Diabetic ketoacidosis

Straight to the point of care
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Summary

Diabetic ketoacidosis is characterised by a biochemical triad of hyperglycaemia, ketonaemia, and metabolic acidosis, with rapid symptom onset.

Common symptoms and signs include increased thirst, polyuria, weight loss, excessive tiredness, nausea and vomiting, dehydration, abdominal pain, hyperventilation, and reduced consciousness.

Successful treatment includes correction of volume depletion, ketogenesis, hyperglycaemia, electrolyte imbalances, and comorbid precipitating events, with frequent monitoring.

Complications of treatment include hypoglycaemia, hypokalaemia, pulmonary oedema, and acute respiratory distress syndrome (ARDS).

Cerebral oedema, a rare but potentially rapidly fatal complication, occurs mainly in children. It may be prevented by avoiding overly rapid fluid and electrolyte replacement.

Definition

Diabetic ketoacidosis (DKA) is an acute metabolic complication of diabetes that is potentially fatal and requires prompt medical attention for successful treatment. It is characterised by absolute insulin deficiency and is the most common acute hyperglycaemic complication of type 1 diabetes mellitus.[1]
**Epidemiology**

In England, the incidence of hospital admissions for DKA among adults with type 2 diabetes increased 4.24% annually between 1998 and 2013; hospitalisations for DKA in adults with type 1 diabetes increased from 1998 to 2007, and remained static until 2013.[8]

In Denmark, the annual incidence of DKA in the general population was estimated to be 12.6/100,000 during the period 1996 to 2002, and was higher in men than in women (14.4 versus 11.4 per 100,000, p<0.0001).[9] Twelve percent of patients, typically those aged over 50 years, were diagnosed with type 2 diabetes. Overall mortality was 4%. [9] In Sweden, 16% of children with new-onset diabetes presented with DKA between 1999 and 2000; cerebral oedema occurred in 0.68% of cases.[10] In Finland, a similar level of DKA (15.2%) was reported in children presenting with type 1 diabetes during the period 1992-2001; children aged under 2 years at diagnosis were at highest risk of DKA.[11] In Brazil, DKA was reported in 32.8% of patients at diagnosis of type 1 diabetes.[12] DKA at diagnosis was more common in children aged below 10 years, and in non-white than in white people.[12]

In the US from 2000 to 2009, the rate of hospitalisations for DKA decreased overall, from 21.9 to 19.5 per 1000 persons with diabetes, but then increased in the period 2009 to 2014 to 30.2 per 1000 persons with diabetes.[13] In 2014, rates of hospitalisation for DKA were highest among people aged <45 years (44.3 per 1000 persons with diabetes), and decreased with age (5.2 per 1000 persons with diabetes aged 45 to 64 years; 1.6 per 1000 persons aged 65 to 74 years; and 1.4 per 1000 persons aged ≥75 years).[13] During the period 2000 to 2014, in-hospital mortality rates among people with DKA consistently decreased, from 1.1% to 0.4%. [13] In 2014, about 207,000 accident and emergency department visits for people aged 18 years or older in the US were for hyperglycaemic crises (e.g., DKA, hyperglycaemic hyperosmolar state).[14]

**Risk factors**

**Strong**

**inadequate or inappropriate insulin therapy**

Reduction in the net effective concentration of insulin leads to impaired carbohydrate, lipid, and ketone metabolism in DKA. Decreased insulin results in increased gluconeogenesis, accelerated glycogenolysis, and impaired glucose utilisation by peripheral tissues.[1]

Non-compliance with insulin therapy has been found to be the leading precipitating factor in black people,[26] and is present in over 30% of patients with DKA.[16] Psychological and social factors may impact on glycaemic control, and low socio-economic status is correlated with a higher risk for DKA.[27] [28]

**infection**

The most common precipitating factor in DKA is infection. Increased counter-regulatory hormones, particularly adrenaline, as a systemic response to infection lead to insulin resistance, increased lipolysis, ketogenesis, and volume depletion, which may contribute to the development of hyperglycaemic crises in patients with diabetes.[1]

**myocardial infarction**

Underlying cardiovascular events, particularly myocardial infarction, provoke the release of counter-regulatory hormones likely to result in DKA in patients with diabetes.[1] [29]
Diabetic ketoacidosis

Theory

Weak pancreatitis

Medical conditions such as pancreatitis, characterised by increased levels of counter-regulatory hormones and compromised access to water and insulin, may contribute to the development of hyperglycaemic crises.[1] [30]

stroke

Acute medical events such as stroke, with increased levels of counter-regulatory hormones and compromised access to water and insulin, may contribute in the development of hyperglycaemic crises.[1]

acromegaly

Hormonal derangements in some endocrine glands lead to increased counter-regulatory hormones and development of DKA in patients with concomitant diabetes.[31]

hyperthyroidism

Hormonal derangements in some endocrine glands lead to increased counter-regulatory hormones and development of DKA in patients with concomitant diabetes.[32]

drugs (e.g., corticosteroids, thiazides, pentamidine, sympathomimetics, second-generation antipsychotics, cocaine, immune checkpoint inhibitors, or SGLT2 inhibitors)

Drugs that affect carbohydrate metabolism may precipitate hyperglycaemic crises.[33] [18] [34] [35] A recent report suggests that cocaine abuse is an independent risk factor associated with recurrent DKA.[36] [37]

Sodium-glucose co-transporter-2 (SGLT2) inhibitors (e.g., canagliflozin, dapagliflozin, empagliflozin), used for glycaemic control of type 2 diabetes, have been the subject of an FDA warning about a risk for DKA.[38]

Immune checkpoint inhibitor therapy for cancer (PD-1 and PD-L1 blocking antibodies such as nivolumab, pembrolizumab and avelumab) appears to be associated with a risk for DKA and type 1 diabetes mellitus.[39] [40]

Cushing’s syndrome

Hypercortisolism leads to insulin resistance and may occasionally precipitate DKA in patients with concomitant diabetes; it more commonly precipitates hyperosmolar hyperglycaemic state.

Hispanic or black ancestry

Ancestry plays a role in ketosis-prone diabetes, with DKA a presenting manifestation of undiagnosed type 2 diabetes in young adults. Approximately 80% of obese black patients with DKA have type 2 diabetes, characterised by higher insulin secretion, the absence of autoimmune markers, and a lack of HLA genetic association compared with lean patients with type 1 diabetes.[4]

bariatric surgery

DKA has been reported in patients with type 1 diabetes who have had bariatric surgery.[41]
Aetiology

In DKA, there is a reduction in the net effective concentration of circulating insulin along with an elevation of counter-regulatory hormones (glucagon, catecholamines, cortisol, and growth hormone). These alterations lead to the extreme manifestations of metabolic derangements that can occur in diabetes. The two most common precipitating events are infection and discontinuation of, or inadequate, insulin therapy. Underlying medical conditions, such as myocardial infarction or pancreatitis, that provoke the release of counter-regulatory hormones are also likely to result in DKA in patients with diabetes. Drugs that affect carbohydrate metabolism, such as corticosteroids, thiazides, sympathomimetic agents (e.g., dobutamine and terbutaline), second-generation antipsychotics, immune checkpoint inhibitors, cocaine, and cannabis may contribute to the development of DKA. The use of sodium-glucose co-transporter 2 (SGLT2) inhibitors has also been implicated in the development of DKA in patients with both type 1 and type 2 diabetes.

Pathophysiology

Reduced insulin concentration or action, along with increased insulin counter-regulatory hormones, leads to the hyperglycaemia, volume depletion, and electrolyte imbalance that underlie the pathophysiology of DKA. Hormonal alterations lead to increased gluconeogenesis, hepatic and renal glucose production, and impaired glucose utilisation in peripheral tissues, which results in hyperglycaemia and hyperosmolarity. Insulin deficiency leads to release of free fatty acids from adipose tissue (lipolysis), hepatic fatty acid oxidation, and formation of ketone bodies (beta-hydroxybutyrate and acetoacetate), which result in ketonaemia and acidosis. Studies have demonstrated the elevation of pro-inflammatory cytokines and inflammatory biomarkers (e.g., C-reactive protein [CRP]), markers of oxidative stress, lipid peroxidation, and cardiovascular risk factors with hyperglycaemic crises. All of these parameters return to normal following insulin and hydration therapies within 24 hours of hyperglycaemic crises. Elevation of pro-inflammatory cytokines, and markers of lipid peroxidation and oxidative stress, have also been demonstrated in non-diabetic patients with insulin-induced hypoglycaemia. The observed pro-inflammatory and pro-coagulant states in hyperglycaemic crises and hypoglycaemia may be the result of adaptive responses to acute stress, and not hyperglycaemia or hypoglycaemia per se. It has also been postulated that ketosis-prone diabetes comprises different syndromes based on auto-antibody status, HLA genotype, and beta-cell functional reserve.
Diabetic ketoacidosis

**Pathogenesis of DKA and HHS**; triggers include stress, infection, and insufficient insulin. FFA: free fatty acid; HHS: hyperosmolar hyperglycaemic state

**Classification**

**Severe DKA**

The presence of one or more of the following may indicate severe DKA:[2]

- Blood ketones >6 mmol/L
- Bicarbonate <5 mmol/L
- Venous/arterial pH <7.0
- Hypokalaemia on admission (<3.5 mmol/L)
- Glasgow Coma Scale <12
- Oxygen saturation <92% on air (assuming normal baseline respiratory function)
- Systolic blood pressure (SBP) <90 mmHg
- Pulse >100 bpm or <60 bpm
- Anion gap >16
Case history

Case history #1

A 20-year-old man is brought to the accident and emergency department with abdominal pain, nausea, and vomiting with increasing polyuria, polydipsia, and drowsiness since the previous day. He was diagnosed with type 1 diabetes 2 years previously. He mentions that he ran out of insulin 2 days ago. Vital signs at admission are: BP 106/67 mmHg, heart rate 123 beats per minute, respiratory rate 32 breaths per minute, temperature 37.1°C (98.8°F). On mental status examination, he is drowsy. Physical examination reveals Kussmaul's breathing (deep and rapid respiration due to ketoacidosis) with acetone odour and mild generalized abdominal tenderness without guarding and rebound tenderness. Initial laboratory data are: blood glucose 25.0 mmol/L (450 mg/dL), arterial pH 7.24, PCO₂ 25 mmHg, bicarbonate 12 mmol/L (12 mEq/L), WBC count 18.5 × 10⁹/L (18,500/microlitre), sodium 128 mmol/L (128 mEq/L), potassium 5.2 mmol/L (5.2 mEq/L), chloride 97 mmol/L (97 mEq/L), serum urea 11.4 mmol/L (32 mg/dL), creatinine 150.3 micromol/L (1.7 mg/dL), serum ketones strongly positive.

Other presentations

It is now well recognised that new-onset type 2 diabetes can manifest with DKA. These patients are obese and have undiagnosed hyperglycaemia, impaired insulin secretion, and insulin resistance. However, after treatment of the acute hyperglycaemic episode with insulin, beta-cell function and insulin effects improve, so these patients are able to discontinue insulin therapy and may be treated orally or by diet alone, with 40% remaining insulin-independent 10 years after the initial episodes of DKA. These patients do not have the typical autoimmune laboratory findings of type 1 diabetes.[3] This type of diabetes has been labelled as ‘type 1 and 1/2’ or ‘type 1 and a half’ diabetes, ‘Flatbush’ diabetes, or ‘ketosis-prone’ diabetes. Conversely, an extreme hyperosmolar state similar to hyperosmolar hyperglycaemic state (HHS) has been reported in combination with DKA in type 1 diabetes.[4] [5] [6] [7]
Diabetic ketoacidosis

Diagnosis

Recommendations

Urgent

Consider DKA in:

- Patients with known diabetes who are unwell[2][17]
  - DKA is most common in people with type 1 diabetes but can also present in those with type 2 diabetes.[42][46][47]
  - Any patient with increased thirst, polyuria, recent unexplained weight loss, or excessive tiredness, AND any of the following:[17][48]
    - Nausea and vomiting
    - Abdominal pain[2][49]
    - Hyperventilation (Kussmaul's respiration)[50]
    - Dehydration
    - Reduced consciousness.

Urgently order a venous blood gas, blood ketones, and capillary blood glucose.[42]

- These tests should be done at the bedside.

Diagnose DKA if:[51][17][47][52]

- Blood ketones are ≥3.0 mmol/L OR there is ketonuria (more than 2+ on standard urine sticks)
  AND
  - Blood glucose is >11.1 mmol/L OR known diabetes
    - This blood glucose cut-off is recommended in the 2020 Joint British Diabetes Societies (JBDS) guideline "Diabetes at the front door" and supersedes the 11.0 mmol/L cut-off recommended in the 2013 JBDS guideline "The management of diabetic ketoacidosis in adults".[42][52]
  AND
  - Bicarbonate ($\text{HCO}_3^-$) is <15.0 mmol/L, AND/OR venous pH is <7.3.

Ensure continuous cardiac monitoring and involve senior or critical care support if:[42][17]

- There is persistent hypotension (systolic blood pressure <90 mmHg) or oliguria (urine output <0.5 ml/kg/hour) despite intravenous fluids
- Glasgow Coma Scale <12
- Blood ketones >6 mmol/L
- Venous bicarbonate <5 mmol/L
- Venous pH <7.0
- Potassium <3.5 mmol/L on admission
- Oxygen saturations <92% on air
- Pulse >100 bpm or <60 bpm
- Anion gap >16
- The patient is pregnant or has heart or kidney failure or other serious comorbidities.

Involve the specialist diabetes team as soon as possible and definitely within 24 hours.[42]
Key Recommendations

Clinical presentation

Other features of DKA are:

- Acetone smell on breath[17]
  - Smells like pear drops or nail varnish remover
- Hypothermia[53]
  - Suspect sepsis as a precipitant if there is fever as this is not a feature of DKA. Sepsis may also cause hypothermia, however.

History

Ask about causes of DKA. These are:

- Infection[17] [47]
  - The most common causes are pneumonia and urinary tract infection.
  - Suspect sepsis as a cause of DKA if there is fever or hypothermia, hypotension, refractory acidosis, or lactic acidosis.[51]
- Discontinuation of insulin (either unintentional or deliberate)[17] [47]
- Inadequate insulin
  - Due to:
    - Malfunctioning insulin pen or pump[54]
    - Degradation of insulin due to storage at incorrect temperature.[55]
- New onset of diabetes[17]
- Acute illness
  - Common causes include myocardial infarction, sepsis, and pancreatitis.[47] [15] [30]
- Physiological stress
  - This includes:
    - Pregnancy[17]
    - Trauma[56]
    - Surgery.[56]
- Drugs[17]
  - Corticosteroids[57]
  - Thiazides
  - Sympathomimetics[26]
  - Second-generation antipsychotics[58]
  - Immune checkpoint inhibitors[59]
  - Cocaine, cannabis, and acute intoxication with alcohol[56] [60]
  - Sodium-glucose co-transporter 2 (SGLT2) inhibitors.[21] [22]
Examination

Examine the chest:

- Look for **hyperventilation** (Kussmaul's respiration).[17]
- Auscultate for crepitations or reduced air entry.
  - This may indicate pneumonia as a cause of DKA or pulmonary oedema.
- Monitor for **pulmonary oedema**. This typically occurs several hours after treatment is started and can occur even in patients with normal cardiac function.[42] [17]

Assess for signs of **dehydration**:[17]

- Dry mucous membranes
- Decreased skin turgor or skin wrinkling
- Slow capillary refill
- Tachycardia with a weak pulse
- Hypotension.

