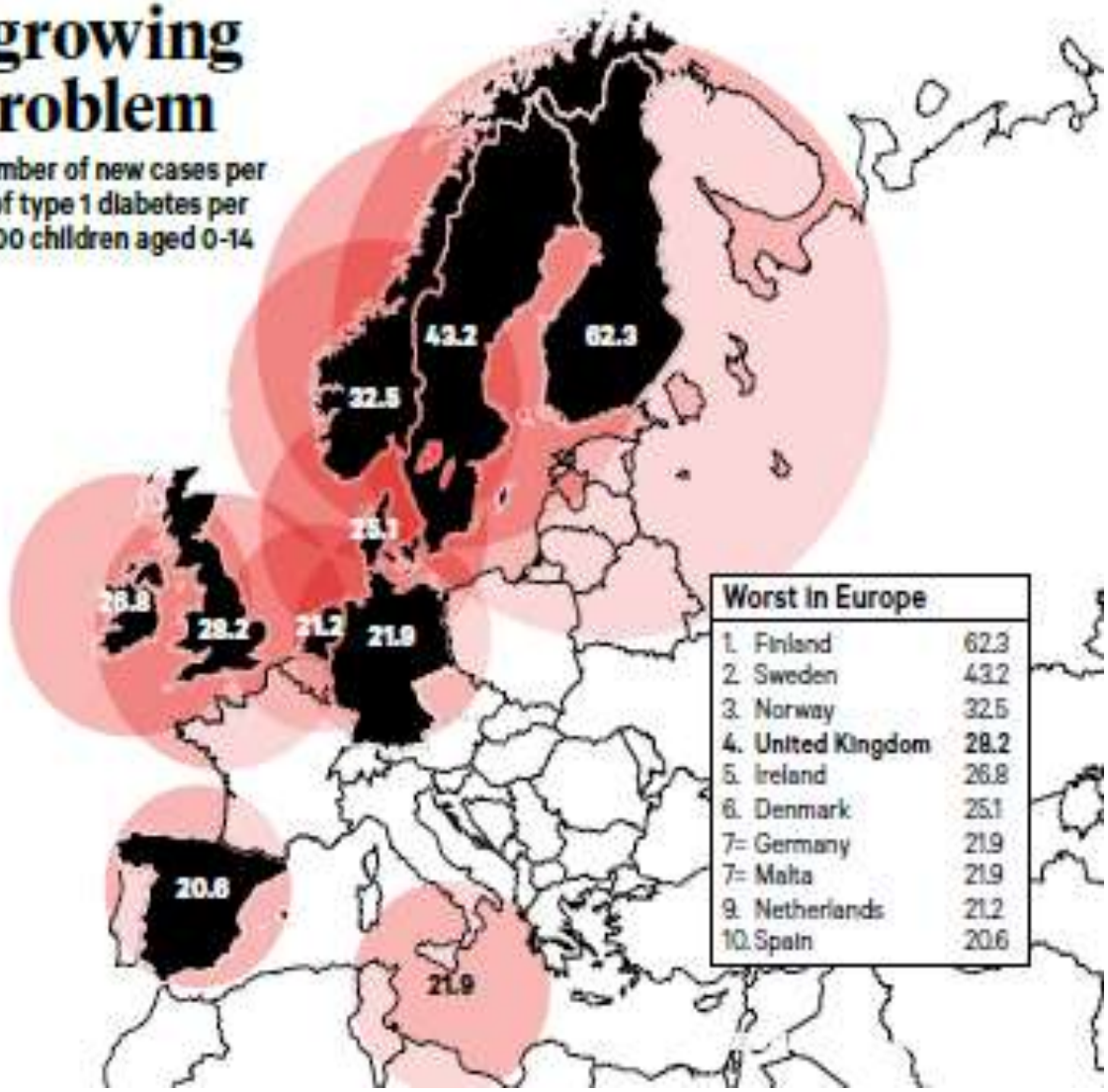
Paediatric Diabetic ketoacidosis Integrated Care Pathway

Dr Nirupa D'Souza and Dr Ambika Shetty

Thanks to Dr John Barton for the Integrated care pathway and teaching material

A growing problem

The number of new cases per year of type 1 diabetes per 100,000 children aged 0-14



