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Adult Diabetic Ketoacidosis Guideline

1. Purpose

This guideline describes the management of patients who present to a WA Country Health Service (WACHS) hospital with diabetic ketoacidosis (DKA). This usually occurs in patients with Type 1 diabetes but may also be seen in patients with Type 2 diabetes.

2. Guideline

This guideline is to be used in conjunction with the MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart. See the following for DKA management in specific patient populations:

- pregnant women, refer to section 2.13
- paediatric patients, refer to the Perth Children's Hospital (PCH) Emergency department Diabetic ketoacidosis Guidelines.

This guideline must **not** be used in the management of Hyperglycaemic Hyperosmolar State (HHS).

2.1 General management principles

General management principles are:

- **Aim to correct the cause of the acidosis,** i.e., the **ketonaemia** rather than primarily focusing on treatment of the hyperglycaemia.
- Aim to cease high-dose fixed rate insulin infusion as soon as ketones are cleared and convert to subcutaneous insulin. If insulin infusion is still required (i.e. patient not eating and drinking normally) medical team should convert to variable rate intravenous (IV) insulin infusion with glucose as per MR157A WACHS Insulin Infusion Order Chart.
- Monitor bedside capillary ketones and glucose.
- Use sodium chloride 0.9% for resuscitation, not colloid.
- Give sodium chloride 0.9% and glucose 10% together if ketones are greater than 0.6 mmol/L and glucose is less than 14 mmol/L.
- Continue usual subcutaneous basal insulin in addition to IV insulin or commence basal insulin at outset if patient is newly diagnosed.

2.2 Diagnostic criteria

Obtain venous blood gases (VBG), capillary ketone +/- capillary glucose levels:

- Glucose: **greater than** 11 mmol/L or known diabetes **and**
- Ketones: **≥** 3 mmol/L or urine ketones ≥ 2+ **and**
- Acidosis: venous pH **less than** 7.35 **or** bicarbonate **less than** 18 mmol/L.

Note: The standard of care is venous bicarbonate. Arterial blood gases should **ONLY** be considered on patients with impaired consciousness.

Table 1: DKA Severity Assessment

	Severity	
Parameter	**Mild to Moderate**	**Severe**
Systolic blood pressure	**≥** 90 mmHg	**less than** 90 mmHg
Venous pH	7.1 to 7.35	**less than** 7.1
Capillary ketones	3 to 6 mmol/L	**greater than** 6 mmol/L
Blood bicarbonate	10 to 18 mmol/L	**less than** 10 mmol/L
Glasgow Coma Scale	15	**less than** 15
Serum potassium	**≥** 3.5 mmol/L on admission	**less than** 3.5 mmol/L on admission

Management should occur in the most appropriate location in each health service (ward, emergency department, High Dependency Unit (HDU)) depending upon the severity of the presentation and local expertise and resources. Consider the need to transfer to an alternate site with additional resources early in the admission and plan as appropriate in collaboration with the WACHS Acute Patient Transfer Coordination (APTC) Service.

Discuss with senior medical clinician and consider level of care (high dependence unit [HDU], intensive care unit [ICU], transfer) if:
- ☐ Severe ketoacidosis
- ☐ Serum potassium < 3.5 mmol/L on admission
- ☐ Significant acute kidney injury or low urine output despite fluid resuscitation
- ☐ Decreased alertness (Glasgow Coma Scale (GCS) < 12)
- ☐ Haemodynamic instability (shock)
- ☐ Failure to respond to treatment
- ☐ Patient is pregnant
- ☐ Patient is young (16 - 25 years old)

2.3 Serious complications

Serious complications include:
- Both hyperkalaemia and hypokalaemia can be life threatening. Seek early advice from a senior medical clinician.
- Hypoglycaemia - blood sugar can fall rapidly with DKA treatment. When this occurs use additional glucose rather than reducing the insulin infusion.
- Cerebral oedema is rare but has a high mortality rate. Monitor carefully and seek specialist input early.
- Pulmonary oedema is uncommon, but cautious fluid resuscitation is necessary if the patient also has cardiac or renal impairment. Seek early specialist advice.

2.4 Resuscitation and IV fluids

Considerations for resuscitation and IV fluids:
- Establish 2 large bore intravenous cannulas. Ideally consideration should be given to making one of these cannulas a three-way extension (“chook foot”) for the concurrent administration of glucose and the intravenous Actrapid® insulin (insulin neutral). Insulin infusions and glucose infusions must run on separate pumps.
- Patients often require a third cannula for repeat bloods.