Assess **conscious level** hourly using the Glasgow Coma Scale to monitor for cerebral oedema.[42]

- Signs include headache, irritability, slowing pulse, rising blood pressure, reducing conscious level. These may occur several hours after starting treatment.[51] [61]
- Involve immediate critical care input and give mannitol.[62]

Examine the abdomen

- Look for an intra-abdominal cause of DKA such as pancreatitis.[47] [15] [30]
- However, **DKA commonly causes abdominal pain** and may be mistaken for an acute abdomen.[63]

**Check the patient’s feet** to look for new ulceration or infection.[64]

**Check the patient’s skin** for rashes, signs of cellulitis, or open wounds that may have precipitated DKA.

Investigations

**Always order:**

- Venous blood gas
  - This will show a **metabolic acidosis** with a **raised anion gap**. Involve senior or critical care support if pH is <7.0.[42]
  - Check the **potassium** level. Involve senior or critical care support if it is <3.5 mmol/L.[42]
  - Calculate plasma osmolality. This is high (>320 mmol/kg) in patients with DKA.[53] [61]
- Blood ketones
  - This will show **ketonaemia** (ketones ≥3.0 mmol/L).[42]
  - Use urinary ketones if near-patient blood ketone testing is unavailable. This will show ketonuria (more than 2+ on standard urine sticks).[42]
- Blood glucose
  - **Hyperglycaemia** (blood glucose >11.1 mmol/L) is common.[52]
Diabetic ketoacidosis

Diagnosis

- This blood glucose cut-off is recommended in the 2020 Joint British Diabetes Societies (JBDS) guideline “Diabetes at the front door” and supersedes the 11.0 mmol/L cut-off recommended in the 2013 JBDS guideline “The management of diabetic ketoacidosis in adults”.[42] [52]
- Be aware that some patients can present with euglycaemic DKA and have a normal blood glucose.[65]
  - Urea and electrolytes
    - This commonly shows hyponatraemia and hyperkalaemia, but hypokalaemia may also be present and indicates severe DKA.[42] [46]
    - It may also show hypomagnesaemia and hypophosphataemia.[42] [66]
  - Full blood count[46]
    - Leukocytosis is common.
    - Suspect infection if there is a leukocytosis of more than $25 \times 10^9/L$ (25,000/microlitre).[46]

Full Recommendations

Clinical presentation

Consider DKA in:

- Patients with known diabetes who are unwell[2] [17]
  - DKA is most common in people with type 1 diabetes but can also present in those with type 2 diabetes.[46]
  - Any patient with increased thirst, polyuria, recent unexplained weight loss, or excessive tiredness AND any of the following:[17] [48]
    - Nausea and vomiting
    - Abdominal pain[49] [2]
    - Hyperventilation (Kussmaul's respiration)[50]
    - Dehydration
    - Reduced consciousness.
    - This is strongly associated with more severe DKA and a worse prognosis.[67]

Practical tip

Patients with type 2 diabetes who have increased risk of DKA are those with newly diagnosed diabetes or obesity.[61]

Practical tip

DKA is the initial presentation in up to 25% of patients with newly diagnosed diabetes.[46]
DKA is easily missed, especially when it is the initial presentation of diabetes in infants or older patients, or when patients present with other acute medical illnesses such as stroke or myocardial infarction.[61]

Other features of DKA are:

- Acetone smell on breath[17]
Diabetic ketoacidosis

Diagnosis

• The patient’s breath smells like pear drops or nail varnish remover. This is due to high ketone levels.
• A significant proportion of people are unable to smell acetone even if it is present.

• Hypothermia

• Severe hypothermia is associated with a mortality rate of 30% to 60%. [68]
• Mild hypothermia may be seen in some patients with DKA due to peripheral vasodilation. [46]

Practical tip

Fever is not a feature of DKA but DKA may be caused by sepsis. Suspect sepsis as a cause of DKA if there is fever or hypothermia, hypotension, refractory acidosis, or lactic acidosis. [51]

Ensure continuous cardiac monitoring and involve senior or critical care support if: [42]

• There is persistent hypotension (systolic blood pressure <90 mmHg) or oliguria (urine output <0.5 ml/kg/hour) despite intravenous fluids
• Glasgow Coma Scale <12
• Blood ketones >6 mmol/L
• Venous bicarbonate <5 mmol/L
• Venous pH <7.0
• Potassium < 3.5 mmol/L on admission
• Oxygen saturations <92% on air
• Pulse >100 bpm or <60 bpm
• Anion gap >16
• The patient is pregnant or has heart or kidney failure or other serious comorbidities.

• DKA in pregnancy can result in significant morbidity and mortality for both the mother and the fetus. [69]

Evidence: Clinical predictors of outcomes in DKA

Prognostic factors for survival in patients with DKA are unclear.

There is limited evidence from a case series of patients with DKA in India for several favourable prognostic indicators, including being male, having lower APACHE scores, and having lower serum phosphate levels on presentation.

• A case series assessed 270 patients hospitalised with DKA in India over 2 years. [70]

• It found that survival was more likely among males than females (odds ratio [OR] 7.93, 95% CI 3.99 to 13.51). [70]
• Other favourable prognostic factors in multivariate analysis (adjusting for type of diabetes, blood pressure, total leukocyte count, urea, serum creatinine, serum magnesium, serum osmolality, serum glutamic oxaloacetic transaminases, serum glutamic pyruvic transaminases, and serum albumin) were lower APACHE scores (OR 2.86, 95% CI 1.72 to 7.03) and lower serum phosphate (OR 2.71, 95% CI 1.51 to 6.99) at presentation. [70]
• However, this study reported a high overall mortality rate and may not represent the UK or European context. [70]

Involve the specialist diabetes team as soon as possible and definitely within 24 hours. [42]

• The specialist diabetes team should also be involved in the assessment of the cause of DKA.
Diabetic ketoacidosis

Diagnosis

• It is unsafe to manage DKA without the specialist diabetes team and could compromise patient care.[42]

History

Ask about possible causes of DKA. These include:[46] [42] [53] [26] [33] [71] [35] [36]

• Infection (most common cause of DKA)[17] [53] [26]
  • The most common causes are pneumonia and urinary tract infection.
  • Suspect sepsis as a cause of DKA if there is fever or hypothermia, hypotension, refractory acidosis, or lactic acidosis.[51]
• Discontinuation of insulin (unintentional or deliberate; second most common cause of DKA)[17] [53] [26]
  • Ask sensitively about reasons for deliberate discontinuation of insulin, which may include fear of weight gain or hypoglycaemia, financial barriers, and psychological factors such as needle phobia and stress.[2] [17]
  • Younger patients with type 1 diabetes may omit insulin due to fear of hypoglycemia, weight gain, eating disorders, or the stress of having a chronic disease. These factors may account for 20% of recurrent DKA.[72]
• Inadequate insulin
  • Common reasons are:
    • Malfunctioning insulin pen or pump[54] [55]
    • Degradation of insulin due to storage at incorrect temperature.[55]
• New onset of diabetes[17]
• Acute illness
  • Common causes include myocardial infarction, sepsis, and pancreatitis[15] [30]
    • Maintain a high level of suspicion for myocardial infarction as patients with diabetes often present with atypical symptoms.
• Physiological stress
  • This includes pregnancy, trauma, and surgery.
  • Some women may develop DKA during menstruation.[73] [74]
• Past medical history
  • History of diabetes:
    • DKA is most common in people with type 1 diabetes but can occur in those with type 2 diabetes.[46]
• Drug history[17]
  • Drugs that may cause DKA include:
    • Corticosteroids (increase insulin resistance)[57]
Diabetic ketoacidosis

Diagnosis

- Thiazides (unclear cause but may increase insulin resistance, inhibit glucose uptake, and decrease insulin release)
- Sympathomimetics (alter glucose metabolism)[26]
- Second-generation antipsychotics (alter glucose metabolism)[58]
- Immune checkpoint inhibitors (cause insulin deficiency)[59]
- Cocaine, cannabis, and acute intoxication with alcohol (DKA is associated with cocaine use but the mechanism is unclear)[56] [60]
- SGLT2 inhibitors (prevent reabsorption of glucose and facilitate its excretion in urine).[21] [22]

**Practical tip**

Some patients with diabetes may present with a ‘silent myocardial infarction’ with no or minimal chest pain. This is thought to be due to cardiac autonomic dysfunction.[75] [76]

**Practical tip**

Diagnosis of DKA in pregnancy is often delayed because it can occur at lower blood glucose levels and faster than in non-pregnant patients.[77] DKA usually occurs in the second and third trimesters due to increased insulin resistance.[77]

**Examination**

Examine the chest.

- Look for hyperventilation (Kussmaul's respiration).[17] [50]
  - This is a late sign of DKA and occurs with more severe acidosis.
  - Characterised by deep sighing respirations at a slow or normal rate.

Auscultate for crepitations or reduced air entry.[78]

- This may be due to pneumonia, which can be caused by aspiration from gastroparesis in DKA or a primary infection.[51] [79] [80] [81]
- Basal crepitations are also a sign of pulmonary oedema or acute respiratory distress syndrome (ARDS) secondary to fluid overload. This is an uncommon complication of treatment for DKA.[42] [82]

Check for signs of dehydration. These are:[17]

- Dry mucous membranes
- Decreased skin turgor or skin wrinkling
- Slow capillary refill
- Tachycardia with a weak pulse
- Hypotension.

Assess conscious level hourly using the Glasgow Coma Scale to monitor for cerebral oedema.[42]

- Mental status can range from alert in mild DKA to coma in severe DKA.[53]
- Cerebral oedema can develop during treatment of DKA due to rapid correction of hyperglycaemia.[42]

  - Signs include headache, irritability, slowing pulse, rising blood pressure, reducing conscious level. These may occur several hours after starting treatment.[51] [61]

  - Papilloedema is a late sign of cerebral oedema.[51]
Diabetic ketoacidosis

Diagnosis

- Involve immediate critical care input and give mannitol.[62]
- Cerebral oedema has a mortality rate of 70%. It is most common in children and adolescents but can occur in adults.[2]

Examine the abdomen for a possible cause of DKA, such as pancreatitis.[47] [15] [30] DKA can both cause and mimic an acute abdomen.[49]

- Look for abdominal distension, which may indicate bowel obstruction.[83]
- Palpate the abdomen to check for rebound tenderness and guarding caused by irritation of the peritoneum.[83]
- Auscultate for bowel sounds.[84]

  - Hyperactive ‘tinkling’ bowel sounds may be present in early bowel obstruction.
  - Reduced or absent bowel sounds may be present in late bowel obstruction, perforated viscus, haemoperitoneum, or any cause of peritoneal inflammation.

- Perform a rectal examination.[83]

  - Ensure you take a chaperone with you.
  - Assess for occult or frank blood, pain, or a mass.

Practical tip

The severity of abdominal pain caused directly by DKA correlates strongly with the severity of the metabolic acidosis.[49]

Check the patient’s feet to look for new ulceration or infection.[64]

Practical tip

Check the feet for loss of protective sensation in any patient with diabetes.

- Follow your local guidelines, but a quick simple test is the Ipswich Touch Test©#, which involves lightly touching/resting the tip of the index finger for 1 to 2 seconds on the tips of the first, third, and fifth toes and the dorsum of the hallux.[85]
- If your patient has reduced sensation, they are at high risk of pressure ulceration. Inform the nursing staff and provide pressure-relieving devices.

A daily heel check for signs of pressure trauma should be done by nursing or healthcare assistant staff.

  - There is a debate about whether compression stockings should or should not be used in people with diabetes - do not use them if there is vascular disease.

Check the patient’s skin for rashes and signs of cellulitis or open wounds.

- Infections such as meningitis or cellulitis may precipitate DKA.[86] [87]
- Periumbilical discolouration (Cullen’s sign) or bruising of the flanks (Grey Turner’s sign) indicates haemorrhagic pancreatitis.[88]

Investigations

Diagnose DKA if:[51] [17] [47] [52]

- Blood ketones are ≥3.0 mmol/L OR there is ketonuria (more than 2+ on standard urine sticks)

AND

- Blood glucose is >11.1 mmol/L OR known diabetes
Diabetic ketoacidosis

**Diagnosis**

- This blood glucose cut-off is recommended in the 2020 Joint British Diabetes Societies (JBDS) guideline "Diabetes at the front door" and supersedes the 11.0 mmol/L cut-off recommended in the 2013 JBDS guideline "The management of diabetic ketoacidosis in adults".[42] [52]

AND

- Bicarbonate (HCO₃⁻) is <15.0 mmol/L AND/OR venous pH is <7.3.

**Practical tip**

Assessment of glucose, ketones, and electrolytes, including bicarbonate and venous pH, should be done at or near the bedside.[42]

- Order laboratory measurements in certain circumstances, such as when blood glucose or ketone meters are ‘out of range’.

**Practical tip**

Rarely, patients present with euglycaemic DKA (EDKA) and have a normal blood glucose level.[17] [89]

- Exclude other causes of an anion gap metabolic acidosis before confirming EDKA.
- The mechanism of EDKA is unclear but may be due to decreased insulin secretion with increased counter-regulatory hormone secretion (cortisol, glucagon, catecholamines, and growth hormone).[19]
- Possible precipitants of EDKA are pregnancy, starvation, alcohol use, insulin pumps, and SGLT2 inhibitors.[89] [19]
- Patients with EDKA secondary to treatment with an SGLT2 inhibitor may have less polyuria and polydipsia due to a lower glucose level. They may instead present with malaise, anorexia, tachycardia, or tachypnoea with or without fever.[17]

**Always order the following investigations**

Venous blood gas[42]

- This will show a **metabolic acidosis** with a **raised anion gap**.
  - Anion gap >16 indicates severe DKA.
  - Use the pH to determine the severity of DKA.
    - pH ≥7.0 indicates mild or moderate DKA.
    - pH <7.0 indicates severe DKA. Discuss these patients with critical care.
  - Use the **potassium level** on venous blood gas to **replace potassium if ≤5.5 mmol/L**. Discuss with a senior or critical care if potassium is <3.5 mmol/L.
  - Calculate the plasma osmolality.
    - Plasma osmolality is high (>320 mmol/kg) in DKA and is an indication of dehydration.[53] [61]

**Evidence: Use of a venous versus arterial blood gas**

*Venous blood gas measurements are widely used instead of arterial blood gas measurements and evidence from case studies suggests there is sufficient agreement between them, when combined with other clinical findings, to use a venous blood gas to guide initial treatment.*
A clinical review article aimed to answer the question “can venous blood gas analysis replace arterial blood gas analysis in emergency care?” [90]

- Venous blood gas testing may have a lower risk of serious adverse events (e.g., vascular occlusion or infection), is less painful for the patient, and is technically easier to perform than arterial blood gas testing.
- There is little difference in pH values between venous and arterial samples (based on 13 studies; 2009 participants, with 3 studies [295 patients] in patients with DKA).[91]
- Bicarbonate values also show close agreement between venous and arterial samples (8 studies; 1211 patients).[91]
- Agreement for PCO$_2$ is poor and unpredictable (8 studies; 965 patients), but a venous PCO$_2$ ≤45 mmHg (6 kPa) reliably excludes clinically significant hypercarbia (4 studies; 529 patients; 100% sensitivity).[91]
- Agreement on lactate is close enough to categorise as high or normal (3 studies; 338 patients).[92]
- Evidence regarding arteriovenous agreement for base excess is unclear (2 studies; 429 patients; only 1 study reporting close agreement).[93] [94]
- If data from the venous blood gas does not appear to match the patient’s clinical condition, an arterial blood gas should be performed.[90]

Blood ketones[42]

- This will show ketonaemia (ketones ≥3.0 mmol/L) in DKA.[42]
- Use urinary ketones if near patient blood ketone testing is unavailable. This will show ketonuria (more than 2+ on standard urine sticks).[42]

**Practical tip**

Bear in mind that a patient’s medications can cause errors in detecting ketone bodies.[46] Some drugs, such as the ACE inhibitor captopril, contain sulfhydryl groups that can react with the reagent in the nitroprusside test (used to test for ketone bodies) to give a false-positive reaction. Therefore, use clinical judgement and other biochemical tests in patients who are taking these medications.

