



Management of DKA and Emergencies in DKD

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Disclosures

- In the last 12 months I have received honoraria, travel or fees for speaking or advisory boards from
 - Abbott Diabetes
 - AstraZeneca
 - Boehringer-Ingelheim
 - Eli Lilly
 - Menarini
 - Novo Nordisk
 - Roche
 - Sanofi Diabetes

What Emergencies?

- Diabetic Ketoacidosis (DKA)
- Hyperosmolar Hyperglycaemic State (HHS)
- Hypoglycaemia
- The 'Diabetic Foot'

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CONSENSUS REPORT



Hyperglycaemic crises in adults with diabetes: a consensus report

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Hyperglycemic Crises in Adults With Diabetes: A Consensus Report

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Word Limit!

Table 4 Features of DKA and HHS occurring in special populations

Special population	Clinical characteristics and presentation	Diagnostic considerations	Specific management considerations	Future care considerations
Frail or older adults [181]	<ul style="list-style-type: none"> • High rate of preexisting comorbidities. • High risk for hospital mortality, prolonged hospitalisation and DKA recurrences. 	<ul style="list-style-type: none"> • Isolated HHS and mixed DKA/HHS occur more frequently than DKA. • Evaluate for specific precipitating factors and concurrent diagnoses (cardiovascular events, infection, medications). 	<ul style="list-style-type: none"> • Fluid resuscitation and rate of fluid replacement need to account for comorbidities and acute precipitating events. • Address polypharmacy. 	<ul style="list-style-type: none"> • Assessment of cognitive and functional status, including capacity for self-management. • Continued management of comorbidities and risk factors for DKA/HHS recurrence.
SGLT2 inhibitor [91, 93, 103, 182]	<ul style="list-style-type: none"> • May be spontaneous or preceded by metabolic decompensation 	<ul style="list-style-type: none"> • May present with near-normal glucose 	<ul style="list-style-type: none"> • Acute management as for 'general' 	<ul style="list-style-type: none"> • SGLT2 inhibitor therapy is not recommended for acute management with T1D
End-stage kidney disease [2, 183]	<ul style="list-style-type: none"> • About 4% of patients with diabetes and end-stage kidney disease experienced DKA/HHS. • May present with fluid overload. High preexisting comorbidity burden with increased risk of mortality. 	<ul style="list-style-type: none"> • Patients with end-stage kidney disease usually present with greater hyperglycaemia, more frequent hyponatraemia, higher osmolality, hyperkalaemia, and lower ketone concentrations of β-hydroxybutyrate compared with patients without end-stage kidney disease. 	<ul style="list-style-type: none"> • Careful fluid administration and potassium replacement are needed. • Greater risk of cardiac co-complications. 	<ul style="list-style-type: none"> • Holistic multidisciplinary care and aggressive multiple risk factor intervention is necessary. • Closer glucose and ketone monitoring is necessary.
Pregnancy [160, 184]	<ul style="list-style-type: none"> • Up to 2% of pregnancies with pregestational diabetes develop DKA. • Most cases occur with preexisting T1D. • The incidence of DKA in gestational diabetes is low (<0.1%). 	<ul style="list-style-type: none"> • Euglycaemic DKA (glucose <11.1 mmol/l [200 mg/dl]) may occur. • Mixed acid-base disturbances may occur with hyperemesis, making the diagnosis challenging. 	<ul style="list-style-type: none"> • The significant fetomaternal risk requires immediate expert senior medical and obstetric intervention. • Ideally patients should be cared for in delivery suites or high-dependency units. 	<ul style="list-style-type: none"> • Management guidelines in the emergency department or obstetric unit should include sections on the management of DKA in pregnancy as well as sick day rules.
COVID-19 [79, 185]	<ul style="list-style-type: none"> • Higher frequency of DKA during the COVID-19 pandemic. • At-risk groups are adults with preexisting T2D. • High risk for complications, need for ICU care, longer hospital stays, and mortality. 	<ul style="list-style-type: none"> • Usual diagnostic criteria. • Higher frequency of mixed DKA/HHS especially in older adults. 	<ul style="list-style-type: none"> • Treatment with high-dose steroids requires higher-dose insulin to treat refractory ketonaemia. • In newly diagnosed individuals presenting with diabetes in DKA, diabetes phenotyping may be helpful. 	<ul style="list-style-type: none"> • Discharge on insulin treatment with careful follow-up.