Worst in Europe

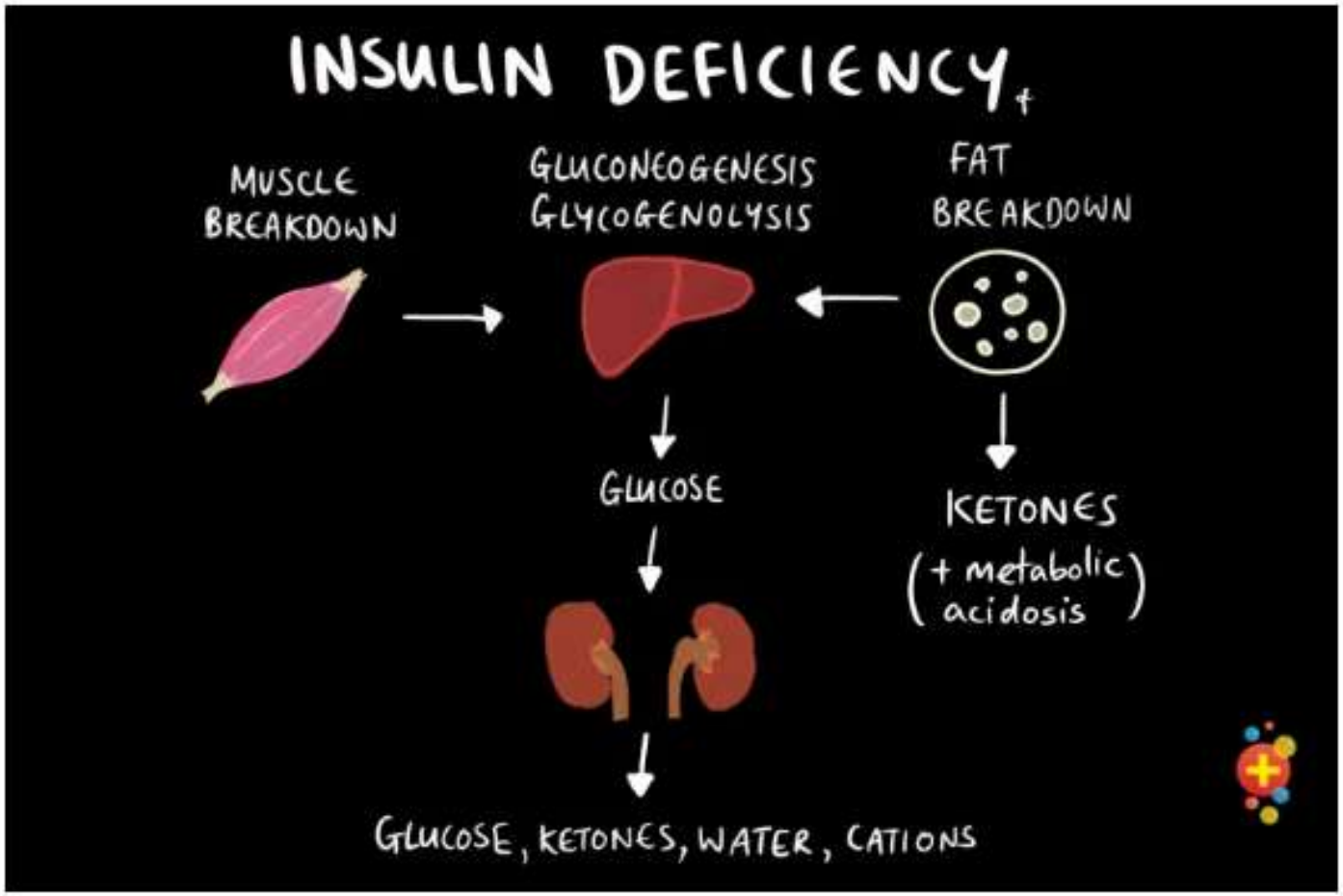
1.	Finland	62.3
2.	Sweden	43.2
3.	Norway	32.5
4.	**United Kingdom**	**28.2**
5.	Ireland	26.8
6.	Denmark	25.1
7=	Germany	21.9
7=	Malta	21.9
9.	Netherlands	21.2
10.	Spain	20.6

Introduction

- 1500 children with diabetes in Wales: 150 new cases/year
- 96% have type 1 diabetes.
- 25% of cases are in DKA at diagnosis

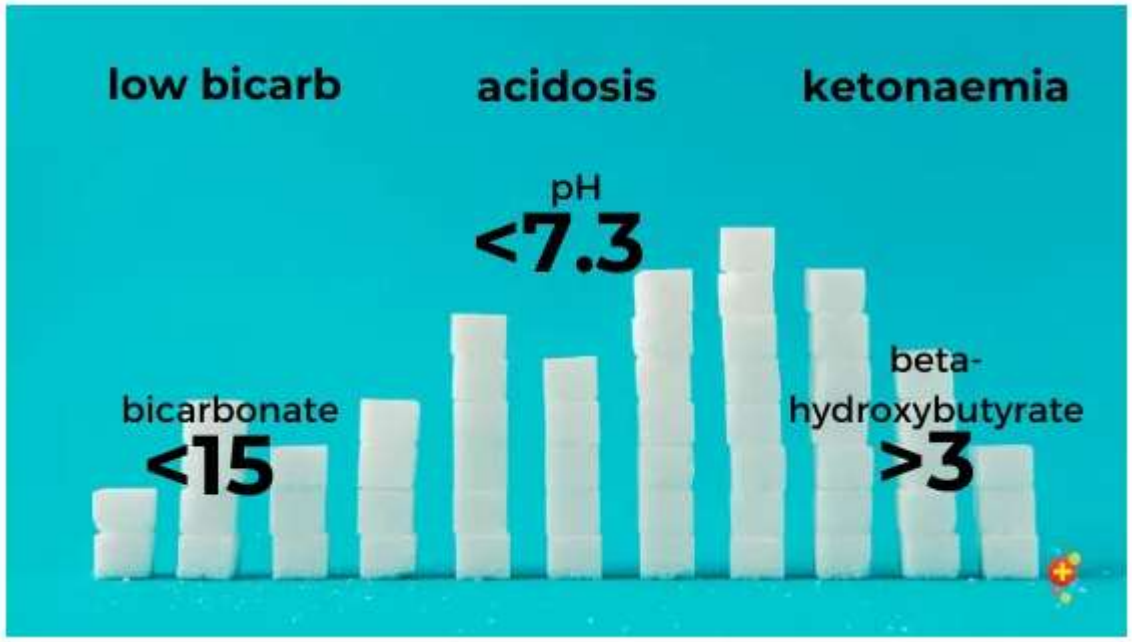
- DKA:
  - requires intensive medical intervention
  - is traumatizing for the child
  - may have a long-term adverse effect on their diabetes control
  - **is the commonest cause of death in children with diabetes**