Blood glucose

- **Hyperglycaemia** (blood glucose >11.1 mmol/L) is common.[52]
  - This blood glucose cut-off is recommended in the 2020 Joint British Diabetes Societies (JBDS) guideline “Diabetes at the front door” and supersedes the 11.0 mmol/L cut-off recommended in the 2013 JBDS guideline “The management of diabetic ketoacidosis in adults”.[42] [52]
  - Be aware that some patients can present with euglycaemic DKA and have a normal blood glucose.[65]

Urea and electrolytes

- **Hyponatraemia** is common in DKA.[42]
  - Hyponatraemia with hyperglycaemia indicates severe dehydration, however.[46]
- **Hyperkalaemia** is common but hypokalaemia is an indicator of severe DKA.[42] [46]
  - Hypokalaemia on arrival indicates severe total-body potassium deficit and is an indicator of severe DKA.[46] This is because the total body potassium concentration is low due to increased diuresis.
Diabetic ketoacidosis (DKA)

**Diagnosis**

- Hyperkalaemia is due to an extracellular shift of potassium caused by insulin insufficiency, hypertonicity, and acidosis.
- Hypomagnesaemia and hypophosphataemia may also be present.[42] [66]

**Full blood count**

- **Leukocytosis** is common in DKA and correlates with blood ketone levels.[46]
- However, leukocytosis more than $25 \times 10^9/\text{L}$ (25,000/microlitre) may indicate infection and requires further investigation.[46]

**Consider ordering the following investigations**

**Urinalysis**

- Order if near-patient testing for ketones is unavailable or you suspect a urinary tract infection.[42] [51]
- Shows ketonuria (more than 2+ on standard urine sticks) in patients with DKA.[42]
- May be positive for glucose.[95]
- Other findings include leukocytes and nitrates in the presence of infection, and myoglobinuria and/or haemoglobinuria in rhabdomyolysis.[95] [96] [97]

**ECG**

- Use to look for cardiac precipitants of DKA such as myocardial infarction.[42]
  - Findings may include abnormal T or Q waves or ST segment changes.[98]
  - Look for cardiac effects of electrolyte abnormalities.
    - Evidence of hypokalaemia (U waves) or hyperkalaemia (tall ‘peaked’ T waves) may be present.[99] [100]

**Pregnancy test**

- Order in all women of childbearing age.[42]

**Amylase and lipase**

- Amylase is elevated in most patients with DKA.[46]
- Serum lipase is usually normal in patients with DKA.[46]
  - This may differentiate DKA from pancreatitis (lipase level will be elevated in patients with pancreatitis). However, mildly elevated serum lipase level in the absence of pancreatitis has also been reported in patients with DKA.

**Cardiac enzymes**

- Order troponin T or I if you suspect myocardial infarction as a precipitant.[101]

**Creatinine kinase**

- Elevated if rhabdomyolysis is present. This is common in DKA and present in around 10% of patients.[96]

**Chest x-ray**

- Order if there are reduced oxygen saturations.[42]
• Signs of pulmonary oedema are pleural effusions, interstitial and alveolar oedema, prominent superior vena cava, Kerley B lines, and dilated upper lobe blood vessels.[102]
• Consolidation occurs in pneumonia.

Liver function tests (LFTs)

• Use to screen for an underlying hepatic precipitant of DKA. Abnormal LFTs indicate underlying liver disease (e.g., non-alcoholic fatty liver disease or congestive heart failure).[103] [104]

Blood, urine, and sputum cultures

• Order these if there are signs of infection.
• The most common infections are pneumonia and urinary tract infections.[56]
• Patients with DKA who have an infection are usually normothermic or hypothermic due to peripheral vasoconstriction, so fever may not be seen.[53]

Procedural videos

History and exam

Key diagnostic factors

known diabetes or features of diabetes (common)

Consider DKA in:

• Patients with known diabetes who are unwell[2] [42] [17]
  • DKA is most common in people with type 1 diabetes but can also present in those with type 2 diabetes.[42] [46]
  • Patients with features of diabetes AND any of the following:[17] [48]
    • Nausea and vomiting
    • Abdominal pain[2] [49]
    • Hyperventilation (Kussmaul's respiration)[50]
    • Dehydration
    • Reduced consciousness.

Features of diabetes are increased thirst, polyuria, recent unexplained weight loss, or excessive tiredness.[17] [48]

nausea and vomiting (common)

Suspect DKA if this is present in a patient with known diabetes, increased thirst, polyuria, recent unexplained weight loss, or excessive tiredness.[17] [48]

abdominal pain (common)

dehdration (common)

Check for signs of dehydration. These are:[17]
Diabetic ketoacidosis

Diagnosis

• Dry mucous membranes
• Decreased skin turgor or skin wrinkling
• Slow capillary refill
• Tachycardia with a weak pulse
• Hypotension.

hyperventilation (common)

This is a late sign of DKA and occurs with more severe acidosis. Characterised by deep sighing respirations at a slow or normal rate.

reduced consciousness (common)

Assess conscious level hourly using the Glasgow Coma Scale to monitor for cerebral oedema. Reduced consciousness is strongly associated with more severe DKA and a worse prognosis.

• Mental status can range from alert in mild DKA to coma in severe DKA.
• Cerebral oedema can develop during treatment of DKA due to rapid correction of hyperglycaemia.

  • Signs include headache, irritability, slowing pulse, rising blood pressure, reducing conscious level. These may occur several hours after starting treatment.
  • Papilloedema is a late sign of cerebral oedema.
  • Involve immediate critical care input and give mannitol.
  • Cerebral oedema has a mortality rate of 70%. It is most common in children and adolescents but can occur in adults.

risk factors (common)

Infection

• This is the most common cause of DKA.
  • The most common causes are pneumonia and urinary tract infection.

Discontinuation of insulin (unintentional or deliberate)

• This is the second most common cause of DKA.
  • Ask sensitively about reasons for deliberate discontinuation of insulin, which may include fear of weight gain or hypoglycaemia, financial barriers, and psychological factors such as needle phobia and stress.
  • Younger patients with type 1 diabetes may omit insulin due to fear of hypoglycemia, weight gain, eating disorders, or the stress of having a chronic disease. These factors may account for 20% of recurrent DKA.

Inadequate insulin

• Common reasons are:
Diabetic ketoacidosis

**Diagnosis**

- Malfunctioning insulin pen or pump\[54\] [55]
- Degradation of insulin due to storage at incorrect temperature.[55]

**New onset of diabetes[17]**

- A common cause of DKA.

**Acute illness**

- Common causes include myocardial infarction, sepsis, and pancreatitis\[15\] [30]
  - Maintain a high level of suspicion for myocardial infarction as patients with diabetes often present with atypical symptoms.

**Practical tip**

Some patients with diabetes may present with a ‘silent myocardial infarction’ with no or minimal chest pain. This is thought to be due to cardiac autonomic dysfunction.[75] [76]

**Physiological stress**

- This includes pregnancy, trauma, and surgery.
- Some women may develop DKA during menstruation.[73] [74]

**Practical tip**

Diagnosis of DKA in pregnancy is often delayed because it can occur at lower blood glucose levels and faster than in non-pregnant patients.[77]

DKA usually occurs in the second and third trimesters due to increased insulin resistance.[77]

**Past medical history**

- History of diabetes:
  - DKA is most common in people with type 1 diabetes but can occur in those with type 2 diabetes.[46]

**Drug history[17]**

- Drugs that may cause DKA include:
  - Corticosteroids (increase insulin resistance)[57]
  - Thiazides (unclear cause but may increase insulin resistance, inhibit glucose uptake, and decrease insulin release)
  - Sympathomimetics (alter glucose metabolism)[26]
  - Second-generation antipsychotics (alter glucose metabolism)[58]
  - Immune checkpoint inhibitors (cause insulin deficiency)[59]
  - Cocaine, cannabis, and acute intoxication with alcohol (DKA is associated with cocaine use but the mechanism is unclear)[56] [60]
Diabetic ketoacidosis

Diagnosis

- SGLT2 inhibitors (prevent reabsorption of glucose and facilitate its excretion in urine).[21][22]

hypothermia (uncommon)

Severe hypothermia is associated with a mortality rate of 30% to 60%.[68] Mild hypothermia may be seen in some patients with DKA due to peripheral vasodilation.[46]

Practical tip

Fever is not a feature of DKA but DKA may be caused by sepsis. Suspect sepsis as a cause of DKA if there is fever or hypothermia, hypotension, refractory acidosis, or lactic acidosis.[51]

Other diagnostic factors

acetone smell on breath (common)

The patient’s breath smells like pear drops or nail varnish remover.[17] This is due to high ketone levels.

Practical tip

A significant proportion of people are unable to smell acetone even if it is present.
## Investigations

### 1st test to order

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>venous blood gas</td>
<td>metabolic acidosis with a raised anion gap</td>
</tr>
<tr>
<td></td>
<td>• anion gap &gt;16 indicates severe DKA.</td>
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<tr>
<td></td>
<td><strong>Diagnosis</strong></td>
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<td><strong>Test</strong></td>
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<tr>
<td>venous blood gas</td>
<td>Take a venous (rather than arterial) blood gas in all patients with</td>
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<td>suspected DKA.[42]</td>
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<td></td>
<td>• Use the pH to determine the severity of DKA.</td>
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<td>• pH ≥7.0 indicates mild or moderate DKA.</td>
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<td>• pH &lt;7.0 indicates severe DKA. Discuss these patients with</td>
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<td>• Hyperkalaemia is common.[46]</td>
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<td>• Use the potassium level on venous blood gas to replace potassium if</td>
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<td>≤5.5 mmol/L. Discuss with critical care if potassium is &lt;3.5 mmol/L.</td>
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<td>• Calculate the plasma osmolality.</td>
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<td>• Plasma osmolality is high (&gt;320 mmol/kg) in DKA and is an</td>
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<td>indication of dehydration.[53] [61]</td>
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<td>• There is persistent hypotension (systolic blood pressure &lt;90 mmHg) or oliguria (urine output &lt;0.5 ml/kg/hour) despite intravenous fluids</td>
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<td>• Glasgow Coma Scale &lt;12</td>
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<td></td>
<td>• Blood ketones &gt;6 mmol/L</td>
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<td>• Venous bicarbonate &lt;5 mmol/L</td>
</tr>
<tr>
<td></td>
<td>• Venous pH &lt;7.0</td>
</tr>
<tr>
<td></td>
<td>• Potassium &lt;3.5 mmol/L on admission</td>
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<tr>
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<td>• Oxygen saturations &lt;92% on air</td>
</tr>
<tr>
<td></td>
<td>• Pulse &gt;100 bpm or &lt;60 bpm</td>
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<tr>
<td></td>
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</tr>
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<tr>
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*pregnancy test*  
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*amylase and lipase*  
Amylase is elevated in most patients with DKA.  
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## Diabetic ketoacidosis

### Diagnosis

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<td><strong>cardiac enzymes</strong></td>
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<td><strong>creatine kinase</strong></td>
<td>Elevated if rhabdomyolysis is present. This is common in DKA and present in around 10% of patients.[96] elevated with rhabdomyolysis</td>
</tr>
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<td><strong>chest x-ray</strong></td>
<td>Order if there are reduced oxygen saturations.[42]</td>
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<tr>
<td></td>
<td>• signs of pulmonary oedema are pleural effusions, interstitial and alveolar oedema, prominent superior vena cava, Kerley B lines, and dilated upper lobe blood vessels[102]</td>
</tr>
<tr>
<td></td>
<td>• consolidation occurs in pneumonia</td>
</tr>
<tr>
<td><strong>liver function tests</strong></td>
<td>Use to screen for an underlying hepatic precipitant of DKA. Abnormal LFTs indicate underlying liver disease (e.g., non-alcoholic fatty liver disease or congestive heart failure).[103] [104] elevated with liver disease</td>
</tr>
<tr>
<td><strong>blood, urine, and sputum cultures</strong></td>
<td>Order these if there are signs of infection. The most common are pneumonia and urinary tract infections.[56] positive if infection present</td>
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## Differentials

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<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
</table>
| Hyperosmolar hyperglycaemic state (HHS)       | • Patients are typically older than patients with DKA and are usually patients with type 2 diabetes. Older nursing home residents with poor fluid intake are at high risk.  
  • Symptoms evolve insidiously over days to weeks.  
  • Mental obtundation and coma are more frequent. Focal neurological signs (hemianopia and hemiparesis) and seizures are also seen. Seizures may be the dominant clinical features.[1] | • Serum glucose is >33.3 mmol/L (>600 mg/dL). Serum osmolality is usually >320 mmol/ kg (>320 mOsm/kg).  
  • Urine ketones are normal or only mildly positive. Serum ketones are negative.  
  • Anion gap is variable but typically <12 mmol/L (<12 mEq/L).  
  • Total chloride deficit is 5 to 15 mmol/kg (5 to 15 mEq/ kg).  
  • ABG: arterial pH is typically >7.30, whereas in DKA it ranges from 7.00 to 7.30. Arterial bicarbonate is >15 mmol/L (>15 mEq/L). |
| Lactic acidosis                                 | • The presentation is identical to that of DKA. In pure lactic acidosis, the serum glucose and ketones should be normal and the serum lactate concentration should be elevated. | • Serum lactate >5 mmol/L.[1]                                                                                                                                                                                    |
| Starvation ketosis                              | • Starvation ketosis results from inadequate carbohydrate availability resulting in physiologically appropriate lipolysis and ketone production to provide fuel substrates for muscle. |                                                                                                                                                        |
| Alcoholic ketoacidosis                          | • Classically, these are people with long-standing alcohol use disorder for whom ethanol has been the main caloric source for days to weeks. The ketoacidosis occurs when for some reason alcohol and caloric intake decreases. | • The blood glucose is usually normal. Although the urine can have large amounts of ketones, the blood rarely does. Arterial pH is normal and the anion gap is at most mildly elevated.[1] |
| Salicylate poisoning                            | • Can be differentiated by history and laboratory investigation. Salicylate intoxication produces an anion gap metabolic acidosis | • In isolated alcoholic ketoacidosis, the metabolic acidosis is usually mild to moderate in severity. The anion gap is elevated. Serum and urine ketones are always present. Blood alcohol may be undetectable and the patient may be hypoglycaemic.[1] |

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**Diagnosis**

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Diabetic ketoacidosis

**Diagnosis**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Differentiating signs / symptoms</th>
<th>Differentiating tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic ketoacidosis</td>
<td>usually with a respiratory alkalosis.</td>
<td>or urine. It should be noted that salicylates may cause false-positive or false-negative urinary glucose determination.[1]</td>
</tr>
<tr>
<td>Ethylene glycol/methanol intoxication</td>
<td>• Methanol and ethylene glycol also produce an anion gap metabolic acidosis without hyperglycaemia or ketones.</td>
<td>• Methanol/ethylene glycol serum levels are elevated. They can produce an increase in the measured serum osmolality.[1]</td>
</tr>
<tr>
<td>Uraemic acidosis</td>
<td>• This is characterised by markedly elevated serum urea and creatinine with normal plasma glucose. The pH and anion gap are usually mildly abnormal.</td>
<td>• Elevated urea usually &gt;71.4 mmol/L (&gt;200 mg/dL) and elevated creatinine usually &gt;884 micromol/L (&gt;10 mg/dL).[1]</td>
</tr>
</tbody>
</table>

**Criteria**

Diagnose DKA if:[51] [42] [17]

- Blood ketones are ≥3.0 mmol/L OR there is ketonuria (more than 2+ on standard urine sticks) AND
- Blood glucose is >11.1 mmol/L OR known diabetes
  
  - This blood glucose cut-off is recommended in the 2020 Joint British Diabetes Societies (JBDS) guideline "Diabetes at the front door" and supersedes the 11.0 mmol/L cut-off recommended in the 2013 JBDS guideline "The management of diabetic ketoacidosis in adults".[42] [52]

  AND

  - Bicarbonate (HCO₃⁻) is <15.0 mmol/L AND/OR venous pH is <7.3.

Rarely, patients present with euglycaemic DKA and have a normal blood glucose level.[89] [17]

**Screening**

Consider DKA in:

- Patients with known diabetes who are unwell[2] [42] [17]
  
  - DKA is most common in people with type 1 diabetes but can also present in those with type 2 diabetes.[46] [42]
  
  - Any patient with increased thirst, polyuria, recent unexplained weight loss or excessive tiredness, AND any of the following:[105] [17]
    
    - Nausea and vomiting
    - Abdominal pain[49] [2]
    - Hyperventilation (Kussmaul’s respiration)[50]
    - Dehydration
Diabetic ketoacidosis

Diagnosis

- Reduced consciousness.