- **If systolic BP less than 90 mmHg:** administer 500 – 1,000 mL of sodium chloride 0.9% solution over 15 minutes. If systolic BP remains **less than** 90 mmHg repeat and continue resuscitation under senior medical officer direction.
- **If the systolic BP is greater than 90 mmHg:** prescribe sodium chloride 0.9% (with or without potassium supplementation) as per Table 2. Adjust the rate of fluid replacement according to the patient's age, fitness and dehydration state. Plan for fluid replacement and use clinical judgement.

2.5 Potassium replacement

ATTENTION

Initial potassium level is often normal or high, but the patient's total body potassium is low. Potassium levels will drop rapidly with fluid and insulin replacement, thus it is important to replace potassium early, as low potassium can cause serious harm or death.

Cardiac monitoring **must** be in place when the rate of potassium is more than 10 mmol/hr (i.e. more than 250 mL/hr of a 40 mmol/L bag), i.e. for the 2nd and 3rd bags. Engage senior medical clinician for advice if needed.

Refer to: WACHS Potassium Supplementation Policy

Potassium - goal between 4 mmol/L and 5.5 mmol/L

- Serum potassium **greater than** 5.5 mmol/L – nil replacement.
- Serum potassium 3.5 to 5.5 mmol/L – replace with 40 mmol/L premixed bags (in 1,000 mL sodium chloride 0.9%).
- Serum potassium **less than** 3.5 mmol/L - senior medical clinician advice is required.
- Refer to **Table 2** for intravenous fluid and pre-mixed potassium infusion rates.
- Manage electrolytes - supplement as required and monitor.
- Prescribe required potassium on the MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart.
- 40 mmol / L potassium chloride bags can be administered via peripheral large bore cannula. The maximum rate of potassium via a peripheral venous line is 10 mmol/hr. One exception is in DKA where patients may require 20 mmol/hr for 4 hours via a peripheral venous line. For patients requiring > 4 hours of 20 mmol/hr potassium, consideration should be made for central line insertion or HDU review.

See Table 2 for IV fluid and pre-mixed potassium infusion rates.

Table 2: Intravenous fluid and pre-mixed potassium infusion rates

Bag	Fluid	Serum potassium level and potassium chloride supplementation required			Sodium chloride 0.9% infusion rate adjusted for concurrent		
		Greater than 5.5 mmol/L	3.5 – 5.5 mmol/L	Less than 3.5 mmol/L Senior medical review required	WITHOUT concurrent glucose	WITH concurrent glucose 10% (125 mL/hr)	WITH concurrent glucose 10% (187 mL/hr)
1st	1,000 mL sodium chloride 0.9%	Nil	Nil	Nil	1,000	875	813
2nd	1,000 mL sodium chloride 0.9%	Nil	40 mmol potassium	40 mmol potassium	500	375	313
Cardiac monitoring must be in place when the rate of potassium is more than 10 mmol/hr (i.e. more than 250 mL/hr of a 40 mmol/L bag), i.e. for the 2nd and 3rd bags. Engage senior medical clinician for advice if needed.							
3rd	1,000 mL sodium chloride 0.9%	Nil	40 mmol potassium	40 mmol potassium	500	375	313
4th	1,000 mL sodium chloride 0.9%	Nil	40 mmol potassium	40 mmol potassium	250	125	63
5th	1,000 mL sodium chloride 0.9%	Nil	40 mmol potassium	40 mmol potassium	250	125	63
6th	1,000 mL sodium chloride 0.9%	Nil	40 mmol potassium	40 mmol potassium	167	125	63

2.6 Insulin and glucose infusion

ATTENTION

If a patient has a personal continuous subcutaneous insulin infusion pump, this should be disconnected until DKA resolves.

Follow individual manufacturer's instructions to ensure correct cessation of pump and to prevent pump damage.

- **Insulin -** Commence insulin as a **fixed rate intravenous infusion** at a dose of 0.1 units/kg/hr of actual body weight; discuss with specialist if dose calculated to exceed 15 units/hr.
- Prepare insulin as Actrapid® (neutral insulin) 50 units in 50 mL sodium chloride 0.9%.
- Prescribe required fixed rate insulin infusion on the MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart.
- If ketones **not** falling by ≥ 0.5 mmol/L/hr or BGL not falling by **more than** 3 mmol/L/hr consider:
  - checking cannula site and insulin infusion (i.e. pump and / or residual volume).
  - alerting senior medical officer
  - increasing insulin rate by 1 unit/hr for the first 1-12 hours, then increase by 0.5 unit/hr for hours 12-24.
- **Continue** the patient's regular subcutaneous basal insulin from day 1 on MR156A WACHS Insulin Subcutaneous Order and Blood Glucose Record – Adult Form.
- **Prescribe** required glucose on the MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart.
- When blood glucose level (BGL) is less than 14 mmol/L:
  - add glucose 10% at 125 mL/hr
  - consider reducing the rate of intravenous insulin infusion to 0.05 units/kg/hour to reduce the risk of developing hypoglycaemia and / or hypokalaemia
- If BGL is less than 5 mmol/L, increase glucose 10% rate to 187 mL/hr.
- Reduce sodium chloride proportionately - refer to Table 2.
- Reduce the rate of fluid replacement in the young (16-25 years old), elderly, pregnant or those with heart or renal failure. Seek senior medical clinician advice on this specific issue.