T1D, type 1 diabetes; T2D, type 2 diabetes

Changes in DKA in Renal Disease

	Normal renal function	CKD stages 1-3	CKD stages 4 and 5	ESRD
Insulin degradation	Normal	Normal	Decreased	Decreased
Ketone body formation	Mild to severe	Mild to severe	Moderate to severe	Moderate to severe
Ketonuria	Moderate to severe	Moderate to severe	Mild to moderate	Non-existent to mild depending on ability to form urine
Acidosis	Mild to severe	Mild to severe	Moderate to severe	Depends on timing of latest dialysis session
Hypertonicity	Mild to severe	Mild to severe	Moderate to severe	Depends on timing of latest dialysis session
Potassium (K ⁺) levels	Hyperkalaemia with total body K ⁺ deficit	Hyperkalaemia with total body K ⁺ deficit	Hyperkalaemia with normal total body K ⁺	Depends on timing of latest dialysis session

Treat as per normal DKA guidelines

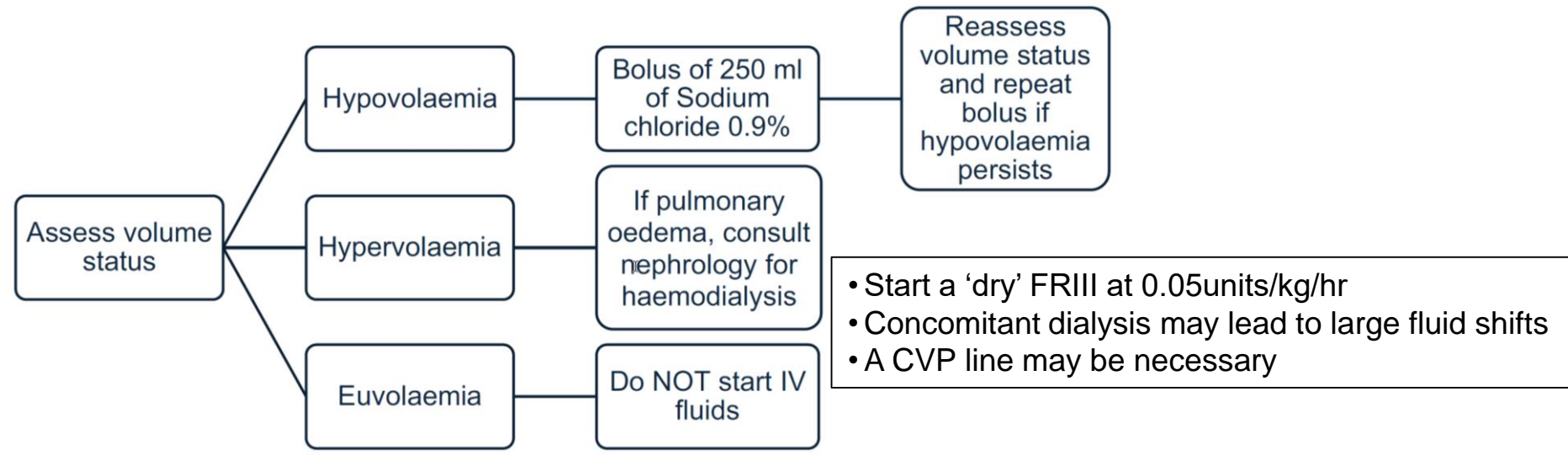
Recommendations

- Don't assume that symptoms in those with advanced CKD are due to the CKD / uraemia
- Assess fluid status (e.g. usual post dialysis weight vs presentation weight)
- Measure ketones and lactate in those with a high anion gap acidosis
- Dialysis improves glucose and acidosis, but not ketosis

Beware Euglycaemic DKA

- DKA can present with normal glucose concentrations
- SGLT2i use induced ketosis
- People should NOT be on a low carbohydrate diet
- Those on glucose free solution CRRT are at particular risk

Management of DKA



Aim for reduction in ketones of 0.5mmol/l/hr, and glucose 3-5mmol/l/hr, and a rise in bicarbonate of 3mmol/l/hr.