Urgently order a venous blood gas, blood ketones, and capillary blood glucose.
Diabetic ketoacidosis

Recommendations

Urgent

Start intravenous fluids as soon as DKA is confirmed.[42] [17] [47] [105]

- Give a fluid bolus of 500 mL of normal saline (0.9% sodium chloride) over 10 to 15 minutes if the initial systolic blood pressure (SBP) is <90 mmHg. [106]
  - Repeat the fluid bolus if SBP remains <90 mmHg and get help from a senior colleague.
  - Repeat the fluid bolus, get an immediate senior review and consider involving critical care if there is no improvement after the second fluid bolus.
- Give 1 L of normal saline over 1 hour if the initial SBP is >90 mmHg OR if SBP is >90 mmHg after fluid resuscitation.
- Give more cautious fluids and consider monitoring central venous pressure (CVP) in patients who:
  - Are young (aged 18-25 years), elderly, or pregnant
  - Have heart or kidney failure or other serious comorbidities.
- Add potassium to the second litre of intravenous fluid if serum potassium is ≤5.5 mmol/L using pre-mixed normal saline with potassium chloride.

Start a fixed-rate intravenous insulin infusion (FRIII) according to local protocols.[42] [17] [47] [105]

Ensure intravenous fluids have already been started before giving a FRIII.

Ensure continuous cardiac monitoring and involve senior or critical care support if:[42]

- There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
- Glasgow Coma Scale <12
- Blood ketones >6 mmol/L
- Venous bicarbonate <5 mmol/L
- Venous pH <7.0
- Potassium <3.5 mmol/L on admission
- Oxygen saturations <92% on air
- Pulse >100 bpm or <60 bpm
- Anion gap >16
- The patient is pregnant or has heart or kidney failure or other serious comorbidities.

Identify and treat any precipitating acute illness.[42]

- Common causes are myocardial infarction, sepsis, and pancreatitis.[47] [30]
Key Recommendations
Management of diabetic ketoacidosis

1. Intravenous fluid

Initial systolic blood pressure (SBP) < 90 mmHg

* Give a fluid bolus of 500 mL normal saline over 10-15 minutes

SBP remains < 90 mmHg after fluid bolus

* Repeat the fluid bolus, get an immediate senior review and consider involving critical care

Initial SBP ≥ 90 mmHg

* Give 1 L of normal saline over 60 minutes

SBP ≥ 90 mmHg after fluid bolus

* Give ongoing fluid replacement as follows:
  - 1 L of normal saline with potassium chloride over next 2 hours
  - 1 L of normal saline with potassium chloride over next 2 hours
  - 1 L of normal saline with potassium chloride over next 4 hours

Give 10% glucose 125 mL/hour in addition to normal saline if blood glucose falls below 14 mmol/L

* Give more cautious fluids in patients who:
  - Are young (aged 18-25 years), elderly or pregnant
  - Have heart or kidney failure or other serious comorbidities

Management of diabetic ketoacidosis 1. Intravenous fluid

by BMJ Knowledge Centre
Management of diabetic ketoacidosis 2. Potassium

By BMJ Knowledge Centre

2. Potassium
Measure urgently on venous blood gas and reassess at 60 minutes, 2 hours and 2 hourly thereafter

- Potassium level <3.5 mmol/L
  Get an immediate senior review as additional potassium needs to be given

- Potassium level 3.5 to 5.5 mmol/L
  Add 40 mmol/L potassium (use premixed normal saline with potassium chloride)

- Potassium level >5.5 mmol/L
  Do not add potassium to initial intravenous fluid

Management of diabetic ketoacidosis 3. Insulin

By BMJ Knowledge Centre

3. Insulin
Start a fixed rate insulin infusion according to local protocols

Assess response to treatment hourly

- Blood ketones falling by at least 0.5 mmol/L/hour
  Continue fixed-rate insulin until:
  Blood ketones are <0.6 mmol/L
  AND
  Venous pH is >7.3
  AND
  Bicarbonate >15 mmol/L

- Blood ketones not falling by at least 0.5 mmol/L/hour (and no insulin pump malfunction)
  Increase the fixed-rate insulin infusion rate according to local protocols
Additional management during the first hour

Protect the airway.

- Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting.[42] [105]

Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment.[42] [105]

Give a dose of long-acting insulin to prevent rebound hyperglycaemia when DKA has resolved and the FRIII is stopped.

- Continue long-acting basal insulin if the patient is already taking this.[42]
- If this is the first presentation of diabetes, start a long-acting basal insulin as soon as possible.

Involve the specialist diabetes team as soon as possible and definitely within 24 hours.[42]

Ongoing management

Give ongoing fluid replacement once the first litre of fluid has been given. Add potassium if serum potassium is ≤5.5 using pre-mixed normal saline (0.9% sodium chloride) with potassium chloride.[17] [105]

- A typical regimen for a 70 kg patient with no other comorbidities is:[42] [105]
Volume of normal saline (with potassium chloride as needed)

<table>
<thead>
<tr>
<th>Volume of saline</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 litre</td>
<td>over 2 hours</td>
</tr>
<tr>
<td>1 litre</td>
<td>over next 2 hours</td>
</tr>
<tr>
<td>1 litre</td>
<td>over next 4 hours</td>
</tr>
<tr>
<td>1 litre</td>
<td>over next 4 hours</td>
</tr>
<tr>
<td>1 litre</td>
<td>over next 6 hours</td>
</tr>
</tbody>
</table>

Continue the FRIII.[42] [17] [105]

- **Add 10% glucose if the blood glucose falls to <14.0 mmol/L.** Give this concurrently with normal saline to correct the dehydration.[47]

Monitor biochemical parameters to ensure these are improving.[42] [105]

- **Measure venous bicarbonate, potassium, pH, blood glucose, and blood ketones as follows:**

<table>
<thead>
<tr>
<th>Ketones</th>
<th>Glucose</th>
<th>Bicarbonate</th>
<th>Potassium</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>1 hour</td>
<td>#</td>
<td>#</td>
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<tr>
<td>2 hours</td>
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<tr>
<td>3 hours</td>
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<tr>
<td>4 hours</td>
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<tr>
<td>5 hours</td>
<td>#</td>
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<tr>
<td>6 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>12 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
</tbody>
</table>

Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.[42]

- Use venous bicarbonate or blood glucose if blood ketone measurement is unavailable. Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.
- Increase the FRIII according to local protocols if these targets are not met.

Monitor for cerebral and pulmonary oedema.[42]

- Assess Glasgow Coma Scale hourly.
- Order a chest x-ray if oxygen saturations fall and consider performing an arterial blood gas.
Resolution of DKA

Involves senior or specialist input if DKA has not resolved within 24 hours. Resolution of DKA is defined as:[42]

- Venous pH >7.3 AND
- Blood ketone level <0.6 mmol/L AND
- Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies (JBDS) guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

Switch to subcutaneous insulin once DKA has resolved and the patient is eating and drinking. This should normally be done by the specialist diabetes team.[42]

- Start subcutaneous insulin with a meal and continue the FRIII for 30 to 60 minutes after this.

Continue intravenous fluids and switch to a variable rate intravenous insulin infusion (VR III) if DKA is resolved but the patient is not eating and drinking.[42]

Discharge

Ensure the patient has been reviewed by the diabetes specialist team before discharge and has follow up.[42]

Counsel patients about causes and early warning symptoms of DKA. Provide access to psychological support.

Full Recommendations

Treatment goals

Treatment should aim to:[42]

- Restore circulatory volume[47]
- Suppress ketogenesis[47]
- Correct electrolyte imbalance[47]
- Normalise blood glucose
- Treat the precipitating cause and prevent complications.

Management during the first hour

Protect the airway.

- Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or persistently vomiting.[42] [105]
- Aspiration is a common complication of DKA due to gastroparesis.[105] [107]

Insert a large bore cannula and start intravenous fluids as soon as DKA is confirmed.[42] [47]

- Seek immediate help from critical care if you are unable to get intravenous access.[42]
Diabetic ketoacidosis

Management

Give a fluid bolus of 500 mL normal saline (0.9% sodium chloride) over 10 to 15 minutes if the initial SBP is <90 mmHg. [42]

- Repeat the fluid bolus if SBP remains <90 mmHg and seek senior help. [42]
- Repeat the fluid bolus, get an immediate senior review and consider involving critical care if there is no improvement after the second fluid bolus.
  - Consider other causes of hypotension (e.g., sepsis, heart failure, acute myocardial infarction). [42]

Practical tip

Most patients require 500 to 1000 mL of fluid rapidly on arrival. [42]

Debate: Management of mild/moderate DKA - an alternative approach

Some experts have suggested an alternative approach for the acute management of mild DKA.

An alternative approach has been suggested by some for patients who are alert, do not otherwise need admission to a critical care area, and have a pH >7.0 and bicarbonate ≥10 mmol/L (≥10 mEq/L). [17]

- This approach involves oral fluids instead of intravenous fluids and subcutaneous rapid-acting insulin instead of intravenous insulin, and it is suggested that these patients may not require hospital admission.
- The majority of patients with DKA are admitted to hospital. However, a national study of around 753,000 emergency department visits by patients with DKA in the US found that this was not the case for all patients; 87% of patients were admitted to hospital from the emergency department. [112]
- It is the opinion of the expert panel member advising on this topic that avoiding hospital admission is unlikely in UK practice for patients diagnosed with DKA.

Specific diagnostic criteria for DKA may vary between different countries.

- Differences in management between countries may reflect the fact that specific diagnostic criteria may vary, as well as the lack of published evidence to guide treatment in many areas. [17]
- The American Diabetes Association guidelines from 2009 and the UK Joint British Diabetes Societies for Inpatient Care guidelines from 2013 both report cut-offs for diagnosing DKA if pH<7.3 and severe DKA if pH<7.0. [42] [46]
- However, the cut-offs for bicarbonate are different in different guidelines for DKA in adults as follows: [17]
  - American Diabetes Association: mild: 15 to 18 mmol/L; moderate: 10 to 14.9 mmol/L; and severe: <10 mmol/L [46]
  - 2013 Joint British Diabetes Societies for Inpatient Care: overall DKA <15 mmol/L and severe: <5 mmol/L [42]
- Cut-offs for the anion gap are also different:
Diabetic ketoacidosis

Management

- American Diabetes Association: severe: >12
- 2013 Joint British Diabetes Societies for Inpatient Care: severe: >16.

Give 1 L of normal saline over 1 hour if SBP >90 mmHg OR if initial SBP is >90 mmHg.

- Typical fluid deficits in DKA are:
  - Water - 100 mL/kg
  - Sodium - 7 to 10 mmol/kg
  - Chloride - 3 to 5 mmol/kg
  - Potassium - 3 to 5 mmol/kg.
- The aim of the first few litres of fluid is to:
  - Correct any hypotension
  - Replenish the intravascular deficit
  - Correct any electrolyte disturbance.

Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:

- Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
- Are elderly or pregnant
- Have heart or kidney failure or other serious comorbidities.

Practical tip

Hartmann’s solution (Ringer’s lactate) is not normally used outside of critical care. This is because it:

- Contains 29 mmol/L of lactate, which can exacerbate the high lactate to pyruvate ratio in DKA and lead to adverse outcomes
- Raises the plasma lactate, which leads to more glucose being produced
- Contains 5 mmol/L of potassium, which can lead to fatal cardiac arrhythmias such as bradycardia or asystole if the patient has hyperkalaemia on arrival
- Contains bicarbonate, which can worsen the existing metabolic acidosis
- Is a hypotonic solution. This increases the risk of cerebral oedema in patients who are hyponatraemic on arrival.

Debate: Normal saline versus Hartmann’s solution for resuscitation

There is a debate about the benefits of using normal saline (0.9% sodium chloride) over Hartmann’s solution (Ringer’s lactate) in patients with DKA, as both have advantages and disadvantages. In the UK, the 2013 Joint British Diabetes Societies for Inpatient Care guideline recommends using normal saline for fluid resuscitation in patients with DKA on the general ward.

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Two randomised controlled trials (RCTs) with small patient numbers comparing balanced electrolyte solution with normal saline and were unable to show clear evidence of a difference in terms of clinical outcomes. [125] [126]

Normal saline for fluid resuscitation in patients with DKA

• Advantages:
  
  • Normal saline is readily available on general wards and clinicians are experienced with this product.[42]
  • Normal saline is available with pre-mixed potassium so it complies with the UK National Patient Safety Agency (NPSA) recommendations. The NPSA states that commercially prepared ready to use diluted solutions containing potassium should be used wherever possible to reduce the risk of misadministration of potassium, so normal saline is recommended in the UK.[127] [42]
  • It is important to avoid the need to add concentrated potassium to resuscitation fluids, as there is a risk of death from misadministration of concentrated potassium.[128]

• Disadvantages:
  
  • A potential disadvantage of normal saline is that hyperchloraemic metabolic acidosis is a possible complication, due to the large volume of sodium chloride required for fluid resuscitation in DKA.[42]
  • Hyperchloraemic metabolic acidosis may result in a delay to resolution of the acidosis because it can cause arterial vasoconstriction in the kidneys and subsequent oliguria.[42]

Hartmann’s solution (Ringer’s lactate) for fluid resuscitation in patients with DKA

• Advantages:
  
  • Hartmann’s solution has a minimal tendency to cause hyperchloraemic metabolic acidosis, due to the lower chloride content than normal saline.[42]

• Disadvantages:
  
  • In general, doctors in the UK are less familiar using Hartmann’s solution clinically and it is not as readily available in clinical areas.[42]
  • Hartmann’s solution contains potassium, which could be harmful in early DKA.[122]
  • However, it also does not contain enough potassium if used alone once the potassium levels begin to fall. It is also not commercially available with pre-mixed potassium and therefore it does not comply with UK NPSA recommendations.[42]
  • Hartmann’s solution can further increase the lactate to pyruvate ratio, which is raised in DKA, worsen acidosis due to the bicarbonate content, and worsen cerebral oedema as it is hypotonic.[122]

In the UK, the 2013 Joint British Diabetes Societies for Inpatient Care guideline on DKA recommends always using normal saline as the preferred fluid for resuscitation in DKA on the general medical ward. [42]
Add potassium to the second litre of intravenous fluids if serum potassium is ≤5.5 mmol/L using pre-mixed normal saline with potassium chloride. Replace according to the potassium level on a venous blood gas as follows:[42] [105]

<table>
<thead>
<tr>
<th>Potassium level (mmol/L)</th>
<th>Potassium replacement (mmol/L of infusion solution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3.5</td>
<td>Involve senior or critical care support as additional potassium needs to be given</td>
</tr>
<tr>
<td>3.5 to 5.5</td>
<td>40</td>
</tr>
<tr>
<td>&gt;5.5</td>
<td>None</td>
</tr>
</tbody>
</table>

Use normal saline with pre-mixed potassium chloride as the default fluid for resuscitation in DKA.

- Manually adding potassium to intravenous fluids in general clinical areas is unsafe as this can result in accidental overdose of potassium, which can be fatal.[127]
- Hyperkalaemia and hypokalaemia are life-threatening complications and common in DKA.[42] [17]
  - These can precipitate life-threatening cardiac arrhythmias.
  - Serum potassium is often high on admission (although total body potassium is low).

Start a FRIII according to local protocols.[42] [17] [47] [105]

- Ensure intravenous fluids have been started before giving a FRIII.
- Seek advice from the diabetes specialist team if >15 units/hour of insulin are required.[42] [54]

**Practical tip**

- Only give an intramuscular bolus of insulin if there is a delay in setting up a FRIII.[42]
- Write out ‘units’ when prescribing insulin. Never use abbreviations such as ‘U’ or ‘IU’. [42]
- Estimate the patient’s weight if necessary.[42]
- If the patient is pregnant, use the current pregnancy weight and call for immediate senior obstetric help.[42]
- Avoid rapid correction of hyperglycaemia as this increases the risk of cerebral oedema.[61]

**Evidence: Insulin rate**

>A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.