A quick science refresh



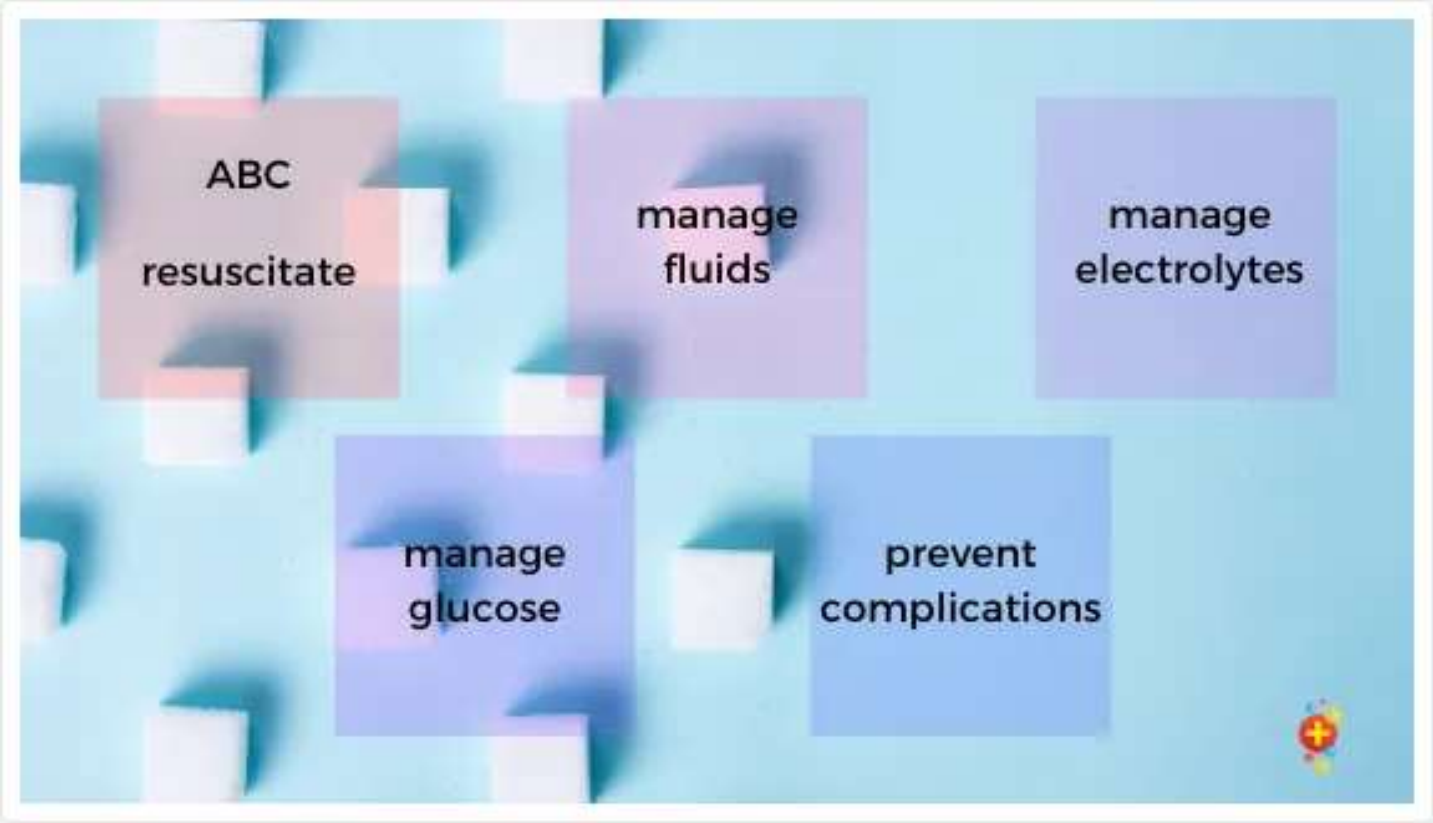
Diabetic Ketoacidosis

BSPED (2020) and ISPAD definition of DKA



Patients presenting with a new diagnosis of diabetes will invariably also be hyperglycaemic but patients with known diabetes may present in DKA with a normal glucose

Principles of management



Children and Young People's Wales Diabetes Network

Guidelines

British Society for Paediatric Endocrinology and Diabetes

NICE National Institute for Health and Care Excellence

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

ISPAD International Society for Pediatric and Adolescent Diabetes

British Society for Paediatric Endocrinology and Diabetes

Integrated care pathway for the management of children and young people with

Diabetic Ketoacidosis

Where to find them

- CYPWDN DKA ICP booklet
- DKA ICP and calculator on your hospital clinical portal
- https://www.bsped.org.uk/clinical-resources/guidelines/
- https://www.bsped.org.uk/media/1742/dka-icp-2020-v1_1.pdf
- https://www.dka-calculator.co.uk/

Name
DOB
Affix Patient Identity Label
HOSP NO
NHS NUMBER

Diabetic Ketoacidosis in Children

Integrated Care Pathway

GIG CYMRU NHS WALES

Children and Young People's Wales Diabetes Network

This document for the management of ketoacidosis in children with diabetes now includes a DKA Integrated Care Pathway (ICP) designed by the BSPED DKA Specialist Interest group in March 2020. The update is based on the ISPAD Clinical Practice Consensus Guideline 2018 and the Clinical Trial of Fluid Infusion Rates for Paediatric Diabetes Ketoacidosis by the PECARN study group, N Engl J Med 2018;378:2275-87. DOI: 10.1056/NEJMoa1716816.

The ICP has been reviewed and endorsed by the Children & Young People's Wales Diabetes Network (& Brecon Group). It is accompanied by a powerpoint teaching resource intended to be used for training and updates for teams at local hospitals across Wales.

Any comments or suggestions may be addressed to

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4th Edition: June 2020; next review December 2023
3rd Edition: March 2016, 2nd Edition: May 2010, 1st Edition: June 2007

Please only use abbreviations in the pathway if they are on the list of approved abbreviations on page 31 of the document.

Contents

■ = Page includes Nursing documentation
■ = Page includes MDT documentation

Signature Sheet

It is *essential* that all staff using the pathway complete the 'signature key box' below, this ensures that those using the pathway can be identified. You can then use your initials in the pathway instead of full signature and printed name.