2.7 Treat any precipitating causes

ATTENTION

Stop SGTL2 inhibitor immediately in DKA. Sodium-glucose co-transporter 2 (SGLT2) inhibitors, e.g. dapagliflozin, may cause DKA in patients with type 1 or type 2 diabetes, in particular when administered pre or post operatively. This may occur with near normal or mildly elevated blood glucose levels, termed euglycaemic ketoacidosis.

Look for and treat likely precipitants of DKA including screening for infection, silent ischaemia and contributing medications.

2.8 Other considerations

Other considerations include:

- Consider the use of **urinary catheter** if patient does not pass urine for two hours or is incontinent.
- Consider the use of a **nasogastric tube** and the potential for aspiration if conscious state is impaired.
- Complete the **venous thromboembolism** risk assessment/anticoagulation on the WA Hospital medication Chart and prescribe appropriate mechanical / chemothromboprophylaxis in accordance with the result; see the WACHS Venous Thromboembolism Prevention Policy.

- **Medications** affecting carbohydrate metabolism such as glucocorticoids, high dose thiazide diuretics, sympathomimetic agents, cocaine and the second-generation atypical antipsychotic agents can precipitate DKA.
- Metformin (particularly in association with renal impairment) can cause a lactic acidosis which must be distinguished from DKA.
- Maintain **oxygen** saturation at greater than 94% unless the patient has a history of carbon dioxide retention e.g., chronic obstructive pulmonary disease (COPD). Provide supplemental oxygen as prescribed. Refer to WACHS Oxygen Therapy and Respiratory Devices – Adults Clinical Practice Standard.
- Administration of **bicarbonate** in the treatment of DKA is not indicated; excessive bicarbonate may lead to a paradoxical increase in cerebrospinal fluid acidosis and delay the fall in blood lactate.

2.9 Monitoring

Monitoring includes:

- Monitor parameters and record data on the MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart.

MONITORING

☐ Capillary BGL hourly
☐ Capillary ketones hourly for the first 6 hours, then 2 hourly until DKA resolves
☐ VBG **hourly** for first 6 hours after initial treatment, then 2-hourly until DKA resolves
☐ Potassium levels 0, 1, 3, 5, 9, 13, 19 hours
☐ Urine output and fluid balance chart hourly to ensure appropriate hydration
☐ If patient has an elevated temperature, monitor hourly until resolved

- If ketones and glucose are not falling as expected, check all infusion lines.
- Consider hyperchloremic acidosis as a cause of delayed clearance of DKA.
- Potassium level to be monitored, as a minimum, prior to commencement of potassium replacement and prior to commencement of each new potassium containing infusion. That is, at time 0 and prior to 1 hour, 3 hours, 5 hours, 9 hours, 13 hours and 19 hours post treatment commencement, until DKA resolves.

For patients in dedicated Intensive Care Unit (ICU) / HDU sites record on the ICU 24-hour flow chart.

2.10 DKA EXIT (resolution) criteria

DKA exit (resolution) criteria are:

- Resolution of ketonaemia (ketones less than 0.6 mmol/L). This should occur within 24 hours, and
- Correction of acidosis (venous bicarbonate ≥ 18 mmol/L or venous pH ≥ 7.35), and
- Treatment / resolution of underlying or precipitating causes where appropriate.

2.11 Conversion to subcutaneous insulin or variable rate insulin infusion

Once ketones are <0.6 mmol/L, transition the patient from DKA protocol to alternate treatment plan.

Patients who are not yet eating and drinking normally:

- Continue intravenous fluids.
- Medical team convert patient to variable rate intravenous insulin infusion with 10% glucose. Guidance on the prescribing of variable rate insulin infusions is found in Appendix 1 of the WACHS Diabetes – Inpatient Management Clinical Practice Standard.
- The variable rate insulin infusion should be commenced based on the patient's BGL.
- Prescribe on the MR157A WACHS Insulin Infusion Order Chart.
- Continue subcutaneous basal insulin. Prescribe on the MR156A WACHS Insulin Subcutaneous Order and Blood Glucose Record – Adult Form.