The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour. [42]
Diabetic ketoacidosis

### Management

- A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.[17]
- The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg bolus of intravenous insulin, based on evidence from a small trial of 37 patients.[46]
- The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.[17]
- One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

<table>
<thead>
<tr>
<th>Evidence: Priming (bolus) dose of insulin</th>
</tr>
</thead>
</table>

There is a lack of research evidence on the use of a priming (bolus) dose of insulin and guidelines vary in their recommendations.

A prospective observational study found no evidence of benefit for a priming bolus dose of insulin. [130]

- This study compared 78 adults with DKA receiving a bolus of insulin with 79 similar patients who did not receive the bolus.
- There were no differences between the groups for the following outcomes:
  - Hypoglycaemia
  - Rate of change of glucose or anion gap
  - Length of hospital stay.

Guidelines vary in their recommendation on whether to use a priming (bolus) dose of insulin in patients with DKA.

- The 2009 American Diabetes Association guideline suggests using a bolus of 0.1 units/kg before the intravenous continuous insulin infusion is started at a rate of 0.1 units/kg/hour, based on evidence from a small trial of 37 patients.[46][46]
- The UK 2013 Joint British Diabetes Societies for Inpatient Care guideline states that a priming dose of insulin is not required as long as the insulin infusion has been started promptly at a rate of at least 0.1 units/kg/hour.[42]

Ensure continuous cardiac monitoring and involve senior or critical care support if:[42]

- There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
- Glasgow Coma Scale <12
- Blood ketones >6 mmol/L
- Venous bicarbonate <5 mmol/L
Diabetic ketoacidosis

Management

- Venous pH < 7.0
- Potassium < 3.5 mmol/L on admission
- Oxygen saturations < 92% on air
- Pulse > 100 bpm or < 60 bpm
- Anion gap > 16
- The patient is pregnant or has heart or kidney failure or other serious comorbidities.

- DKA in pregnancy can result in significant morbidity and mortality for both the mother and the fetus. [69]

Consider giving bicarbonate only if venous pH < 6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment. [131]

- Bicarbonate has been associated with the development of cerebral oedema. [131]

Evidence: Intravenous bicarbonate

*Evidence to date does not justify using intravenous bicarbonate for the emergency treatment of DKA in patients with a pH > 6.9.*

A systematic review reported data from 44 studies of bicarbonate treatment for severe acidaemia in patients with DKA, including three RCTs in adults (total number: 73 adults). [132]

- Two of the included RCTs in adults showed transient improvement in metabolic acidosis with bicarbonate within the initial 2 hours, but no evidence of improved glycaemic control or clinical efficacy. [132]
- It found no studies reporting on cerebral oedema in adults or on patients with an admission pH < 6.85. [132]
  - Retrospective studies in children receiving bicarbonate for DKA have found an increased risk of cerebral oedema and prolonged hospitalisation. [132]

The UK 2013 Joint British Diabetes Societies for Inpatient Care does not recommend routine use of intravenous bicarbonate for DKA in adults. Seek senior advice if your patient has severe acidosis, or if bicarbonate treatment is being considered.

Evidence: Use of intravenous phosphate

*There is a lack of evidence for the benefit of giving intravenous phosphate to patients with DKA, so the UK 2013 Joint British Diabetes Societies for Inpatient Care guidelines do not recommend routine replacement, although it may be considered if there is severe hypophosphataemia with associated skeletal or respiratory muscle weakness.* [42] [66]

A literature review found limited research on the addition of phosphate to standard treatment for patients with DKA. [107]

- Two RCTs cited in this review, including a total of 74 patients with DKA, found that adding phosphate to standard treatment did not reduce the time taken to correct bicarbonate, pH, or glucose levels. [133] [134]
• Phosphate levels are affected in DKA in a similar way to potassium (i.e., extracellular shift but depleted total body levels).

**UK guidelines do not recommend the routine measurement or replacement of phosphate.** [42]

• However, this could be considered in the presence of respiratory and skeletal muscle weakness (based on limited evidence from a case report). [42] [135]

Discuss severe hypomagnesaemia with a senior; magnesium may need to be replaced but there is no guidance for cut-off values.

Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment. [42] [105]

Give a dose of long-acting insulin to prevent rebound hyperglycaemia when DKA has resolved and the FRIII is stopped. [42]

• Continue long-acting basal insulin if the patient is already taking this.
• If this is the first presentation of diabetes, start a long-acting basal insulin as soon as possible.

**Practical tip**

Never omit insulin in any patient with type 1 diabetes as this can precipitate DKA. [17]

• In a UK survey, more than 7% of cases of DKA were in an inpatient population. It is often wrongly assumed that patients aged over 50 years have type 2 diabetes and can tolerate periods of insulin omission when admitted to hospital.
• Continuing long-acting insulin during DKA also prevents rebound hyperglycaemia when the FRIII is stopped. [42]

**Evidence: Continuation of long-acting insulin analogues and basal human insulins**

*Limited evidence suggests that continuation of subcutaneous long-acting insulin analogues during the initial management of DKA, providing background insulin when the intravenous insulin is discontinued, may avoid subsequent rebound hyperglycaemia. Guideline recommendations vary on this issue.*

**An RCT found less frequent episodes of rebound hyperglycaemia with continuation of long-acting insulin analogue.**

• The RCT compared rates of rebound hyperglycaemia (defined as a blood glucose >180 mg/dL [10 mmol/L]) in a total of 61 hospitalised patients with type 1 or type 2 diabetes receiving intravenous insulin therapy (25 of these had DKA). [136]
• Patients were randomised (odd vs. even randomisation method) to receiving once daily subcutaneous insulin glargine (an insulin analogue) or no insulin glargine (no placebo injections were given). [136] The number of patients with DKA were similar in each group.
• Patients receiving subcutaneous insulin glargine experienced significantly fewer episodes of rebound hyperglycaemia during the 12-hour follow-up period (33.3% [10 patients] with one or more episode in the insulin glargine group vs. 93.5% [29 patients] in the control group; P <0.01 using the Z test). The results were described as “equally robust” for the patients with DKA. [136]
Clinical experience suggests that continuation of pre-existing prescriptions of human basal insulins is also safe.

- This is based on the similar onset and duration of action of basal insulins compared with analogues.[42]

The 2013 Joint British Diabetes Societies for Inpatient Care guideline on DKA recommends continuing subcutaneous long-acting analogue/human insulin in patients with DKA. [42]

- However, the evidence is limited and optimal treatment may still be debated and vary between localities.[42]

Involve the **specialist diabetes team** as soon as possible and definitely within 24 hours.[42]

- The specialist diabetes team should also be involved in the assessment of the cause of DKA.
- It is unsafe to manage DKA without the specialist diabetes team and could compromise patient care.[42]

Identify and treat any precipitating acute illness.[42]

- Common causes are myocardial infarction, sepsis, and pancreatitis.[47] [30]

Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated.[42] See our topic VTE prophylaxis.

Ensure effective handover of patients with DKA.

- Give relevant details on the clinical and biochemical progress of the patient and the plan for further management.

**Practical tip**

Handover is a common source of error in managing DKA.

**Ongoing management**

**Management at 1 to 6 hours**

Review the patient hourly to ensure clinical and biochemical improvement and continue the FRIII.[42] [105]

- Order hourly blood glucose and hourly blood ketones.
- Perform a venous blood gas for pH, bicarbonate, and potassium at 60 minutes, 2 hours, and 2 hourly thereafter.

- Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.
- Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.
• Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.

• If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]

  • Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
  • Increase the insulin infusion according to local protocols (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

### Practical tip

Monitor all patients with DKA closely:

• DKA is complicated to manage and needs close monitoring and treatment modifications.[17]
• Treatment protocols are often not followed.[17] However, guidelines and protocols should not replace sound clinical judgement.[17]

Give ongoing fluid replacement after the first litre of fluid has been given. Add potassium if serum potassium is ≤5.5 mmol/L using pre-mixed normal saline with potassium chloride.

• A typical regimen for a 70 kg adult with no other comorbidities is:[42] [17] [105]

<table>
<thead>
<tr>
<th>Volume of normal saline (with potassium chloride as needed)</th>
</tr>
</thead>
</table>
| 1 litre over 2 hours
| 1 litre over next 2 hours
| 1 litre over next 4 hours
| 1 litre over next 4 hours
| 1 litre over next 6 hours |

Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:[42]

• Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
• Are elderly or pregnant
• Have heart or kidney failure or other serious comorbidities.

Maintain an accurate fluid balance chart.[42]

• Aim for a minimum urine output of 0.5 mL/kg/hour.

Maintain the potassium level between 4.0 and 5.0 mmol/L. Adjust potassium replacement as follows:[42]
Diabetic ketoacidosis

Management

<table>
<thead>
<tr>
<th>Potassium level (mmol/L)</th>
<th>Potassium replacement (mmol/L of infusion solution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3.5</td>
<td>Involve senior or critical care support as additional potassium needs to be given</td>
</tr>
<tr>
<td>3.5 to 5.5</td>
<td>40</td>
</tr>
<tr>
<td>&gt;5.5</td>
<td>None</td>
</tr>
</tbody>
</table>

Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L.\(^\text{[42]}\)\(^\text{[47]}\)

- Continue this until the patient is eating and drinking normally.

**Practical tip**

A common mistake is to allow hypoglycaemia to develop as the blood glucose level may drop rapidly as ketoacidosis is corrected.\(^\text{[42]}\)

- This may lead to a rebound ketosis driven by counter-regulatory hormones and lengthen the duration of treatment.
- Severe hypoglycaemia is associated with cardiac arrhythmias, acute brain injury, and death.

It is important to give glucose and sodium chloride solutions concurrently to correct the dehydration.\(^\text{[42]}\)

Monitor for complications regularly throughout treatment of DKA.\(^\text{[42]}\)\(^\text{[105]}\)

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.\(^\text{[42]}\)

  - If you suspect cerebral oedema, seek immediate senior and critical care support.
    - Give mannitol.\(^\text{[62]}\)
    - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.\(^\text{[137]}\)

- Monitor vital signs closely according to local protocols.

  - Request a chest x-ray if oxygen saturations fall as this may be a sign of pulmonary oedema. Consider performing an arterial blood gas.

    - Pulmonary oedema and acute respiratory distress syndrome (ARDS) are rare but significant complications of treatment for DKA and present with fluid overload and low oxygen saturations.\(^\text{[138]}\) They occur when excess fluid is given, even in patients with normal cardiac function.
    - Look for an increased alveolar to oxygen gradient (AaO\(_2\)) and auscultate for lung crepitations.
    - Pulmonary oedema and ARDS are more common in patients who are severely dehydrated or with higher glucose levels on arrival.
Practical tip
Other features of cerebral oedema are recurrent vomiting, incontinence, irritability, abnormal respirations, and cranial nerve dysfunction. These usually occur several hours after starting treatment.[42] [61]
The exact cause of cerebral oedema is unknown. It occurs most commonly in children and adolescents, and is rare over the age of 28. It is the most common cause of mortality in DKA.[2] [42] [61]

Give thromboprophylaxis if indicated.[42] [105]

- See our topic VTE prophylaxis.

Management at 6 to 12 hours
Continue intravenous fluids, potassium correction, and FRIII.[42] [17] Seek senior advice if clinical and biochemical markers are not improving.

- Check ketones, blood glucose, venous pH, bicarbonate, and potassium at 6 hours.

Assess for resolution of DKA. This is defined as:[42]

- Venous pH >7.3 AND
- Blood ketone level <0.6 mmol/L AND
- Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

Practical tip
Do not rely on bicarbonate alone to assess the resolution of DKA.[42] [61]

- A hyperchloraemic acidosis typically persists secondary to high volumes of normal saline. This lowers the bicarbonate and leads to difficulty in assessing whether ketosis has resolved.[42] [17] [61]
- The hyperchloraemic acidosis may cause renal vasoconstriction and oliguria.

Do not rely on urinary ketone clearance to assess resolution of DKA.[42]

- These will still be present when DKA has resolved.

Management at 12 to 24 hours
Check venous pH, bicarbonate, potassium, ketones, and glucose at 12 hours. Ensure DKA has resolved within 24 hours.[42] [105]

Request senior or specialist input if DKA has not resolved within 24 hours.[42]

- It is unusual for patients not to respond to treatment so it is important to identify and treat the cause of DKA.
- Continue the FRIII and intravenous fluids.
• Monitor blood ketones and glucose hourly, and pH, potassium, and bicarbonate every 2 hours to ensure they fall at the specified target rates.

Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking. This should normally be done by the diabetes specialist team and given with a meal.[42][61]

• Switch to subcutaneous insulin from intravenous insulin in the morning if possible as most hospitals have better staffing during daytime, should DKA recur.[107]

Continue intravenous insulin for 30 to 60 minutes after administering subcutaneous insulin to prevent relapse of DKA.[42]

• It is a common error to stop intravenous insulin either too early or before the timing and doses of subcutaneous insulin have been sorted out.[17]

If the patient was on basal bolus insulin:[42]

• This should have been continued if they were taking a long-acting insulin analogue[17]
• Restart their normal short-acting subcutaneous insulin at the next meal
• In general, restart the patient’s previous insulin regimen if their most recent HbA1c shows an acceptable level of control (i.e., HbA1c 64 mmol/mol [<8.0%])[42]
• Do not stop the intravenous insulin if the long-acting insulin has been stopped in error until a form of background insulin has been given.[42]

  • Give half the usual daily dose of basal insulin (using insulin isophane) in the morning if the basal analogue was normally taken once daily in the evening and the intention is to convert to subcutaneous insulin in the morning.
  • Check the blood ketone and glucose levels regularly.

If the patient was on twice daily fixed-mix insulin:[42]

• Re-introduce the subcutaneous insulin before breakfast or before the evening meal. Do not change at any other time.

If the patient was on continuous subcutaneous insulin infusion (CSII):[42]

• Restart the CSII at the normal basal rate
• Continue the intravenous insulin infusion until the meal bolus has been given
• Do not restart CSII at bedtime.

Estimate the total daily dose (TDD) of insulin for patients who were not previously taking insulin.[42]

• Take into account the patient’s sensitivity to insulin, degree of glycaemic control, insulin resistance, and age.
• Calculate TDD by multiplying the patient’s weight (in kg) by 0.5 to 0.75 units. For example: a person weighing 72 kg would require approximately 72 x 0.5 units (36 units) for a TDD. Use 0.75 units/kg for people thought to be more insulin resistant (e.g., adolescents, obese people).
• If using a basal bolus regimen:
  • Give 50% of the TDD with the evening meal as long-acting insulin and divide the remaining dose equally between pre-breakfast, pre-lunch, and pre-evening meal.
  • Give the first dose of fast acting subcutaneous insulin preferably before breakfast.
Diabetic ketoacidosis

Management

• Only give the first dose before the evening meal if monitoring is in place.
• Never convert to a subcutaneous regimen at bed time.

• If using a twice daily pre-mixed regimen:

  • Give two-thirds of the TDD at breakfast and give the remaining third with the evening meal.

Practical tip

Use a basal bolus regimen for most patients, especially the young and fit. Consider a twice daily pre-mixed regimen for older patients as they may not be able to manage a basal bolus regimen.

Continue intravenous fluids if the patient is not eating and drinking.[42] [17]

• Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.
• Measure blood glucose regularly.

Discharge

Counsel patients about the precipitating cause and early warning symptoms of DKA. Consider:[42] [17]

• Review of their usual glycaemic control
• Review of their injection technique, blood glucose monitoring, equipment, and injection sites
• Prevention of recurrence (e.g., provide written ‘sick day rules’)
• Checking the patient’s insulin prior to reuse (this may be expired or denatured)
• Assessing the need for provision of handheld ketone meters for use at home
• Providing a contact number on how to contact the diabetes specialist team out of hours
• Providing a written care plan which allows the patient to have an active role in their diabetes management, with a copy of this sent to their GP.