Print Name	Designation	Work Area	Initials	Signature	Date

Important safety notes

- General guidelines for management
- Treatment may need modification for individual patients
- Does not remove need for detailed re-assessments
- Should be used by or under supervision of clinicians experienced in management of paediatric DKA
- Should be used in conjunction with full BSPED guideline
- Part of official patient care record and should be filed in patients notes
- Must complete box in right hand corner with name, signature, date and time
- Any variation from care plan must be documented on variance sheet

ICP and calculator layout

The flow charts are structured in a systematic way as follows:

Indicates the start of a flow chart, showing how it was reached.

The blank space indicates an entry to be completed by the clinician. A green tick icon indicates that an entry is part of the national DKA audit programme.

Indicates a tick box option.

Indicates a decision point. Follow the appropriate arrow to continue.

Shows additional critical or useful guidance.

Indicates the end of a flow chart sequence, showing which flow chart to use next.

Children and Young People's Wales Diabetes Network

The ICP is divided into sections which are identified by coloured borders at the side of each page.

MAIN PROTOCOL SECTION

COMPLICATIONS SECTION

APPENDICIES SECTION

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FLOW CHART 1 – ASSESSMENT & DIAGNOSIS

Patient Name:
Date of Birth:
Hospital / NHS Number:

START HERE

Suspect DKA

Clinical History:
- Polyuria/polydipsia
- Weight loss
- Abdominal pain
- Weakness
- Vomiting
- Confusion

Clinical Signs:
- Dehydration
- Kussmaul breathing (deep, sighing)
- Ketotic smell
- Lethargy, drowsiness

Biochemistry:
- Hyperglycaemia (>11mmol/L)
- Acidaemia (pH<7.3)
- Ketosis (blood ketones >3mmol/L or urine ketones ++)

Ask for senior support

Check:
Blood Glucose
Blood Ketones
Blood Gas

Record initial values:

Glucose		mmol/L
pH		
Ketones		mmol/L
Bicarb.		mmol/L

Raised blood glucose, pH >7.3 AND bicarbonate >15mmol/L → Consider new diabetes not in DKA Use local guidelines

Very high blood glucose (>35mmol/L), No significant ketosis (<3mmol/L) OR acidosis (pH>7.3, bicarb. >15mmol/L) → Go to flow chart 12 HYPEROSMOLAR HYPERGLYCAEMIC STATE Page 13

pH <7.3 or bicarbonate <15mmol/L AND Blood ketones >3mmol/L → **Diagnose DKA**

Blood glucose levels are generally high (above 11mmol/L) but children and young people with known diabetes may develop DKA with normal blood glucose levels.

ABC resuscitation

Initial management follows principles in APLS

A: Establish airway: Seek urgent anaesthetic review if unable to protect airway.
If child comatose: Insert NG tube on free drainage.

B: Give O_2 100% via face mask with reservoir bag (only omit if child very well).

C: Establish IV access (consider 2nd cannula for later blood samples), take bloods (see box).
Commence cardiac monitoring (peaked T waves may indicate hyperkalaemia).

Weight: kg

Actual / Estimated / Recent

For estimated weight:
- Refer to appendix 2, page 14
- Ensure an accurate weight is obtained before starting maintenance fluids

Recommended bloods:
- Blood ketones
- Blood gas
- $HbA1_c$
- FBC, U+Es, CRP
- Lab glucose

For patients newly diagnosed:
- TFTs
- TTG
- Additional bloods as per your local policy

Is the patient shocked?

- Tachycardia
- Prolonged central capillary refill
- Poor peripheral pulses
- Hypotension (late sign)

Shocked patients should be discussed with the most senior paediatrician or intensivist at the earliest opportunity.

Yes

No

Assessment of shock

- Clinical evaluation of cardiovascular compromise can be challenging in DKA
- Acidosis drives tachycardia and reduces peripheral skin perfusion
- BSPED 2020 states shock as defined by the APLS
  - Tachycardia
  - Prolonged central capillary refill
  - Poor peripheral pulses
  - Hypotension (though this is a late sign of shock)
  - NOT just poor peripheral perfusion.
- Aim to restore adequate circulation

