Pathophysiology

- DKA is a syndrome of hyperglycaemia, metabolic acidosis, ketosis & severe volume depletion.
- DKA occurs in insulin dependent diabetics & severe insulin deficiency is the hallmark of this syndrome.
- Raised levels of stress hormones (GH, glucagon, catecholamines & cortisol) are also a feature.
- Hyperglycaemia results in a glucose load that overloads the resorptive capacity of the renal tubules resulting in osmotic diuresis with fluid & electrolyte depletion.
- The lack of insulin causes increased lipolysis & the formation of ketoacids.

Epidemiology

- Accounts for approximately 6% of all diabetic admissions to hospital.
- Occurs in a younger age group than HONK.

Precipitating factors

- Precipitating factors associated with the development of DKA include:
  1. Lack of insulin due to previously undiagnosed diabetes mellitus or non-compliance.
  2. Physical stressors such as acute infectious illness, myocardial infarction, SIRS (e.g., pancreatitis), glucocorticoid, phenytoin or diuretic therapy.
  3. Post surgical management.
  4. Substance abuse.

Clinical features

- Presenting clinical features of DKA reflect the underlying metabolic derangements of dehydration, ketosis & metabolic acidosis & include:
  1. Thirst & polyuria.
  2. Tachycardia & hypotension.
  3. Reduced skin turgor.
  4. Dry mucous membranes.
  5. Kussmaul respiration & ketotic fetor.
  6. Core temperature is often reduced.

Laboratory tests

- Laboratory tests supporting the diagnosis of DKA include:
  1. Hyperglycaemia.
  2. Spurious hyponatraemia.
  3. Preserved or high levels of serum potassium (reflecting the acid-base status and not the severe total body depletion of potassium that is present).
  4. Variable levels of calcium, magnesium & phosphate (although these are usually low or become low on commencement of therapy).
  5. Hyperosmolality.
  6. Elevated serum urea & creatinine levels.
  7. Elevated serum ketone levels as measured by the concentrations of beta hydroxybutyrate & acetoacetate [3-hydroxybutyrate concentrations in plasma are 2-3 times those of acetoacetate but in acidic states this ratio is increased further. As therapy improves acidosis, levels of acetoacetate rise and methods that measure only acetoacetate concentrations in urine may suggest ketonuria is worsening.
  8. White cell count may be elevated and does not necessarily reflect infection.
  9. Amylase is often elevated (without pancreatitis).

Neurological sequelae

- Patients who present with DKA or HONK commonly have an altered mental state which may range from delirium to coma. Often the patient is very unwell and as a consequence is stuporous and uncommunicative; less commonly delirium is the major feature.
- Often improves rapidly with rehydration and correction of acidosis.
- There is no good correlation between glucose level, osmolality or pH and the patient's presenting mental status which appears to be more a function of the patient's general health, comorbidities and the precipitating cause.
- Localising signs and lack of improvement with correction of metabolic disturbance mandate further investigation.

Neurologic sequelae

- The main metabolic derangements that result in morbidity & must be urgently addressed in the management of both DKA & HONK are dehydration, insulin deficit, electrolyte depletion & metabolic acidosis.
- Although there is no consensus on the ideal approach to fluid management in these patients, prompt restoration of the circulation with isotonic fluid, followed by more moderate replacement of the water deficit using hypotonic fluid are the underlying principles.
- Electrolyte depletion is treated by appropriate replacement of sodium, potassium, magnesium, phosphate & calcium as indicated by frequent testing during the early phase after presentation.
- Metabolic acidosis rarely requires specific therapy & corrects with volume expansion & insulin therapy. Bicarbonate is not generally advocated due to the possibilities of hypokalaemia, intracellular acidosis, reduced myocardial contractility and reduced tissue oxygenation.

Table: DKA & HONK comparison

<table>
<thead>
<tr>
<th>Metabolic Derangement</th>
<th>DKA</th>
<th>HONK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients in DKA</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Serum glucose levels</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Serum sodium levels</td>
<td>Normal</td>
<td>Low</td>
</tr>
<tr>
<td>Serum osmolality</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Serum bicarbonate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Serum ketone levels</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Pathophysiology

- The defining features of HONK include hyperglycaemia, dehydration, & hyperosmolality without ketoacidosis.
- The main differentiation from DKA appears to be the presence of at least some insulin (ie relative, rather than absolute lack of insulin), more variable levels of stress hormones or counterregulatory hormones & the fact renal dysfunction is commonly present.
- Renal dysfunction & impaired tubular function results in less capacity to deal with high solute & osmotic loads. This together with impaired water intake results in severe dehydration.

Clinical features

- More commonly associated with obtundation than DKA.

Laboratory tests

- Laboratory tests are similar to those for DKA but differ in degree.
  1. Serum glucose levels are usually higher.
  2. Serum sodium levels may be normal (inappropriately for serum glucose).
  3. Markers of renal dysfunction are worse.
  4. Hyperosmolality is more marked.
  5. Metabolic acidosis is not as severe.
  6. Anion gap & serum ketone levels are normal.

Seizures

- Focal and generalised seizures are common in patients with hyperglycaemic syndromes and may be resistant to treatment.

Cerebral oedema

- Rapid correction of hyperglycaemia and hyperosmolality is associated with the development of cerebral oedema in patients with hyperglycaemic syndromes.
- Animal studies suggest it is correction of hyperglycaemia and hyperosmolality rather than sodium movement or acidosis that are important.
- The use of isotonic rather than hypotonic solutions for rehydration and avoidance of over rapid correction of hyperglycaemia appear to offer protection against the development of cerebral oedema.
- Cerebral oedema is more common in DKA than HNKS & is more common in the young.
- Manifests with either protracted altered mental state or a new development of altered mental state.
- In adults good supportive care is generally all that is required & manifestations gradually abate over a few days; however, in children cerebral oedema is associated with considerable mortality & urgent treatment with mannitol is often required.

Seizures

- In patients with DKA & HONK are life threatening syndromes caused by metabolic derangement associated with diabetes mellitus.
- DKA is approximately three times as common as HONK in patients presenting with hyperglycaemic syndromes.
- Most deaths due to diabetic emergencies that are appropriately managed are due to coexisting disease such as myocardial infarction.

- DKA & HONK are life threatening syndromes caused by metabolic derangement associated with diabetes mellitus.