Ensure patients have appropriate follow-up with the diabetes specialist team and access to psychological support.[42]

Procedural videos

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer
### Acute

**initial systolic blood pressure <90 mmHg**

- **serum potassium <3.5 mmol/L**
  - 1st: intravenous fluids and potassium replacement
  - plus: supportive care and referral to critical care
  - plus: insulin
  - plus: identify and treat any precipitating acute illness
  - plus: monitor biochemical markers
  - plus: monitor and treat complications
  - consider: sodium bicarbonate
  - consider: thromboprophylaxis

- **serum potassium 3.5 to 5.5 mmol/L**
  - 1st: intravenous fluids and potassium replacement
  - consider: supportive care and referral to critical care
  - plus: insulin
  - plus: identify and treat any precipitating acute illness
  - plus: monitor biochemical markers
  - plus: monitor and treat complications
  - consider: sodium bicarbonate
  - consider: thromboprophylaxis

- **serum potassium >5.5 mmol/L**
  - 1st: intravenous fluids
  - consider: supportive care and referral to critical care
  - plus: insulin
  - plus: identify and treat any precipitating acute illness
  - plus: monitor biochemical markers
  - plus: potassium replacement (once serum potassium is ≤5.5 mmol/L)
  - plus: monitor and treat complications
  - consider: sodium bicarbonate
  - consider: thromboprophylaxis
### Acute

**initial systolic blood pressure ≥90 mmHg**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Initial Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>serum potassium &lt; 3.5 mmol/L</td>
<td>1st intravenous fluids and potassium replacement</td>
</tr>
<tr>
<td></td>
<td>plus supportive care and referral to critical care</td>
</tr>
<tr>
<td></td>
<td>plus insulin</td>
</tr>
<tr>
<td></td>
<td>plus identify and treat any precipitating acute illness</td>
</tr>
<tr>
<td></td>
<td>plus monitor biochemical markers</td>
</tr>
<tr>
<td></td>
<td>plus monitor and treat complications</td>
</tr>
<tr>
<td></td>
<td>consider sodium bicarbonate</td>
</tr>
<tr>
<td></td>
<td>consider thromboprophylaxis</td>
</tr>
</tbody>
</table>

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<th>Condition</th>
<th>Initial Management</th>
</tr>
</thead>
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<td>serum potassium 3.5 to 5.5 mmol/L</td>
<td>1st intravenous fluids and potassium replacement</td>
</tr>
<tr>
<td></td>
<td>consider supportive care and referral to critical care</td>
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<tr>
<td></td>
<td>plus insulin</td>
</tr>
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<td></td>
<td>plus monitor and treat complications</td>
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<td></td>
<td>consider sodium bicarbonate</td>
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<tr>
<td></td>
<td>consider thromboprophylaxis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Initial Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>serum potassium &gt; 5.5 mmol/L</td>
<td>1st intravenous fluids</td>
</tr>
<tr>
<td></td>
<td>consider supportive care and referral to critical care</td>
</tr>
<tr>
<td></td>
<td>plus insulin</td>
</tr>
<tr>
<td></td>
<td>plus identify and treat any precipitating acute illness</td>
</tr>
<tr>
<td></td>
<td>plus monitor biochemical markers</td>
</tr>
<tr>
<td></td>
<td>plus monitor and treat complications</td>
</tr>
<tr>
<td></td>
<td>consider sodium bicarbonate</td>
</tr>
<tr>
<td></td>
<td>consider thromboprophylaxis</td>
</tr>
</tbody>
</table>
Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer.
### Acute Management

<table>
<thead>
<tr>
<th>initial systolic blood pressure &lt;90 mmHg</th>
<th>1st intravenous fluids and potassium replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>serum potassium &lt;3.5 mmol/L</td>
<td>Start intravenous fluids as soon as DKA is confirmed. [42] [17] [105]</td>
</tr>
<tr>
<td></td>
<td>Give a fluid bolus of 500 mL of normal saline (0.9% sodium chloride) over 10 to 15 minutes.</td>
</tr>
</tbody>
</table>

- Repeat the fluid bolus if systolic blood pressure (SBP) remains <90 mmHg and get help from a senior colleague.
- Repeat the fluid bolus, get an immediate senior review and consider involving critical care if there is no improvement after the second fluid bolus.

- Consider other causes of hypotension (e.g., sepsis, heart failure, acute myocardial infarction). [42]

- Give 1 L of normal saline over 1 hour once SBP >90 mmHg. [42]

- Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who: [42]

  - Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
  - Are elderly or pregnant
  - Have heart or kidney failure or other serious comorbidities.

- Add potassium to the second litre of intravenous fluids using pre-mixed normal saline with potassium chloride. Involve senior or critical care support as a high dose of additional potassium needs to be given. [42] [105]
Diabetic ketoacidosis

Management

**Acute**

- A typical fluid regimen for a 70 kg, well adult is:[42] [17] [105]

<table>
<thead>
<tr>
<th>Volume of normal saline (with potassium chloride as needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 litre over 2 hours</td>
</tr>
<tr>
<td>1 litre over next 2 hours</td>
</tr>
<tr>
<td>1 litre over next 4 hours</td>
</tr>
<tr>
<td>1 litre over next 4 hours</td>
</tr>
<tr>
<td>1 litre over next 6 hours</td>
</tr>
</tbody>
</table>

- Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L. [42] [47]
  - Continue this until the patient is eating and drinking normally.

**plus supportive care and referral to critical care**

Treatment recommended for ALL patients in selected patient group

- Protect the airway.
  - Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting.[42] [105]
  - Ensure continuous cardiac monitoring and involve senior or critical care support if:[42] [17]
    - There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
    - Glasgow Coma Scale <12
    - Blood ketones >6 mmol/L
    - Venous bicarbonate <5 mmol/L
    - Venous pH <7.0
    - Potassium <3.5 mmol/L on admission
    - Oxygen saturations <92% on air
    - Pulse >100 bpm or <60 bpm
    - Anion gap >16
    - The patient is pregnant or has heart or kidney failure or other serious comorbidities.
Diabetic ketoacidosis

**Management**

### Acute

- Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment.[42] [105]

**plus insulin**

Treatment recommended for ALL patients in selected patient group

**Primary options**

- **insulin neutral**: consult local protocols for dosing guidelines

- **Start a fixed-rate intravenous insulin infusion (FRIII) at a dose of 0.1 units/kg/hour or according to local protocols.** [42] [17] [105]

  - Ensure intravenous fluids have been started before giving a FRIII.
  - Seek advice from the **diabetes specialist team** if >15 units/hour of insulin are required.[42] [54]
  - Use the following table as a guide:

<table>
<thead>
<tr>
<th>Weight in kg</th>
<th>Insulin dose per hour (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-69</td>
<td>6</td>
</tr>
<tr>
<td>70-79</td>
<td>7</td>
</tr>
<tr>
<td>80-89</td>
<td>8</td>
</tr>
<tr>
<td>90-99</td>
<td>9</td>
</tr>
<tr>
<td>100-109</td>
<td>10</td>
</tr>
<tr>
<td>110-119</td>
<td>11</td>
</tr>
<tr>
<td>120-129</td>
<td>12</td>
</tr>
<tr>
<td>130-139</td>
<td>13</td>
</tr>
<tr>
<td>140-149</td>
<td>14</td>
</tr>
<tr>
<td>&gt;150</td>
<td>15</td>
</tr>
</tbody>
</table>

**Evidence: Insulin rate**

*A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.*
The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour. [42]

- A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.[17]
- The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg bolus of intravenous insulin, based on evidence from a small trial of 37 patients.[46]
- The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.[17]
- One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

» Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking. This should normally be done by the diabetes specialist team and given with a meal.[42] [61]

- Continue intravenous insulin for 30 to 60 minutes after administering subcutaneous insulin to prevent relapse of DKA.[42]

» Continue intravenous fluids if the patient is not eating and drinking.[42] [17]
Diabetic ketoacidosis

Management

**Acute**

- Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.
- Measure blood glucose regularly.

Plus identify and treat any precipitating acute illness

Treatment recommended for ALL patients in selected patient group

- Common causes of DKA are myocardial infarction, sepsis, and pancreatitis.[47][30]

Plus monitor biochemical markers

Treatment recommended for ALL patients in selected patient group

- Monitor biochemical markers as follows:[42][105]

<table>
<thead>
<tr>
<th>Time</th>
<th>Ketone</th>
<th>Glucose</th>
<th>Bicarb</th>
<th>Potass</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>1 hour</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>2 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>3 hours</td>
<td>#</td>
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<td></td>
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<tr>
<td>4 hours</td>
<td>#</td>
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<td>#</td>
<td>#</td>
<td>#</td>
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<tr>
<td>5 hours</td>
<td>#</td>
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<td></td>
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<tr>
<td>6 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>12 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
</tbody>
</table>

- Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.

- Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.

- Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.
Diabetic ketoacidosis

Management

Acute

- If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]
  - Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
  - Increase the insulin infusion by 1 unit/hour (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

» Assess for resolution of DKA. This is defined as:[42]
  - Venous pH >7.3 AND
  - Blood ketone level <0.6 mmol/L AND
  - Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

plus monitor and treat complications

Treatment recommended for ALL patients in selected patient group

» Monitor for complications regularly throughout treatment of DKA.[42] [105]

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]
  - If you suspect cerebral oedema, seek immediate senior and critical care support.
    - Give mannitol.[62]
    - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.[137]
  - Monitor vital signs closely according to local protocols.

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Acute

- Request a chest x-ray if oxygen saturations fall as this may be a sign of pulmonary oedema. Consider performing an arterial blood gas.

Consider sodium bicarbonate

Treatment recommended for SOME patients in selected patient group

- Only consider giving bicarbonate if venous pH <6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment. [131]

Consider thromboprophylaxis

Treatment recommended for SOME patients in selected patient group

- Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated. [42] See our topic VTE prophylaxis.

Serum potassium 3.5 to 5.5 mmol/L

1st intravenous fluids and potassium replacement

- Start intravenous fluids as soon as DKA is confirmed. [42] [17] [105]

- Give a fluid bolus of 500 mL of normal saline (0.9% sodium chloride) over 10 to 15 minutes.

  - Repeat the fluid bolus if SBP remains <90 mmHg and get help from a senior colleague.
  - Repeat the fluid bolus, get an immediate senior review and consider involving critical care if there is no improvement after the second fluid bolus.

    - Consider other causes of hypotension (e.g., sepsis, heart failure, acute myocardial infarction). [42]

- Give 1 L of normal saline over 1 hour once SBP >90 mmHg. [42]
Diabetic ketoacidosis

Management

Acute

- Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:[42]
  - Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
  - Are elderly or pregnant
  - Have heart or kidney failure or other serious comorbidities.

  » Add 40 mmol/L potassium to the second litre of intravenous fluids using pre-mixed normal saline with potassium chloride.[42] [105]

  - A typical fluid regimen for a 70 kg, well adult is:[42] [17] [105]

<table>
<thead>
<tr>
<th>Volume of normal saline (with potassium chloride as needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 litre over 2 hours</td>
</tr>
<tr>
<td>1 litre over next 2 hours</td>
</tr>
<tr>
<td>1 litre over next 4 hours</td>
</tr>
<tr>
<td>1 litre over next 4 hours</td>
</tr>
<tr>
<td>1 litre over next 6 hours</td>
</tr>
</tbody>
</table>

  » Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L. [42] [47]

  - Continue this until the patient is eating and drinking normally.

consider supportive care and referral to critical care

Treatment recommended for SOME patients in selected patient group

  » Protect the airway.

  - Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting.[42] [105]

  » Ensure continuous cardiac monitoring and involve senior or critical care support if:[42] [17]
Diabetic ketoacidosis

Management

Acute

- There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
- Glasgow Coma Scale <12
- Blood ketones >6 mmol/L
- Venous bicarbonate <5 mmol/L
- Venous pH <7.0
- Oxygen saturations <92% on air
- Pulse >100 bpm or <60 bpm
- Anion gap >16
- The patient is pregnant or has heart or kidney failure or other serious comorbidities.

» Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment. [42] [105]

**plus insulin**

Treatment recommended for ALL patients in selected patient group

**Primary options**

- insulin neutral: consult local protocols for dosing guidelines

- Start a fixed-rate intravenous insulin infusion (FRIII) at a dose of 0.1 units/kg/hour or according to local protocols. [42] [17] [105]

- Ensure intravenous fluids have been started before giving a FRIII.
- Seek advice from the diabetes specialist team if >15 units/hour of insulin are required. [42] [54]
- Use the following table as a guide:

<table>
<thead>
<tr>
<th>Weight in kg</th>
<th>Insulin dose per hour (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-69</td>
<td>6</td>
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<td>90-99</td>
<td>9</td>
</tr>
<tr>
<td>100-109</td>
<td>10</td>
</tr>
</tbody>
</table>
Diabetic ketoacidosis

### Acute

<table>
<thead>
<tr>
<th>Weight in kg</th>
<th>Insulin dose per hour (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110-119</td>
<td>11</td>
</tr>
<tr>
<td>120-129</td>
<td>12</td>
</tr>
<tr>
<td>130-139</td>
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</tr>
<tr>
<td>140-149</td>
<td>14</td>
</tr>
<tr>
<td>&gt;150</td>
<td>15</td>
</tr>
</tbody>
</table>

### Evidence: Insulin rate

A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.

**The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour.**

- A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.

- The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg bolus of intravenous insulin, based on evidence from a small trial of 37 patients.

- The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.
**Acute**

- One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

  » Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking. This should normally be done by the diabetes specialist team and given with a meal.[42] [61]

- Continue intravenous insulin for 30 to 60 minutes after administering subcutaneous insulin to prevent relapse of DKA.[42]

  » Continue intravenous fluids if the patient is not eating and drinking.[42] [17]

- Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.

- Measure blood glucose regularly.

**plus** identify and treat any precipitating acute illness

Treatment recommended for ALL patients in selected patient group

» Common causes of DKA are myocardial infarction, sepsis, and pancreatitis.[47] [30]

**plus** monitor biochemical markers

Treatment recommended for ALL patients in selected patient group

» Monitor biochemical markers as follows:[42] [105]

<table>
<thead>
<tr>
<th>Ketone</th>
<th>Glucose</th>
<th>Bicarb</th>
<th>Potass</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>1 hour</td>
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<td>#</td>
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<tr>
<td>2 hours</td>
<td>#</td>
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<td>#</td>
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<tr>
<td>3 hours</td>
<td>#</td>
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<tr>
<td>4 hours</td>
<td>#</td>
<td>#</td>
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<td>#</td>
</tr>
<tr>
<td>5 hours</td>
<td>#</td>
<td>#</td>
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**Diabetic ketoacidosis**

**Management**

### Acute

<table>
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<tr>
<th>Ketone</th>
<th>Glucose</th>
<th>Bicarb</th>
<th>Potass</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>12 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
</tbody>
</table>

- Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.

  - Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.

  - Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.

  - If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]
    - Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
    - Increase the insulin infusion by 1 unit/hour (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

- Assess for resolution of DKA. This is defined as:[42]
  - Venous pH >7.3 AND
  - Blood ketone level <0.6 mmol/L AND
  - Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

**plus** monitor and treat complications

Treatment recommended for ALL patients in selected patient group
## Acute

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor for complications regularly throughout treatment of DKA.</td>
<td>[42] [105]</td>
</tr>
<tr>
<td>- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.</td>
<td>[42]</td>
</tr>
<tr>
<td>- If you suspect cerebral oedema, seek immediate senior and critical care support.</td>
<td></td>
</tr>
<tr>
<td>- Give mannitol.</td>
<td>[62]</td>
</tr>
<tr>
<td>- Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.</td>
<td>[137]</td>
</tr>
<tr>
<td>- Monitor vital signs closely according to local protocols.</td>
<td></td>
</tr>
<tr>
<td>- Request a chest x-ray if oxygen saturations fall as this may be a sign of pulmonary oedema. Consider performing an arterial blood gas.</td>
<td></td>
</tr>
<tr>
<td><strong>consider sodium bicarbonate</strong></td>
<td>Treatment recommended for SOME patients in selected patient group</td>
</tr>
<tr>
<td>- Only consider giving bicarbonate if venous pH &lt;6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment.</td>
<td>[131]</td>
</tr>
<tr>
<td><strong>consider thromboprophylaxis</strong></td>
<td>Treatment recommended for SOME patients in selected patient group</td>
</tr>
<tr>
<td>- Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated.</td>
<td>[42] See our topic VTE prophylaxis.</td>
</tr>
<tr>
<td><strong>serum potassium &gt;5.5 mmol/L</strong></td>
<td>1st intravenous fluids</td>
</tr>
<tr>
<td>- Start intravenous fluids as soon as DKA is confirmed.</td>
<td>[42] [17] [105]</td>
</tr>
<tr>
<td>- Give a fluid bolus of 500 mL of normal saline (0.9% sodium chloride) over 10 to 15 minutes.</td>
<td></td>
</tr>
</tbody>
</table>
**Diabetic ketoacidosis**

**Management**

### Acute

- Repeat the fluid bolus if SBP remains <90 mmHg and get help from a senior colleague.
- Repeat the fluid bolus, get an immediate senior review and consider involving critical care if there is no improvement after the second fluid bolus.
  - Consider other causes of hypotension (e.g., sepsis, heart failure, acute myocardial infarction). [42]

» **Give 1 L of normal saline over 1 hour once SBP >90 mmHg.** [42]

- Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:[42]
  - Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
  - Are elderly or pregnant
  - Have heart or kidney failure or other serious comorbidities.