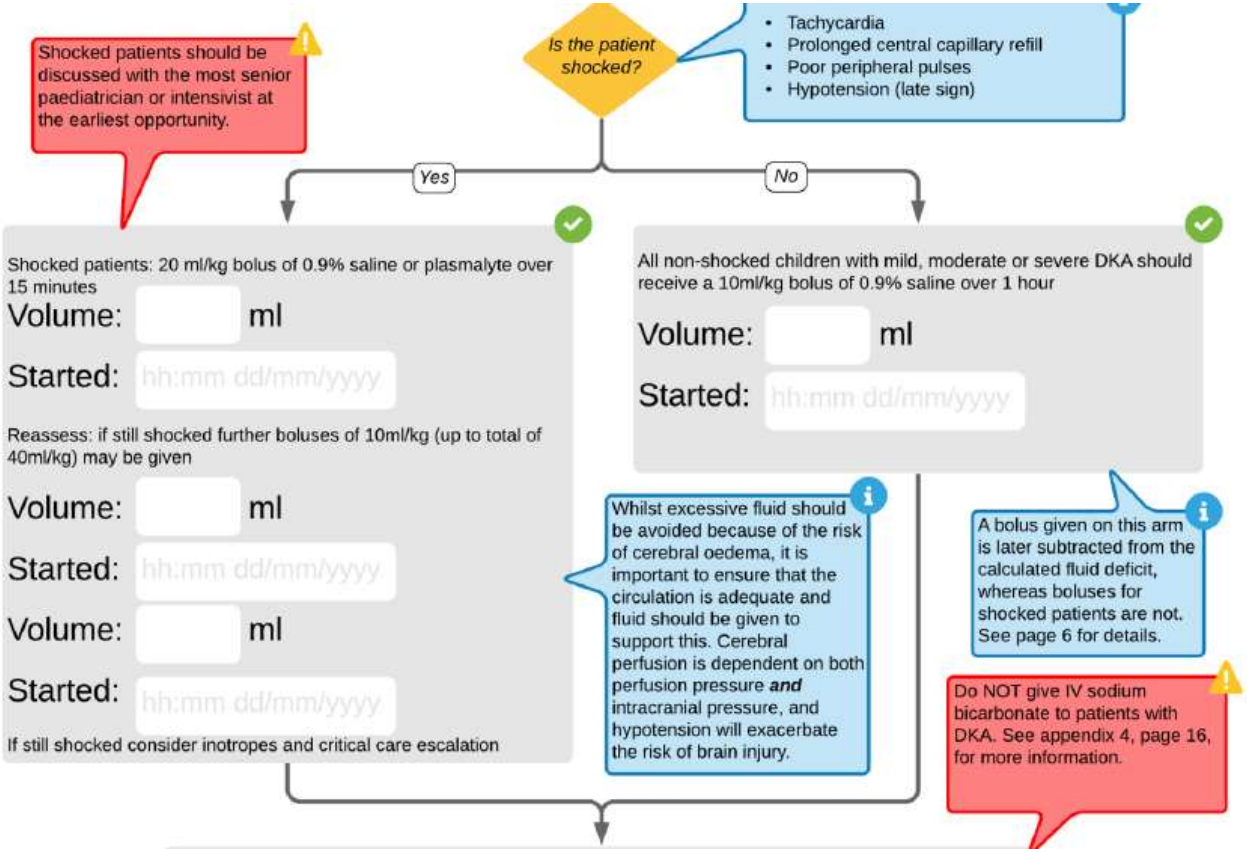
Assessment of dehydration

- Clinical evaluation of hydration in DKA is very difficult

- **pH to categorise the severity of DKA and to determine the degree of dehydration**
  - **Mild DKA** – venous pH 7.2- 7.29 or bicarbonate < 15 mmol/l with **5% dehydration**
  - **Moderate DKA** – venous pH 7.1-7.19 or bicarbonate < 10 mmol/l with **7% dehydration**
  - **Severe DKA** – venous pH less than 7.1 or serum bicarbonate < 5 mmol/l with **10% dehydration**

- Koves et al

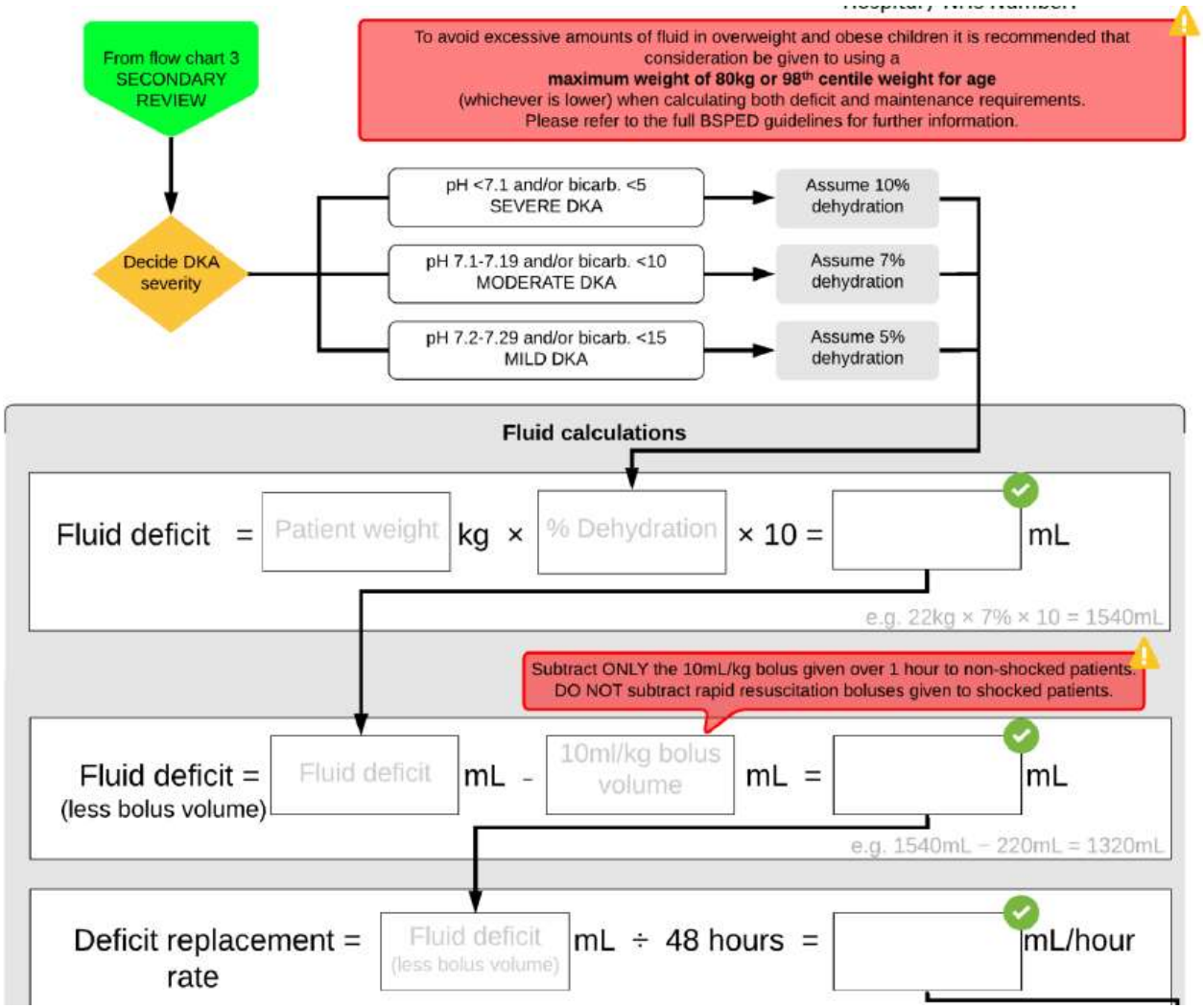
Resuscitation versus rehydration bolus



Resuscitation bolus should NOT be subtracted from the calculated fluid deficit.