Patients who are eating and drinking normally:

- If the patient is maintaining oral intake, they may transition directly from the fixed rate insulin infusion to subcutaneous insulin without the requirement of a variable rate insulin infusion.
- The patient's basal (long acting) subcutaneous insulin regimen should have been continued during their DKA treatment. If this has been ceased, specialist advice should be sought for the transition back to subcutaneous insulin.
- There should be an overlap between the insulin infusion and the first injection of rapid-acting insulin. Patients should be recommenced on a bolus subcutaneous insulin regimen at a mealtime and monitored. If no adverse events occur the intravenous insulin infusion should be ceased 30 to 60 minutes after the meal.

For patients with known diabetes on multiple daily injections:

- Recommence usual bolus or premixed insulin with next meal.
- Cease IV insulin infusion 30 minutes after bolus or premixed insulin.

For patients who are on insulin pump therapy:

- Consider pump failure as a cause of DKA before restarting pump.
- Seek advice from specialist diabetes team.
- If appropriate, recommence pump.
- Cease IV insulin infusion 30 minutes after recommencing pump.

For patients with newly diagnosed type 1 diabetes:

- Commence basal insulin on the day of admission.
- Start bolus insulin with the next meal.
- Cease IV insulin infusion 30 minutes after bolus insulin given.
- Suggested starting doses:
  - bolus (mealtime) insulin – e.g. 4 to 6 units of Novorapid® (insulin aspart) subcutaneously
  - basal (once a day) insulin – e.g. 10 units of Optisulin® (glargine insulin) or Levemir® (detemir insulin) subcutaneously.

Note: if no basal insulin has been given for > 24 hours aim to convert to subcutaneous insulin with evening meal and give basal dose **OR** convert at breakfast with half basal dose and then give remainder of dose with evening meal.

2.12 Discharge planning

Discharge planning includes:

- referral to inpatient diabetes educator and dietician
- outpatient follow-up by general practitioner

- outpatient diabetes educator and dietician
- referral to specialist diabetes services and / or endocrinologist.

2.13 DKA in pregnant women

Pregnant women with diabetes are more prone to severe and rapidly progressive episodes of DKA at lower glycemic levels and can develop DKA with 'normal' BGL. Fetal mortality from maternal DKA is as high as 30% and complications include fetal hypoxia, acidosis, preterm delivery, and neonatal intensive care admissions. Although more commonly associated with Type 1 diabetes, DKA can also occur in Type 2 or gestational diabetes in the context of severe illness such as sepsis, insulin disruption, myocardial infarction or medication administration (e.g. corticosteroids for fetal lung maturity or tocolysis).

Pregnant women with DKA must be managed by a multidisciplinary team that includes:

- Regional obstetric specialist,
- Regional paediatric specialist,
- Maternal Fetal Medicine (MFM) / diabetes team consult at King Edward Memorial Hospital (KEMH), and
- Regional physician specialist.

Difficult decisions regarding timing of delivery and patient transfer will be improved by a collaborative approach.

Please see WNHS Diabetes Clinical Practice Guideline for DKA management in pregnancy.

In general:

- Pregnant patients with severe DKA or sepsis should be managed in an ICU.
- Continuous fetal monitoring is standard of care and can be an additional vital sign for understanding the metabolic condition of the mother. Fetal traces during maternal acidosis will likely appear non-reassuring with decreased variability. The general goal is to correct the maternal acidosis prior to deciding on need for imminent delivery. Fetal monitoring may improve when maternal acidosis resolves, but not always.
- Due to the correlation between DKA and sepsis, threatened preterm labour is common. Remember to include obstetric causes of sepsis in your differential diagnosis.

Consider transfer in collaboration with the WACHS APTC Service.

3. Roles and Responsibilities

Prescribers are responsible for appropriate prescribing, monitoring and review of patients with DKA per this guideline.

Nurses / midwives are responsible for appropriate preparation and administration of medicines / therapies, and monitoring of patients with DKA per this guideline.

Pharmacists are responsible for providing clinical review of medicines as per this guideline.