» Give ongoing fluid replacement after the first litre of fluid has been given. **Do not add potassium chloride until potassium is ≤5.5 mmol/L.**

- A typical fluid regimen for a 70 kg, well adult is:[42] [17] [105]

<table>
<thead>
<tr>
<th>Volume of normal saline (with potassium chloride as needed)</th>
</tr>
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<tbody>
<tr>
<td>1 litre over 2 hours</td>
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<tr>
<td>1 litre over next 6 hours</td>
</tr>
</tbody>
</table>
**Acute**

- Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L. [42] [47]
  - Continue this until the patient is eating and drinking normally.

**consider** support care and referral to critical care

Treatment recommended for SOME patients in selected patient group

- Protect the airway.
  - Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting. [42] [105]
  - Ensure continuous cardiac monitoring and involve senior or critical care support if:
    - There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
    - Glasgow Coma Scale <12
    - Blood ketones >6 mmol/L
    - Venous bicarbonate <5 mmol/L
    - Venous pH <7.0
    - Oxygen saturations <92% on air
    - Pulse >100 bpm or <60 bpm
    - Anion gap >16
    - The patient is pregnant or has heart or kidney failure or other serious comorbidities.
  - Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment. [42] [105]

**plus** insulin

Treatment recommended for ALL patients in selected patient group

**Primary options**

- insulin neutral: consult local protocols for dosing guidelines

- Start a fixed-rate intravenous insulin infusion (FRIII) at a dose of 0.1 units/kg/hour or according to local protocols. [42] [17] [105]
  - Ensure intravenous fluids have been started before giving a FRIII.
Diabetic ketoacidosis

Management

Acute

• Seek advice from the diabetes specialist team if >15 units/hour of insulin are required.[42] [54]
• Use the following table as a guide:

<table>
<thead>
<tr>
<th>Weight in kg</th>
<th>Insulin dose per hour (units)</th>
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</thead>
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</table>

Evidence: Insulin rate

A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.

The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour. [42]

• A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.[17]
• The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg
Diabetic ketoacidosis

MANAGEMENT

Acute

- bolus of intravenous insulin, based on evidence from a small trial of 37 patients.[46]
  - The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.[17]
  - One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

» Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking. This should normally be done by the diabetes specialist team and given with a meal.[42] [61]
  - Continue intravenous insulin for 30 to 60 minutes after administering subcutaneous insulin to prevent relapse of DKA.[42]

» Continue intravenous fluids if the patient is not eating and drinking.[42] [17]
  - Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.
  - Measure blood glucose regularly.

plus identify and treat any precipitating acute illness

Treatment recommended for ALL patients in selected patient group

» Common causes of DKA are myocardial infarction, sepsis, and pancreatitis.[47] [30]

plus monitor biochemical markers

Treatment recommended for ALL patients in selected patient group

» Monitor biochemical markers as follows:[42] [105]
### Diabetic ketoacidosis

#### Management

<table>
<thead>
<tr>
<th>Acute</th>
<th>Ketone Glucose</th>
<th>Bicarb</th>
<th>Potass</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hours</td>
<td>#</td>
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<tr>
<td>5 hours</td>
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<td></td>
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<tr>
<td>6 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>12 hours</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
</tbody>
</table>

» Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.

- Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.

  - Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.

- If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]

  - Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)

  - Increase the insulin infusion by 1 unit/hour (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

» Assess for resolution of DKA. This is defined as:[42]

- Venous pH >7.3 AND
### Diabetic ketoacidosis

#### Management

**Acute**

- Blood ketone level <0.6 mmol/L AND
- Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FR III should be continued until bicarbonate is >18 mmol/L.[42]

**plus potassium replacement (once serum potassium is ≤5.5 mmol/L)**

Treatment recommended for ALL patients in selected patient group

- Add potassium to intravenous fluids once serum potassium is ≤5.5 mmol/L using pre-mixed normal saline with potassium chloride.[42]

**plus monitor and treat complications**

Treatment recommended for ALL patients in selected patient group

- Monitor for complications regularly throughout treatment of DKA.[42][105]

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]
  - If you suspect cerebral oedema, seek immediate senior and critical care support.
  - Give mannitol.[62]
  - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.[137]

- Monitor vital signs closely according to local protocols.
  - Request a chest x-ray if oxygen saturations fall as this may be a sign of pulmonary oedema. Consider performing an arterial blood gas.

**consider sodium bicarbonate**

Treatment recommended for SOME patients in selected patient group

- Only consider giving bicarbonate if venous pH <6.9 and after discussion with a senior
## Acute

<table>
<thead>
<tr>
<th>Acute</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>serum potassium $&lt;$ 3.5 mmol/L</td>
<td>1st intravenous fluids and potassium replacement</td>
</tr>
<tr>
<td>initial systolic blood pressure $\geq$ 90 mmHg</td>
<td></td>
</tr>
</tbody>
</table>

### Acute Consultation
- Monitor the patient in a critical care environment.\[131\]

### Consider Thromboprophylaxis
- Treatment recommended for SOME patients in selected patient group
  - Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated.\[42\] See our topic VTE prophylaxis.

### Acute Treatment
- Start intravenous fluids as soon as DKA is confirmed.\[42\] [17] [105]
  - Give 1 L of normal saline (0.9% sodium chloride) over 1 hour.\[42\]
    - Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:\[42\]
      - Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients
      - Are elderly or pregnant
      - Have heart or kidney failure or other serious comorbidities.
    - Add potassium to the second litre of intravenous fluids using pre-mixed normal saline with potassium chloride. Involve senior or critical care support as a high dose of additional potassium needs to be given.\[42\] [105]
      - A typical fluid regimen for a 70 kg, well adult is:\[42\] [17] [105]
        - **Volume of normal saline (with potassium chloride as needed)**
        - 1 litre over 2 hours
**Acute**

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» Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L. [42] [47]

- Continue this until the patient is eating and drinking normally.

**plus** supportive care and referral to critical care

Treatment recommended for ALL patients in selected patient group

» Protect the airway.

- Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting. [42] [105]

» Ensure continuous cardiac monitoring and involve senior or critical care support if: [42] [17]

- There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
- Glasgow Coma Scale <12
- Blood ketones >6 mmol/L
- Venous bicarbonate <5 mmol/L
- Venous pH <7.0
- Potassium <3.5 mmol/L on admission
- Oxygen saturations <92% on air
- Pulse >100 bpm or <60 bpm
- Anion gap >16
- The patient is pregnant or has heart or kidney failure or other serious comorbidities.

» Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment. [42] [105]

**plus** insulin
Diabetic ketoacidosis

Management

Acute

Treatment recommended for ALL patients in selected patient group

Primary options

» **insulin neutral**: consult local protocols for dosing guidelines

» **Start a fixed-rate intravenous insulin infusion (FRIII)** at a dose of 0.1 units/kg/hour or according to local protocols. [42] [17] [105]

  - Ensure intravenous fluids have been started before giving a FRIII.
  - Seek advice from the **diabetes specialist team** if >15 units/hour of insulin are required. [42] [54]
  - Use the following table as a guide:

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<thead>
<tr>
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Evidence: Insulin rate

*A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.*

The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting
**Acute**

**intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour.** [42]

- A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.[17]
- The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg bolus of intravenous insulin, based on evidence from a small trial of 37 patients.[46]
- The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.[17]
- One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

» **Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking.** This should normally be done by the diabetes specialist team and given with a meal.[42] [61]

- Continue intravenous insulin for 30 to 60 minutes after administering subcutaneous insulin to prevent relapse of DKA.[42]

» **Continue intravenous fluids if the patient is not eating and drinking.**[42] [17]

- Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.
- Measure blood glucose regularly.
Diabetic ketoacidosis

**Management**

### Acute

**plus** identify and treat any precipitating acute illness

Treatment recommended for ALL patients in selected patient group

- Common causes of DKA are myocardial infarction, sepsis, and pancreatitis.[47] [30]

**plus** monitor biochemical markers

Treatment recommended for ALL patients in selected patient group

- Monitor biochemical markers as follows:[42] [105]

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- Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.

  - Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.

  - Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.

  - If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]
**Acute**

- Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
- Increase the insulin infusion by 1 unit/hour (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

  » Assess for resolution of DKA. This is defined as:[42]

  - Venous pH >7.3 AND
  - Blood ketone level <0.6 mmol/L AND
  - Bicarbonate >15 mmol/L

- The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

**plus monitor and treat complications**

Treatment recommended for ALL patients in selected patient group

» Monitor for complications regularly throughout treatment of DKA.[42] [105]

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]

  - If you suspect cerebral oedema, seek immediate senior and critical care support.
    - Give mannitol.[62]
    - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.[137]

- Monitor vital signs closely according to local protocols.

  - Request a chest x-ray if oxygen saturations fall as this may be
Diabetic ketoacidosis

Management

**Acute**

| consider sodium bicarbonate |
| Treatment recommended for SOME patients in selected patient group |
| » Only consider giving bicarbonate if venous pH <6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment.[131] |

| consider thromboprophylaxis |
| Treatment recommended for SOME patients in selected patient group |
| » Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated.[42] See our topic VTE prophylaxis. |

**serum potassium 3.5 to 5.5 mmol/L**

| 1st intravenous fluids and potassium replacement |
| Start intravenous fluids as soon as DKA is confirmed.[42] [17] [105] |
| » Give 1 L of normal saline (0.9% sodium chloride) over 1 hour. [42] |
| • Give more cautious intravenous fluids and consider monitoring central venous pressure in patients who:[42] |
| • Are young (aged 18-25 years) as rapid fluid replacement may increase the risk of cerebral oedema in these patients |
| • Are elderly or pregnant |
| • Have heart or kidney failure or other serious comorbidities. |
| » Add 40 mmol/L potassium to the second litre of intravenous fluids using pre-mixed normal saline with potassium chloride.[42] [105] |
| • A typical fluid regimen for a 70 kg, well adult is:[42] [17] [105] |
Diabetic ketoacidosis

**Management**

### Acute

<table>
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<th>Volume of normal saline (with potassium chloride as needed)</th>
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- Give 10% glucose in addition to normal saline if the glucose level falls below 14.0 mmol/L. [42] [47]
  - Continue this until the patient is eating and drinking normally.

Consider supportive care and referral to critical care

Treatment recommended for SOME patients in selected patient group

- Protect the airway.
  - Insert a nasogastric tube and aspirate if the patient is unresponsive to commands or is persistently vomiting. [42] [105]

- Ensure continuous cardiac monitoring and involve senior or critical care support if: [42] [17]
  - There is persistent hypotension (SBP <90 mmHg) or oliguria (urine output <0.5 mL/kg/hour) despite intravenous fluids
  - Glasgow Coma Scale <12
  - Blood ketones >6 mmol/L
  - Venous bicarbonate <5 mmol/L
  - Venous pH <7.0
  - Oxygen saturations <92% on air
  - Pulse >100 bpm or <60 bpm
  - Anion gap >16
  - The patient is pregnant or has heart or kidney failure or other serious comorbidities.

- Insert a urinary catheter if there is incontinence or no urine is passed after 1 hour of starting treatment. [42] [105]

**plus** insulin
Diabetic ketoacidosis

Management

Acute

Treatment recommended for ALL patients in selected patient group

**Primary options**

- **insulin neutral**: consult local protocols for dosing guidelines

- **Start a fixed-rate intravenous insulin infusion (FRIII) at a dose of 0.1 units/kg/hour or according to local protocols.** [42] [17] [105]

  - Ensure intravenous fluids have been started before giving a FRIII.
  - Seek advice from the diabetes specialist team if >15 units/hour of insulin are required. [42] [54]
  - Use the following table as a guide:

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<tr>
<th>Weight in kg</th>
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**Evidence: Insulin rate**

A fixed-rate insulin infusion is recommended by UK guidelines to suppress hepatic glucose production, ketogenesis, and lipolysis.

The primary purpose of insulin in managing patients with DKA is to halt lipolysis and ketogenesis, and a UK guideline recommends starting
MANAGEMENT

**Acute**

*intravenous regular insulin at a fixed weight-based dose of 0.1 units/kg/hour.* [42]

- A 2019 clinical review on acute decompensated diabetes in adults highlights the difference in guideline recommendations on the issue of insulin regimens.[17]
- The American Diabetes Association recommends one of two options: either intravenous regular insulin at a fixed weight-based dose of 0.14 units/kg/hour or a fixed weight-based dose of 0.1 units/kg/hour after a 0.1 units/kg bolus of intravenous insulin, based on evidence from a small trial of 37 patients.[46]
- The clinical review states that the recommendation by the UK 2013 Joint British Diabetes Societies for Inpatient Care guideline of no bolus insulin injection and an intravenous insulin infusion at a fixed weight-based dose of 0.1 units/kg/hour may not be sufficient to suppress hepatic glucose production and stimulate peripheral glucose uptake, but is likely sufficient to suppress lipolysis and ketogenesis.[17]
- One study comparing low dose intravenous insulin infusion (0.1 units/kg/hour) with higher dose (1 unit/kg/hour) in children with DKA found an increased risk of hypokalaemia with the high dose regimen.[129]

» Start regular subcutaneous insulin when DKA is resolved and the patient is eating and drinking. This should normally be done by the diabetes specialist team and given with a meal.[42] [61]

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- Start a variable rate intravenous insulin infusion (VRIII) for these patients if DKA has resolved.
- Measure blood glucose regularly.
Diabetic ketoacidosis

Management

Acute

- Identify and treat any precipitating acute illness
- Monitor biochemical markers

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  - If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates.[42]
**MANAGEMENT**

**Acute**

- Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
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**plus** monitor and treat complications

Treatment recommended for ALL patients in selected patient group

  » Monitor for complications regularly throughout treatment of DKA.[42] [105]

  - Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]

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  - Give mannitol.[62]
  - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.[137]

  - Monitor vital signs closely according to local protocols.

  - Request a chest x-ray if oxygen saturations fall as this may be...
**Acute**

- **serum potassium >5.5 mmol/L**

  - **1st intravenous fluids**
    - **Consider sodium bicarbonate**
      - Treatment recommended for SOME patients in selected patient group
      - Only consider giving bicarbonate if venous pH <6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment.\[131\]
    - **Consider thromboprophylaxis**
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- **A sign of pulmonary oedema. Consider performing an arterial blood gas.**
**Management**

**Acute**

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**plus insulin**
Diabetic ketoacidosis

**Management**

**Acute**

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Acute

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**Acute**

**plus**

**identify and treat any precipitating acute illness**

Treatment recommended for ALL patients in selected patient group

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**plus**

**monitor biochemical markers**

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**Acute**

- Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
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  - The 2013 Joint British Diabetes Societies for Inpatient Care guideline advises that the FRIII should be continued until bicarbonate is >18 mmol/L.[42]

**plus** potassium replacement (once serum potassium is ≤5.5 mmol/L)

Treatment recommended for ALL patients in selected patient group

> Add potassium to intravenous fluids once serum potassium is ≤5.5 mmol/L using pre-mixed normal saline with potassium chloride.[42]

**plus** monitor and treat complications

Treatment recommended for ALL patients in selected patient group

> Monitor for complications regularly throughout treatment of DKA.[42][105]

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]

  - If you suspect cerebral oedema, seek immediate senior and critical care support.
    - Give mannitol.[62]
    - Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating
**Diabetic ketoacidosis**

**Management**

**Acute**

- or the patient has a new or worsening headache.[137]
- *Monitor vital signs closely according to local protocols.*
- *Request a chest x-ray if oxygen saturations fall as this may be a sign of pulmonary oedema. Consider performing an arterial blood gas.*

**consider sodium bicarbonate**

Treatment recommended for SOME patients in selected patient group

- Only consider giving bicarbonate if venous pH <6.9 and after discussion with a senior consultant. Monitor the patient in a critical care environment.[131]

**consider thromboprophylaxis**

Treatment recommended for SOME patients in selected patient group

- Consider thromboprophylaxis with low-molecular weight heparin in older patients or high-risk patients, unless it is contraindicated.[42] See our topic VTE prophylaxis.