Rehydration bolus SHOULD be subtracted from the calculated fluid deficit

Fluid deficit calculations



Fluid deficit should be replaced over 48hrs

Maintenance fluids

- A mainstay of management in paediatric DKA has been restriction of intravenous fluids
- Rapid administration of intravenous fluids reduces serum osmolality, resulting in cerebral oedema
- Retrospective reviews demonstrated better outcomes in children with DKA who received less fluid
- HOWEVER - association vs causation with possible confounding factors

Calculation of maintenance fluid in DKA

e.g. Fluids for a 12 kg child in DKA

	Maintenance ml/hr	Total fluid/24 hrs
ISPAD 2018/BSPED 2020	45ml/hr	1100ml
BC Canada /John Hunters Children's (Aus)	45ml/hr	1100ml
Royal Melbourne Hospital	53-70ml/hr	1272-1680 ml
BSPED 2009	40 ml/hr	960 ml
BSPED 2015	**12ml/hr**	**288ml**

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THE NUMBERS

1389
EPISODES

3.5%
DECLINE IN GCS TO <14

→ NO DIFFERENCE BETWEEN GROUPS

0.9%
CLINICALLY APPARENT BRAIN INJURY

→ NO DIFFERENCE BETWEEN GROUPS

BOTTOM LINE

Neither rapid fluid delivery nor the use of hypotonic 0.45% saline led to a worsening of any of the primary or secondary outcomes.

Our traditionally cautious approach to brain injury in children with DKA is not supported. Fluid administration is unlikely to be the cause of brain injury in DKA.

8; 378:2275-2287

Fluid maintenance calculations

Use Holliday-Segar formula: i.e. 100mL/kg for first 10kg; 50mL/kg for next 10kg; 20mL/kg thereafter.

Note: deficit is replaced over 48 hours, maintenance rate is calculated over 24 hours.

Maintenance = rate [Daily fluid requirement] mL ÷ 24 hours = [ ] mL/hour

e.g.(for 22kg) (1000mL+500mL+40mL) ÷ 24hours = 64.2mL/hour

STARTING FLUID = RATE (after bolus complete) [Maintenance rate] mL/ hour + [Deficit replacement rate] mL/ hour = [ ] mL/ hour

e.g. 64.2mL/hour + 27.5mL/hour = 91.7mL/hour

Plasmalyte 148 can be used as an alternative to 0.9% Sodium Chloride but must have added potassium.

If potassium is above normal range add potassium to fluids only after the patient has passed urine **or** after the Potassium has fallen to within the normal range.

Once initial bolus is complete:
Start 0.9% Sodium Chloride + 20mmol Potassium Chloride in 500mL at STARTING FLUID RATE as above

Fluid start time / date [hh:mm dd/mm/yyyy]

Go to flow chart 5 INSULIN Page 7

Chart completed by: _____

GMC number: _____

Signature: _____

Time / Date: _____

Starting insulin

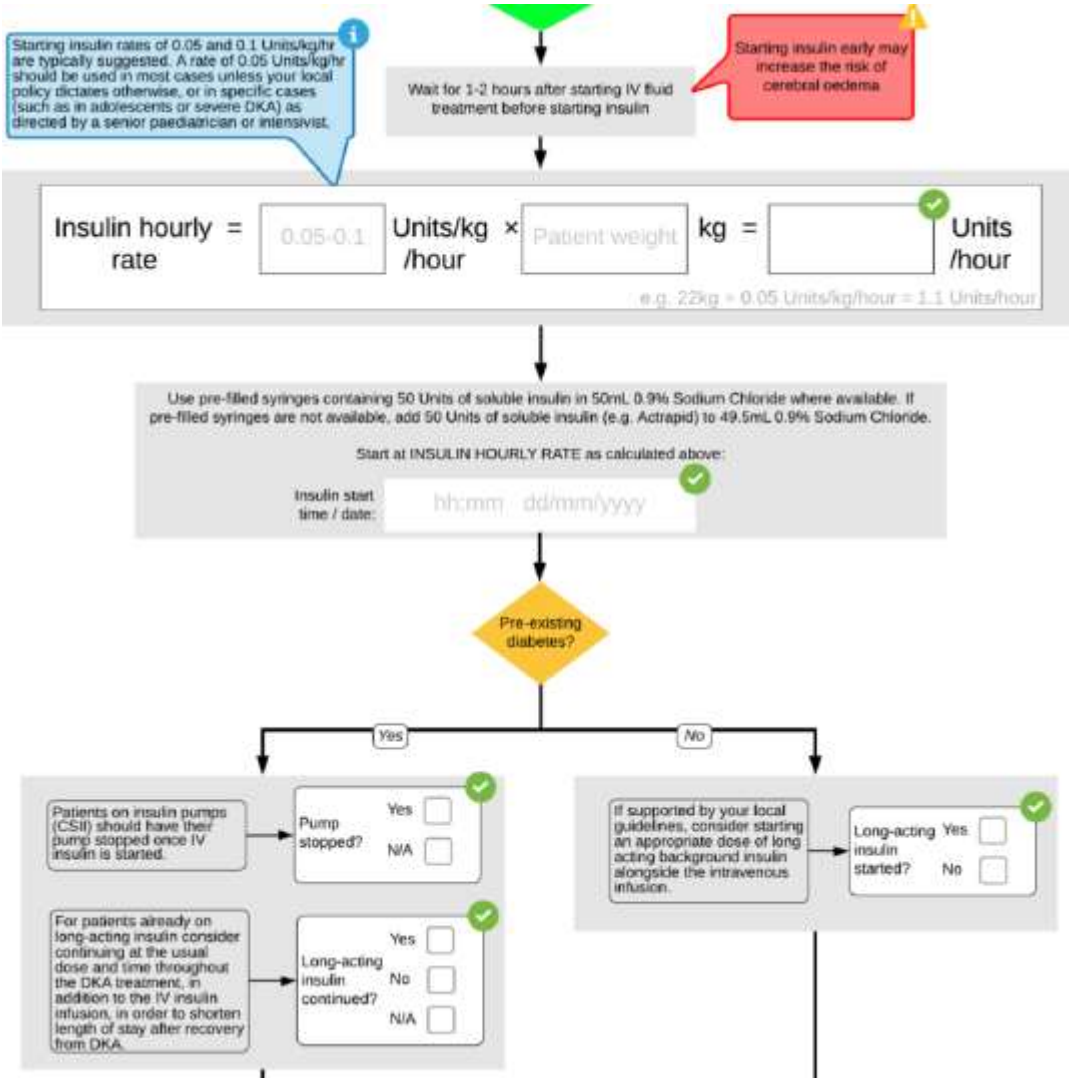
- Start the insulin infusion **1-2hrs** after beginning intravenous fluid therapy
- Start at **0.05units/kg/hr** to 0.1units/kg/hr (severe DKA or adolescents)
- Children **under 5yrs should be given 0.05units/kg/hr**
- **Stop all other short-acting insulin including CSII**
- Continue long-acting insulin
- Consider starting long-acting insulin in newly diagnosed