Calculated osmolality should not fall by more than 8mOsmol/Kg/hr

Electrolytes

- Do not give potassium unless it is $<3.5\text{mmol/l}$
- Hyperkalaemia should improve with insulin therapy
- If potassium is $>5.0\text{mmol/l}$ use a cardiac monitor
- If potassium is $>6.5\text{mmol/l}$ consider RRT
- Consider bicarbonate replacement and / or RRT if $\text{pH}<7.2$

Resolution of DKA

- Resolution of DKA is defined as ketones $<0.6\text{mmol/l}$ and venous pH >7.3

HHS – Diagnosis

- Hypovolaemia
- Raised plasma osmolality ($>320\text{mOsm/kg}$)
- Hyperglycaemia ($>30.0\text{mmol/l}$) without significant ketonaemia ($<3.0\text{mmol/l}$) or acidosis ($\text{pH} >7.3$) and bicarbonate ($>15.0\text{mmol/l}$)
- In mixed HHS/DKA, pH is <7.3 , bicarbonate is $<15\text{ mmol/l}$ and ketone $>3\text{ mmol/l}$

Changes in HHS in Renal Disease

	Normal renal function	CKD stages 1-3	CKD stages 4 and 5	ESRD
Hypovolaemia	Severe	Severe	Moderate to severe	If residual urine production, moderate to severe
Urine output	Significantly increased	Significantly increased	Variable	Variable
Osmolality	Moderately to significantly increased	Moderately to significantly increased	Significantly increased	Significantly increased
Effective osmolality	Moderately to significantly increased	Moderately to significantly increased	Moderately to significantly increased	Moderately to significantly increased
Hyperglycaemia	Severe	Severe	Severe	Severe

Treat as per normal HHS guidelines

Electrolytes

- Do not give potassium unless it is $<3.5\text{mmol/l}$
- If potassium is $>5.5\text{mmol/l}$ use a cardiac monitor
- If potassium is $>6.5\text{mmol/l}$ consider RRT
- Consider RRT if osmolality $>350\text{mOsmol/Kg}$

Treatment Aims – Fluid

- Effective osmolality should not fall by more than 8mOsmol/Kg/hr (if it is faster, reduce fluid infusion rate)
- Aim for fluids given at 20-25ml/kg/hr
- Even if sodium rises, if osmolality is falling, continue 0.9% sodium chloride. Only change to 0.45% if sodium is rising and osmolality is rising, or not falling at the expected rate

Treatment Aims – Glucose

- Check glucose and electrolytes hourly for the first 6 hours, then 2 hourly
- If glucose is dropping <5.0 mmol/L per hour, check fluid balance
- If positive balance is inadequate increase infusion rate
- If fluid replacement is adequate and glucose not falling, start FRIII at 0.05 units/kg/h
- In people with ESRD, start FRIII at 0.02 units/kg/h

Resolution of HHS

- Measured or calculated serum osmolality falls to less than 320mOsm/kg
- Renal function has returned to baseline
- Hyperglycaemia has been corrected (<13.9 mmol/l)
- Cognitive status has improved

Hypoglycaemia Prevention

- Everyone with diabetes with significant renal disease should be on a CGM (ideally with an alarm)
- Reduce insulin doses by 25% on haemodialysis days
- If the pre-dialysis glucose is $<7\text{mmol/L}$, give 20–30g low GI CHO
- All dialysis units (and patients) should have a hypo kit