---

**Primary prevention**

Patient education about management of their diabetes during periods of mild illness (sick-day management) is vital for preventing DKA. Counsel patients about the precipitating cause and early warning symptoms of DKA. Consider: [42] [17]

- Review of their usual glycaemic control
- Review of their injection technique, blood glucose monitoring, equipment, and injection sites
- Prevention of recurrence (e.g., provide written ‘sick day rules’)
- Checking the patient’s insulin prior to reuse (this may be expired or denatured)
- Assessing the need for provision of handheld ketone meters for use at home
- Provision of a contact number on how to contact the diabetes specialist team out of hours
- Provision of a written care plan which allows the patient to have an active role in their diabetes management, with a copy of this sent to their GP.

SGLT2 inhibitor-associated DKA in patients with type 2 diabetes is typically precipitated by insulin omission or significant dose reduction, severe acute illness, dehydration, extensive exercise, surgery, low-carbohydrate diets, or excessive alcohol intake. DKA prevention strategies should include withholding SGLT2 inhibitors when precipitants are present, and avoiding insulin omission or large insulin dose reduction.[43] [44]
Diabetic ketoacidosis
Management

Many cases can be prevented by better access to medical care, proper education, and effective communication with a healthcare provider during an intercurrent illness. Adequate supervision by family and healthcare provider may decrease the rates of hospitalisation and mortality.[1] [45]

Patient discussions

Management should be reviewed periodically with all patients. This should include:

- When to contact the healthcare provider
- Blood glucose goals and the use of supplemental short- or rapid-acting insulin during illness
- Means to suppress fever and treat infection
- Initiation of an easily digestible fluid diet containing electrolytes and glucose during illness.

Patients should be advised to always continue insulin during illness and to seek professional advice early. Sodium-glucose co-transporter 2 (SGLT2) inhibitor-associated DKA in patients with type 2 diabetes is typically precipitated by insulin omission or significant dose reduction, severe acute illness, dehydration, extensive exercise, surgery, low-carbohydrate diets, or excessive alcohol intake. DKA prevention strategies should include withholding SGLT2 inhibitors when precipitants are present, and avoiding insulin omission or large insulin dose reduction.[43] [44]

The patient (or family member or carer) must be able to accurately measure and record blood glucose, insulin administration, temperature, respiratory rate, and pulse. Blood ketone (BOHB) should be checked when blood glucose is more than 16.7 mmol/L (300 mg/dL), and if it is high the patient should present to hospital for further evaluation. The frequency of blood glucose monitoring depends on the patient's clinical condition: in uncontrolled diabetes (HbA1c >53 mmol/mol [>7.0%]) it is recommended to check blood glucose before each meal, plus at bedtime.[1] [201]
Diabetic ketoacidosis

Follow up

Monitoring

DKA is complicated to manage and needs close monitoring and treatment modifications.[17]

It is possible to manage mild DKA without admission to the intensive care unit (ICU); however, many cases will require ICU care.

After admission to ICU, central venous and arterial lines are usually required. Swan-Ganz catheterisation and continuous percutaneous oximetry are needed in patients with haemodynamic instability. Monitoring of respiratory parameters is also required to ensure adequate oxygenation and airway protection.

1 to 6 hours

Review the patient hourly to ensure clinical and biochemical improvement and continue the fixed-rate intravenous insulin infusion (FRIII).[42] [105]

- Order hourly blood glucose and hourly blood ketones.
- Perform a venous blood gas for pH, bicarbonate, and potassium at 60 minutes, 2 hours, and 2 hourly thereafter.

  - Aim for a reduction in blood ketones of 0.5 mmol/L/hour if blood ketone measurement is available.
  - Use venous bicarbonate or blood glucose measurement if blood ketone measurement is not available.

  - Aim for an increase in venous bicarbonate of 3.0 mmol/L/hour or a reduction in blood glucose of 3.0 mmol/L/hour.
  - If the blood ketones, blood glucose, and venous bicarbonate are not falling at the target rates:[42]

    - Check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
    - Increase the insulin infusion according to local protocols (if there is no insulin pump malfunction) until ketones, glucose, and bicarbonate are falling at the target rates.

  - Maintain the potassium level between 4.0 and 5.0 mmol/L.
  - Maintain an accurate fluid balance chart.[42]

  - Aim for a minimum urine output of 0.5 ml/kg/hour.

Monitor for complications regularly throughout treatment of DKA.[42] [105]

- Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]
- Monitor vital signs closely according to local protocols.

  - Request a chest x ray if oxygen saturations fall as this may be a sign of pulmonary oedema.
  - Consider performing an arterial blood gas.
6 to 12 hours
Seek senior advice if clinical and biochemical markers are not improving.

- Check ketones, blood glucose, venous pH, bicarbonate, and potassium at 6 hours.

Assess for resolution of DKA. This is defined as:[42]

- Venous pH >7.3 AND
- Blood ketone level <0.6 mmol/L

12 to 24 hours
Check venous pH, bicarbonate, potassium, ketones, and glucose at 12 hours. Ensure DKA has resolved within 24 hours.[42][105]
Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Timeframe</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>hypokalaemia</td>
<td>short term</td>
<td>high</td>
</tr>
<tr>
<td>This iatrogenic complication can occur with excessive high-dose insulin therapy and bicarbonate therapy. It can be prevented by following current treatment protocols with frequent monitoring of potassium levels and appropriate replacement.[1] [198] [199]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hypoglycaemia</td>
<td>short term</td>
<td>medium</td>
</tr>
<tr>
<td>This iatrogenic complication can occur with excessive high-dose insulin therapy. It can be prevented by following current treatment protocols with frequent monitoring of plasma glucose and use of glucose-containing intravenous fluids.[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>arterial or venous thromboembolic events</td>
<td>short term</td>
<td>medium</td>
</tr>
<tr>
<td>Standard prophylactic low-dose heparin is certainly reasonable in these patients.[1] [45] [200] Applying prophylactic treatment is based on clinical evaluation by the physician of risk factors for thromboembolic events. Currently no evidence exists for full anticoagulation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cerebral oedema/brain injury</td>
<td>short term</td>
<td>low</td>
</tr>
<tr>
<td>Assess Glasgow Coma Scale hourly to monitor for cerebral oedema.[42]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Other features of cerebral oedema are recurrent vomiting, incontinence, irritability, abnormal respirations, and cranial nerve dysfunction. These usually occur several hours after starting treatment.[42] [61]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- If you suspect cerebral oedema, seek immediate senior and critical care support.</td>
<td></td>
<td></td>
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<tr>
<td>- Give mannitol.[62]</td>
<td></td>
<td></td>
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<tr>
<td>- Consider ordering a CT head if the Glasgow Coma Scale score is deteriorating or the patient has a new or worsening headache.[137]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The exact cause of cerebral oedema is unknown. It occurs most commonly in children and adolescents, and is rare over the age of 28. It is the most common cause of mortality in DKA.[42] [61] [2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pulmonary oedema/acute respiratory distress syndrome (ARDS)</td>
<td>short term</td>
<td>low</td>
</tr>
<tr>
<td>Pulmonary oedema and acute respiratory distress syndrome (ARDS) are rare but significant complications of treatment for DKA and present with fluid overload and low oxygen saturations.[138]</td>
<td></td>
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<tr>
<td>- They occur when excess fluid is given, even in patients with normal cardiac function.</td>
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<tr>
<td>- They are more common in patients who are severely dehydrated or with higher glucose levels on arrival.</td>
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<tr>
<td>- Look for an increased alveolar to oxygen gradient (AaO2) and auscultate for lung crepitations.</td>
<td></td>
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<tr>
<td>- Request a chest x-ray if oxygen saturations fall. Consider performing an arterial blood gas.</td>
<td></td>
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</tr>
<tr>
<td>Pulmonary oedema typically occurs several hours after treatment is started and can occur even in patients with normal cardiac function.[42] [17]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non-anion gap hyperchloraemic acidosis</td>
<td>short term</td>
<td>low</td>
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</table>

Follow up

This PDF of the BMJ Best Practice topic is based on the web version that was last updated: May 01, 2020.
### Prognosis

An improved understanding of the pathophysiology of DKA, together with close monitoring and correction of electrolytes, has resulted in a significant reduction in the overall mortality rate from this life-threatening condition. Mortality rates have fallen significantly in the last 20 years from 7.96% to 0.67%.[42]

Death is rarely caused by the metabolic complications of hyperglycaemia or ketoacidosis but rather relates to the underlying illness. The prognosis is substantially worsened at the extremes of age and in the presence of coma and hypotension.[1]

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<tr>
<td>This occurs due to urinary loss of ketoanions needed for bicarbonate regeneration, and also increased reabsorption of chloride secondary to intensive administration of chloride-containing fluids. This acidosis usually resolves and should not affect the treatment. It is more likely in pregnant women.</td>
<td></td>
<td>[1] [199]</td>
</tr>
</tbody>
</table>
### Diagnostic guidelines

#### Europe

**Diabetes at the front door - a guideline for dealing with glucose related emergencies at the time of acute hospital admission**

*Published by:* Joint British Diabetes Societies for Inpatient Care Group  *Last published:* 2020

**The management of diabetic ketoacidosis in adults**

*Published by:* Joint British Diabetes Societies for Inpatient Care Group  *Last published:* 2013

**Type 1 diabetes in adults: diagnosis and management**

*Published by:* National Institute for Health and Care Excellence  *Last published:* 2016

**Diabetes (type 1 and type 2) in children and young people: diagnosis and management**

*Published by:* National Institute for Health and Care Excellence  *Last published:* 2016

**Diabetes in pregnancy: management from preconception to the postnatal period**

*Published by:* National Institute for Health and Care Excellence  *Last published:* 2015

**Management of diabetes: a national clinical guideline**

*Published by:* Scottish Intercollegiate Guidelines Network  *Last published:* 2017

#### International

**ISPAD clinical practice consensus guidelines 2018**

*Published by:* International Society for Pediatric and Adolescent Diabetes  *Last published:* 2018

#### North America

**Standards of medical care in diabetes -‡2020**

*Published by:* American Diabetes Association  *Last published:* 2020
# Treatment guidelines

## Europe

### The management of diabetic ketoacidosis in adults
- **Published by:** Joint British Diabetes Societies for Inpatient Care Group
- **Last published:** 2013

### Type 1 diabetes in adults: diagnosis and management
- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2016

### Diabetes (type 1 and type 2) in children and young people: diagnosis and management
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- **Published by:** National Institute for Health and Care Excellence
- **Last published:** 2015

### Management of diabetes: a national clinical guideline
- **Published by:** Scottish Intercollegiate Guidelines Network
- **Last published:** 2017

### Management of children and young people under the age of 18 years with diabetic ketoacidosis
- **Published by:** British Society of Paediatric Endocrinology and Diabetes
- **Last published:** 2020

## International

### ISPAD clinical practice consensus guidelines 2018
- **Published by:** International Society for Pediatric and Adolescent Diabetes
- **Last published:** 2018

## North America

### Standards of medical care in diabetes - 2020
- **Published by:** American Diabetes Association
- **Last published:** 2020

## Oceania

### National evidence-based clinical care guidelines for type 1 diabetes for children, adolescents and adults
- **Published by:** National Health and Medical Research Council (Australia)
- **Last published:** 2011
Key articles

- Joint British Diabetes Societies Inpatient Care Group. The management of diabetic ketoacidosis in adults. September 2013 [internet publication]. Full text

References


Diabetic ketoacidosis


38. US Food and Drug Administration. FDA drug safety communication: FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections. December 2015 [internet publication]. Full text


42. Joint British Diabetes Societies Inpatient Care Group. The management of diabetic ketoacidosis in adults. September 2013 [internet publication]. Full text


51. British Society for Paediatric Endocrinology and Diabetes. BSPED interim guideline for the management of children and young people under the age of 18 years with diabetic ketoacidosis. January 2020 [internet publication]. Full text

52. Joint British Diabetes Societies for Inpatient Care Group. Diabetes at the front door. A guideline for dealing with glucose related emergencies at the time of acute hospital admission. March 2020 [internet publication]. Full text


| References |  
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<td>149.</td>
<td>Fritz Z, Slowther AM, Perkins GD. Resuscitation policy should focus on the patient, not the decision. BMJ. 2017 Feb 28;356:j813 Full text Abstract</td>
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<td>159.</td>
<td>Pendlebury ST, Klaus SP, Mather M, et al. Routine cognitive screening in older patients admitted to acute medicine: abbreviated mental test score (AMTS) and subjective memory complaint versus Montreal Cognitive Assessment and IQCODE. Age Ageing. 2015 Oct 13;44(6):1000-5 Full text Abstract</td>
</tr>
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</table>
164. Nova Scotia Health Authority. This is not my Mom. 2012 [internet publication] Full text


176. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med. 2001 Sep;16(9):606-13 Abstract


188. National Centre for smoking cessation and training. Smoking cessation and mental health. 2014 [internet publication]. Full text


Figure 1: Triad of DKA

Figure 2: Pathogenesis of DKA and HHS; triggers include stress, infection, and insufficient insulin. FFA: free fatty acid; HHS: hyperosmolar hyperglycaemic state.
Figure 3: Management of diabetic ketoacidosis 1. Intravenous fluid

by BMJ Knowledge Centre
2. Potassium
Measure urgently on venous blood gas and reassess at 60 minutes, 2 hours and 2 hourly thereafter

- Potassium level <3.5 mmol/L
  - Get an immediate senior review as additional potassium needs to be given

- Potassium level 3.5 to 5.5 mmol/L
  - Add 40 mmol/L potassium (use premixed normal saline with potassium chloride)

- Potassium level >5.5 mmol/L
  - Do not add potassium to initial intravenous fluid

Figure 4: Management of diabetic ketoacidosis 2. Potassium
By BMJ Knowledge Centre
3. Insulin
Start a fixed rate insulin infusion according to local protocols

Assess response to treatment hourly

Blood ketones falling by at least 0.5 mmol/L/hour

- Continue fixed-rate insulin until:
  - Blood ketones are <0.6 mmol/L
  - Venous pH is >7.3
  - Bicarbonate >15 mmol/L

Blood ketones not falling by at least 0.5 mmol/L/hour (and no insulin pump malfunction)

- Increase the fixed-rate insulin infusion rate according to local protocols

Figure 5: Management of diabetic ketoacidosis 3. Insulin

By BMJ Knowledge Centre
**Diabetic ketoacidosis**

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**4. Resolution of DKA**

Defined as:
- pH > 7.3
- bicarbonate > 15.0 mmol/L
- blood ketone level < 0.6 mmol/L

Resolution of DKA < 24 hours

**No**

- Involve senior support and specialist input

**Yes**

- Review by the diabetes specialist team and start subcutaneous insulin once the patient is eating and drinking

---

*Figure 6: Management of diabetic ketoacidosis 4. Resolution*

*By BMJ Knowledge Centre*
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Figure 1 – BMJ Best Practice Numeral Style

5-digit numerals: 10,000
4-digit numerals: 1000
Numerals < 1: 0.25

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This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

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