Low-Dose vs Standard-Dose Insulin in Pediatric Diabetic Ketoacidosis
A Randomized Clinical Trial

Karthi Nallasamy, MD, DM; Muralidharan Jayashree, MD; Sunit Singhi, MD; Arun Bansal, MD

JAMA Pediatr. 2014; 168(11): 999 – 1005

Starting insulin



Destination from ED

- All children with DKA should be admitted to paediatric HDU / ward with 2:1 nursing care
- Those that are high risk should be nursed 1:1 and may need to be managed on PICU
  - pH <7.1
  - <2yrs of age
  - Cardiovascular shock
  - Corrected sodium <130 or >150
  - Hyper or hypokalaemic
  - Altered conscious state
  - Blood glucose >50

Nursing Care

- Strict (hourly) fluid balance, capillary blood glucose
- 1-2hrly capillary blood ketones
- Hourly observations including BP and Modified GCS
- Cardiac monitoring
- Twice daily weights
- Report changes in ECG trace or signs of possible cerebral oedema to medical staff immediately

Intensive Monitoring Chart (Diabetes)

Frequency Requested ½ hrly _____ 1 hrly _____ 2 hrly _____ 4hrly _____ 6hrly _____

(Please circle and date + time changes)

DATE															
TIME															
INITIALS															
* BLOOD PRESSURE mm Hg * PULSE beats/min x RESPS breaths/min	220	* TEMP °C	41												
	210		40												
	200		39												
	190		38												
	180		37												
	170		36												
	160		35												
	150														
	140														
	130														
	120														
	110														
	100														
	90														
	80														
	70														
	60														
	50														
	40														
	30														
	20														
	10														
	Mean BP														
Bedside Blood Glucose															
Bedside Blood Ketones															
SaO_2															
Oxygen %															
GCS	Motor														
	Verbal														
	Eye														
	Total														
ORAL CARE															

Intake/Output Chart

Name
DOB
Affix Patient Identity Label
HOSP NO
NHS NUMBER

➢ ALL IV FLUIDS AND MEDICATION MUST BE PRESCRIBED ON THE **IN-PATIENT MEDICATION ADMINISTRATION CHART**

Weight _____ **kg; Previous 24 hour: Input** _____ **ml; Output** _____ **ml; Balance + / -** _____ **ml**

DATE															
TIME															
INITIALS															
INPUT	MAINTENANCE FLUIDS	**Type of Fluid** vol													
		rate													
		Type of Fluid vol													
		rate													
		Type of Fluid vol													
		rate													
		Type of Fluid vol													
		rate													
		Hourly TOTAL IV Fluids IN													
		Hourly ORAL IN													
	INSULIN	INSULIN (units/kg/hr)													
		Rate of Infusion (ml/hr)													
		Volume Given (ml)													
		Volume Left (ml)													
		Change insulin Infusion 12 hrly													
Hourly TOTAL IN															
Cumulative TOTAL IN (A)															
OUTPUT	PU (ml)														
	BO														
	VOMIT														
	NG ASPS (ml)														
Hourly TOTAL OUT															
Cumulative TOTAL OUT (B)															
Cumulative FLUID BALANCE (A-B)															
Pump Pressure (Insulin)															
Pump Pressure (IVI)															