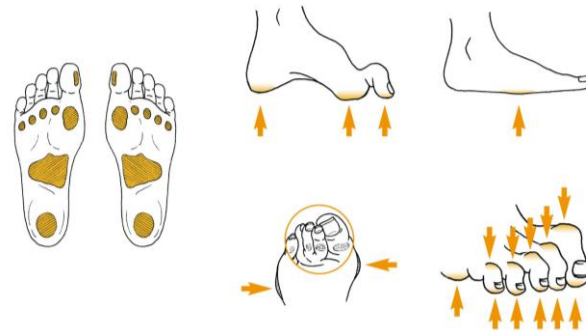
In the Event of Hypoglycaemia

- An appropriate rapid-acting carbohydrate treatment should be provided taking into account fluid, potassium and phosphate restrictions
- Patients and staff should be educated in regard to the appropriate treatment of mild to moderate hypoglycaemia and hypoglycaemia unawareness



Feet!

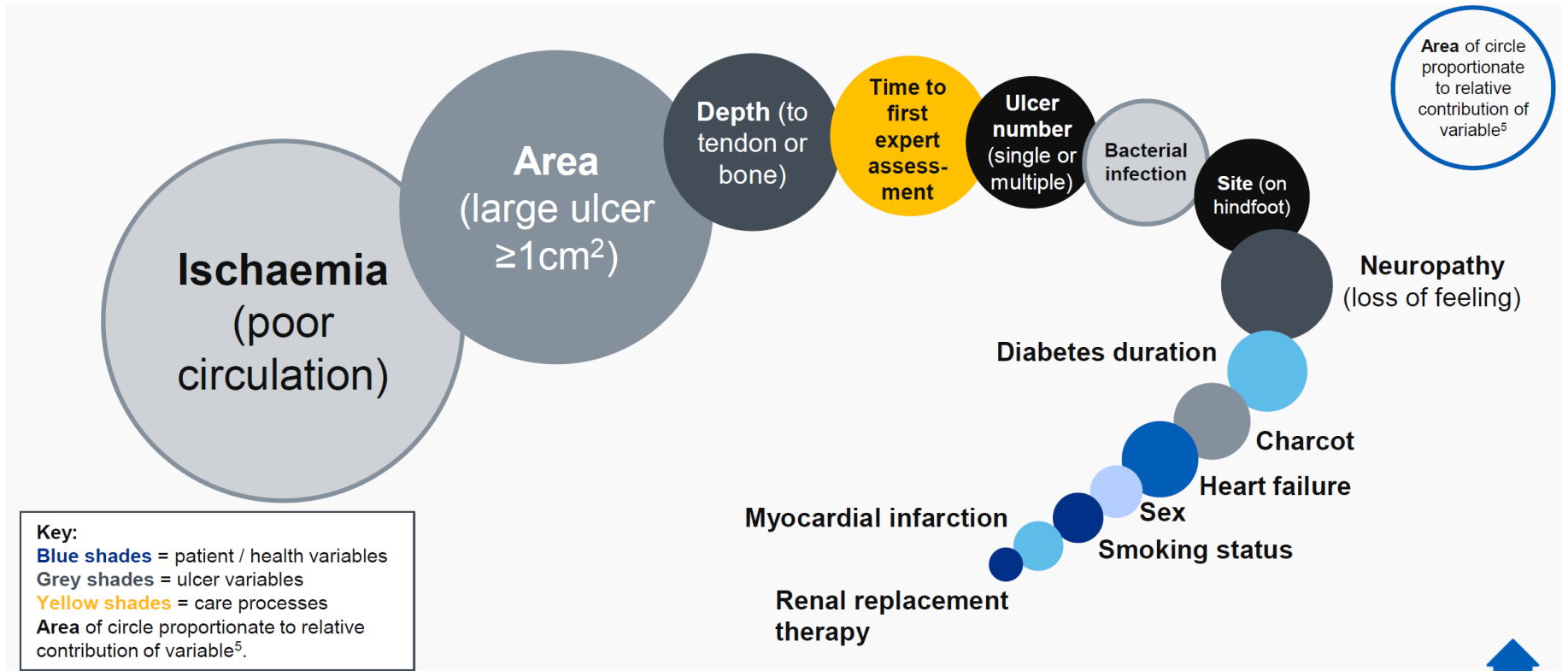
- The feet of a person with ESRD should be inspected at least every month, assessing
 - Vascular status (signs of PAD?)
 - Skin (colour, temperature, oedema, infection, pre-ulceration)
 - Deformity
 - Footwear
 - Foot care



