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<tr>
<td>Infection/Sepsis/Burns/Acute abdomen/GI bleed</td>
<td>Diuretics</td>
<td>Poor diabetic control/non-compliance:</td>
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<td>Stroke/TIA/ICH</td>
<td>Beta-blockers, Calcium-channel blockers.</td>
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<td>Hyperthermia/Hypothermia.</td>
<td>H2-receptor antagonists.</td>
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<td>AKI / Decompensated CKD</td>
<td>Dialysis/TPN/glucose-containing fluids.</td>
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<tr>
<td>Hyperthyroidism/Cushing’s syndrome/ACTH-secreting tumour.</td>
<td>anti-psychotics</td>
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<td>Glucocorticoids, Phenytoin and other anticonvulsants.</td>
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<td>Substance misuse: Alcohol, Cocaine, Amphetamines, MDMA</td>
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SYMPTOMS

- Polydipsia
- Headache
- Nausea
- Vomiting
- Abdo pain
- Polyuria
- Muscle cramps

SIGNS

- Low GCS/Coma
- Confusion
- Seizures
- Tachycardia
- Hypotension
- Dehydration
- Oliguria/Anuria
DIAGNOSTIC CRITERIA

• Hypovolaemia
• Marked hyperglycaemia (Glucose $\geq$ 30 mmol/L) without significant hyperketonaemia (ketones <3 mmol/L) or without acidosis (pH $> 7.3$, bicarbonate $> 15$ mmol/L)
• Osmolality $\geq$ 320 m osmol/kg

Differential Diagnosis:
- DKA
- HHS/DKA mixed picture
  - Euglycemic DKA
  - Alcoholic Ketoacidosis
- Starvational ketoacidosis
MANAGEMENT

Principles and Goals:

To gradually and safely:
- Normalise the osmolality
- Replace fluid and electrolyte losses
- Normalise blood glucose

To prevent:
- Arterial or venous thrombosis
- Other potential complications e.g. cerebral oedema/central pontine myelinolysis
- Foot ulceration

To Treat:
The underlying cause (Eg: MI, drugs, sepsis, bowel infarction)
MANAGEMENT

ABCDE Approach,
2 large bore iv cannulas

Tests: Capillary BG, plasma BG, U&E, FBC, Measured or calculated osmolality (2Na+ glucose + urea), VBG, Blood ketones, lactate, Blood cultures, ECG, CXR, Urinalysis and culture, CRP

Evaluation:
• Does the history suggest sepsis/vascular event or a recent change in medication?
• Assess the degree of dehydration
• Examine for a source of sepsis or evidence of vascular event
• Mental state assessment

0-60 minutes
- Restore circulating volume
  - Give 1L of 0.9% (NaCl) over 60mins.
  - Consider running over 30 minutes if systolic BP < 90 mmHg and safe given pre-existing co-morbidities.

Start Insulin therapy:
- Start fixed rate insulin infusion at 0.05 Units/kg/hr.
- Continue patient’s long acting subcutaneous insulin

Initiate monitoring
- Hourly capillary glucose
- Venous potassium at 60 minutes, 2hours
- 4 hourly plasma electrolytes and osmolality

60 minutes to 6 hours
- Use 0.9% NaCl 0.5-1 L/hr depending on clinical assessment of dehydration/risk of precipitating heart failure
  • Target to achieve positive fluid balance of 2-3 L by 6 hrs

If plasma Na is increasing, but osmolality falling at appropriate rate continue 0.9% NaCl
If osmolality increasing and fluid balance adequate, consider switching to 0.45% NaCl at same rate

Avoid hypoglycaemia
- Aim to keep blood glucose 10-15 mmol/L in first 24 hours
- If blood glucose falls below 14 mmol/L commence 10% glucose at 125 ml/hr AND CONTINUE 0.9% NaCl solution
6 - 12 hours

- Continue charting hourly glucose & Na and calculated osmolality 2-4 hourly
- Aim positive fluid balance 3-6 litres by 12 hr
- Assess for complications of treatment

12 - 24 hours

- Biochemistry may take more than 24 hr to normalise
- Continue actions described in 60 minutes to 6 hours

24 hours to day 3

- Continue IV fluids until drinking normally
- Variable rate insulin if not eating
- Convert to appropriate subcutaneous insulin regime when stable
- Daily urea and electrolytes

Maintain normal potassium

- Supplement fluids with potassium according to K+ level
  - >5.5: No potassium replacement
  - 3.5 - 5.5: 20mmol KCl per litre
  - < 3.5: 40mmol KCl per litre and senior review

Continue treatment of any underlying cause

- If patient not improving seek senior advice
- Avoid hypoglycaemia
- Ensure referral made to Diabetes team on PICS

Continue IV Insulin with or without glucose solution to maintain blood glucose 10-15 mmol/L (adjust Insulin infusion rate hourly by 1 unit/hr increments to achieve this)
CONSIDER HDU/ITU REFERRAL

- osmolality >350 mosmol/kg
- sodium > 160 mmol/L
- venous / arterial pH < 7.1
- hypokalaemia (K<3.5 mmol/L) or hyperkalaemia (K>6 mmol/L) on admission
- GCS <12
- oxygen saturation < 92% on air (assuming normal baseline respiratory function)
- SBP < 90 mmHg
- pulse > 100 or < 60 bpm
- urine output <0.5 ml/kg/hr
- serum creatinine >200 µmol/L
- hypothermia
- macrovascular event such as MI or stroke
- other serious co-morbidity.

ADDITIONAL MEASURES IN MANAGEMENT:

- Assess for: - signs of fluid overload or cerebral oedema
  - evidence of continuing sepsis
  - Foot (daily)

- Regular monitoring:
  - Plasma Osmolality
  - Fluid balance (Minimum U.O 0.5 ml/kg/hr)

- Consider urinary catheterisation
- Measure lab glucose if bedside measurement >33mmol/L
- Aim gradual decline of Plasma osmolality (3-8 mosml/kg/hour)
- Diabetes team referral
- Continue LMWH until day of discharge (consider extended treatment in very high risk patients)
• Ischaemia or infarction affecting any organ, particularly MI and CVA
• Thromboembolic disease (DVT and PE)
• ARDS
• DIC
• Multi-organ failure.
• Rhabdomyolysis.
• Cerebral oedema.
• Central pontine myelinolysis.
• Iatrogenic complications:
  - due to inexpert rehydration and electrolyte management;
  - over-administration of insulin
  - fluid overload leading to cardiac failure.
Most patients should go home on subcutaneous insulin (the regime being determined by their circumstances).

For patients with previously undiagnosed DM or well controlled on oral agents, switching from insulin to the appropriate oral hypoglycaemic agent should be considered after a period of stability (weeks or months).

Ensure patient has appropriate diabetes education prior to discharge and arrange follow-up by diabetes team.

**RESOLUTION of HHS**
- Improvement of mental status
- Blood glucose <16 mmol/L
- S. Osmolality <320 mOsm/kg
SURVEY

POST-SESSION QUESTIONNAIRE
KEY LEARNING POINTS

Differentiating and DKA and HHS

Early recognition is vital to prevent morbidity and mortality

Awareness of exact diagnostic criteria and following the protocol accordingly

Awareness of complications

Patient Education

Referral:
- ITU if needed
- Diabetes team
REFERENCES AND FURTHER READING:

- Trust Guidelines
- Joint British Diabetes Societies
- Oxford Handbook of Clinical Medicine
- https://spectrum.diabetesjournals.org
THANK YOU

ANY QUESTIONS?