All staff are:

- to work within their scope of practice appropriate to their level of training and job role responsibilities.
- to work within policies and guidelines to make sure that WACHS is a safe, equitable and positive place to be
- required to deliver a culturally safe and responsive service, ensuring the rights, views, values, and expectations of Aboriginal people are recognised and respected

4. Monitoring and Evaluation

4.1 Monitoring

Adverse events and clinical incidents relating to the management of DKA, including the prescribing and administration of medicines, are to be reported via the approved clinical incident management system (CIMS) e.g. DATIX, and managed as per the WACHS Medication Prescribing and Administration Policy and the WA Health Clinical Incident Management Policy 2019 MP 0122/19. The WACHS Medication Safety Committee and regional Medicines and Therapeutics Committees reviews clinical incident data relevant to medications.

4.2 Evaluation

This guideline will be reviewed as required to determine effectiveness, relevance and currency. At a minimum it will be reviewed every five years. This will be facilitated by the review contact for this guideline.

5. Compliance

Guidelines are designed to provide staff with evidence-based recommendations to support appropriate actions in specific settings and circumstances. As such, WACHS guidelines should be followed in the first instance. In the clinical context, where a patient's management should vary from an endorsed WACHS guideline, this variation and the clinical opinion as to reasons for variation must be documented in accordance with the Documentation Clinical Practice Standard.

WACHS staff are reminded that compliance with all policies and procedures is mandatory.

6. References

Group Expert. Diabetic Ketoacidosis. Therapeutic Guidelines: Endocrinology (eTG complete). West Melbourne, Australia: Therapeutic Guidelines Limited; 2019.

Joint British Diabetes Societies Inpatient Care Group. The Management of Diabetic Ketoacidosis in Adults. March 2023 (accessed Feb 2024) Joint British Diabetes Societies (JBDS) for Inpatient Care Group | The Association of British Clinical Diabetologists (abcd.care)

Up to Date: Diabetic ketoacidosis and hyperosmolar hyperglycemic state in adults: Clinical features, evaluation, and diagnosis (acessed February 2021) Diabetic ketoacidosis and hyperosmolar hyperglycemic state in adults: Clinical features, evaluation, and diagnosis - UpToDate (health.wa.gov.au)

Fiona Stanley Hospital Adult Diabetic Ketoacidosis Guideline (accessed Feb 2021; and Feb 2024)

Royal Perth Bentley Group Diabetic Ketoacidosis Clinical Guideline (accessed Feb 2021)

WACHS Adult Diabetic Ketoacidosis Guideline - South West (accessed Feb 2021)

Acknowledgement is made of the previous WACHS and SMHS sites endorsed work used to compile this WACHS Adult Diabetic Ketoacidosis (DKA) Guideline.

7. Definitions

Nil

8. Document Summary

Coverage	WACHS wide
Audience	Medical officers, nurses, midwives, pharmacists and other health professionals who manage patients with DKA
Records Management	Health Record Management Policy
Related Legislation	• *Medicines and Poisons Act 2014* (WA) • Medicines and Poisons Regulations 2016 (WA) • *Health Services Act 2016* (WA)
Related Mandatory Policies / Frameworks	• MP 0131/20 High Risk Medication Policy • Clinical Governance, Safety and Quality Framework
Related WACHS Policy Documents	• Diabetes – Inpatient Management Clinical Practice Standard • Documentation Clinical Practice Standard • High Risk Medications Procedure • Handling and Supply of Concentrated Potassium-Containing Solutions Procedure - WACHS South-West • Medication Prescribing and Administration Policy • Oxygen Therapy and Respiratory Devices – Adults Clinical Practice Standard • Venous Thromboembolism Prevention Policy
Other Related Documents	• PCH Diabetic ketoacidosis • WNHS Diabetes Clinical Practice Guideline
Related Forms	• MR156A WACHS Insulin Subcutaneous Order and Blood Glucose Record – Adult Form • MR157A WACHS Insulin Infusion Order Chart • MR157B WACHS Adult Diabetic Ketoacidosis (DKA) Treatment and Monitoring Chart • MR176 WACHS Intravenous Fluid Treatment Chart
Related Training Packages	Nil
Aboriginal Health Impact Statement Declaration (ISD)	ISD Record ID: 2151
National Safety and Quality Health Service (NSQHS) Standards	1.07, 4.13, 4.15
Aged Care Quality Standards	Nil
Chief Psychiatrist's Standards for Clinical Care	Nil

9. Document Control

Version	Published date	Current from	Summary of changes
3.00	17 April 2024	17 April 2024	Supersedes Adult Diabetic Ketoacidosis (DKA) Guideline – South West.

10. Approval

Policy Owner	Executive Director Clinical Excellence
Co-approver	Executive Director Nursing and Midwifery Services
Contact	Clinical Director General Medicine
Business Unit	Medical Services / Pharmacy Services
EDRMS #	ED-CO-17-30028

This document can be made available in alternative formats on request.