Feet

- Poor peripheral circulation, immobility, changes in leg swelling, poor eyesight, etc all contribute to an increased risk of ulceration, infection, and ultimately amputation
- If you do not have one, talk to your local specialist diabetes foot team to get a liaison podiatrist – or at the very least establish a relationship to allow for rapid assessment for foot wounds

Things that Most Influence Wound Healing



Addressing Uncertainty

Digital Evaluation of Ketosis and Other Diabetes Emergencies (DEKODE)

Regular and frequent feedback of specific clinical criteria delivers a sustained improvement in the management of diabetic ketoacidosis 


Authors: Punith Kempegowda,^A Ben Coombs,^B Peter Nightingale,^C Joht Singh Chandan,^D Jaffar Al-Sheikhli,^E Bhavana Shyamanur,^D Kasun Theivendran,^D Anitha Vijayan Melapatte,^F Umesh Salanke,^G Mohammed Akber,^G Sandip Ghosh^G and Parth Narendran^H

Open access

Original research

**BMJ Open
Diabetes
Research
& Care**

Clinical and biochemical profile of 786 sequential episodes of diabetic ketoacidosis in adults with type 1 and type 2 diabetes mellitus

Emma Ooi ,¹ Katrina Nash,² Lakshmi Rengarajan,³ Eka Melson,^{3,4} Lucretia Thomas,² Agnes Johnson,² Dengyi Zhou,² Lucy Wallett,³ Sandip Ghosh,³ Parth Narendran,^{3,5} Punith Kempegowda^{3,4}

QUALITY IMPROVEMENT WINNING PAPER

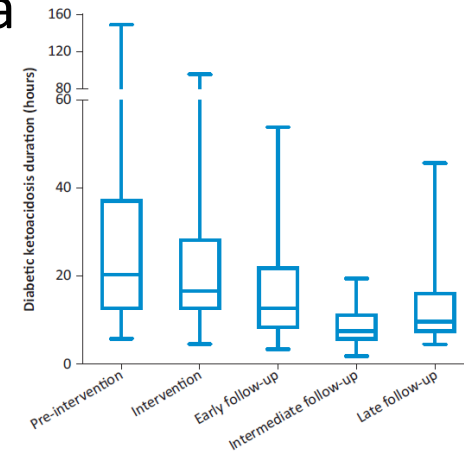
Sustaining improvement in diabetes-related ketoacidosis management through a Quality Improvement Project

LAKSHMI RENGARAJAN,¹ KATRINA NASH,² EMMA OOI,³ CATHERINE COOPER,⁴ AMY BIRCHENOUGH,⁵ MEGAN OWEN,⁴ SANJAY SARAF,¹ MUHAMMAD ALI KARAMAT,¹ PARIJAT DE,⁵ SENTHIL KRISHNASAMY,⁴ PARTH NARENDRAN,^{1,6} PUNITH KEMPEGOWDA,^{1,7} ON BEHALF OF THE DEKODE GROUP

Kempegowda P et al Clin Med 2017;17(5):389-394
Ooi E et al BMJ Open DRC 2021;9:e002451
Regarajan LN et al Brit J Diab 2022;22(2):132-138

DEKODE Database

- Has data on tens of thousands of DKA admissions
- Collected by resident doctors or medical students
- Regular feedback to contributing institutions
- Now international – USA, Italy, Uzbekistan, India
- Several papers currently in preparation
- If you want to join in – just ask!



If Anyone is Interested

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INVITED REVIEW

Management of diabetes-related hyperglycaemic emergencies in advanced chronic kidney disease: Review of the literature and recommendations

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Abstract

Aims: Despite the substantial progress in the management of diabetes mellitus (DM), chronic kidney disease (CKD) remains one of the most common complications. Although uncommon, diabetic emergencies [diabetic ketoacidosis (DKA),



Management of DKA and Emergencies in DKD

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