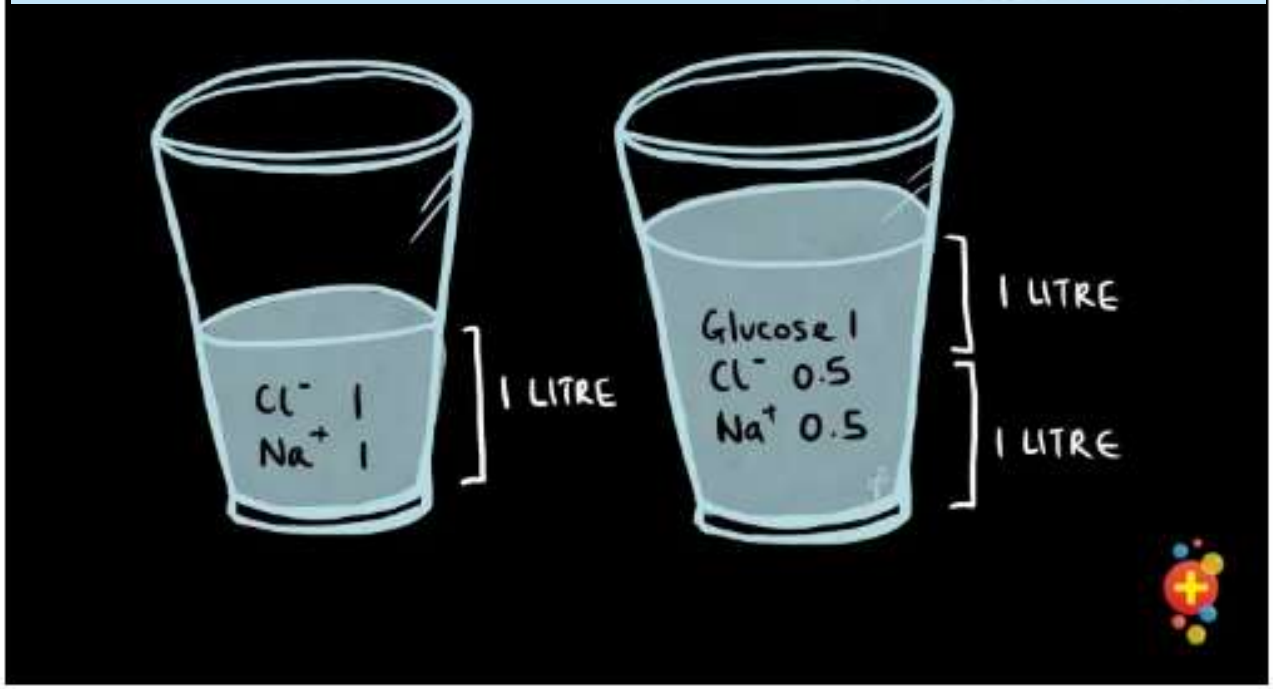
Weigh child every 12 hours - this helps to calculate actual % dehydration at admission and monitor recovery

Medical reviews

- Face to face review, bloods and blood gas
  - At start of treatment
  - 2hrs after
  - 4hrly thereafter
  - More frequently if severe DKA (pH <7.1) or <2yrs
  - Record on serial data sheet
- At each face to face review assess and document
  - Clinical status, ECG
  - Recent results
  - Cumulative fluid balance
  - Specifically consider emerging complications and address according to clinical priority
  - Update to parents
- Consider adjusting total fluid rate using corrected sodium

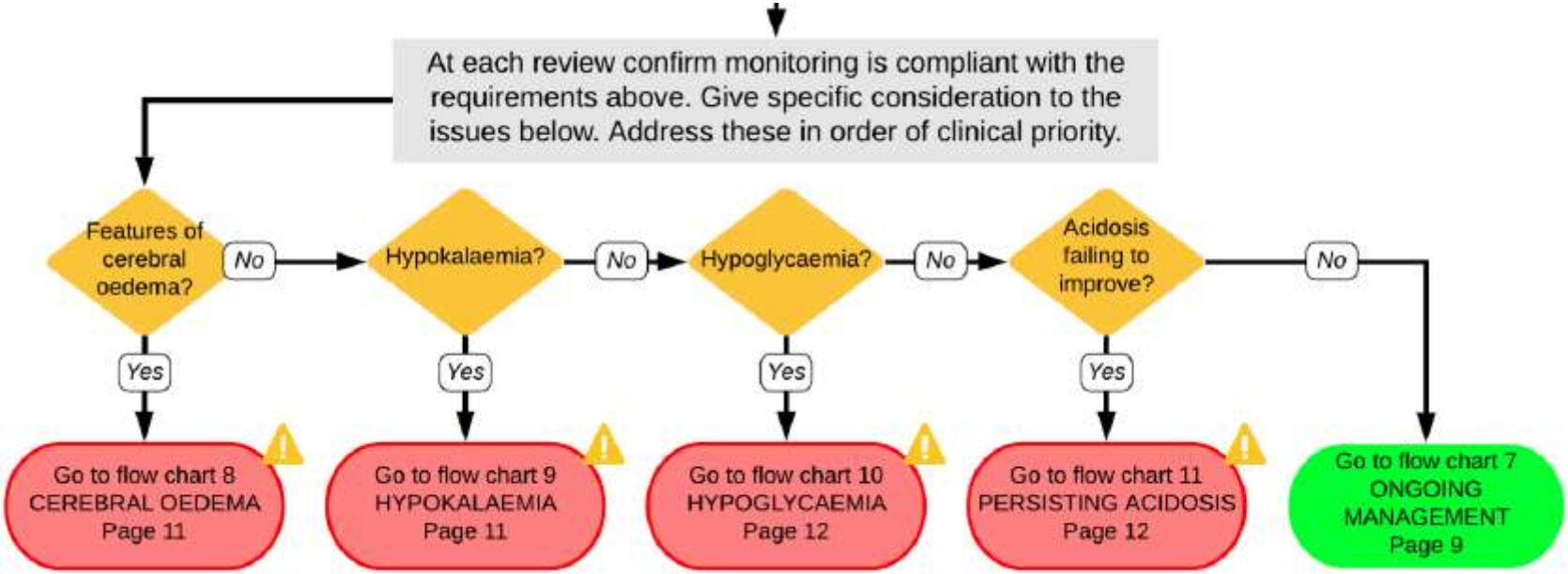
Corrected sodium

$$Na_{corr} = Na_{measured} + \left(\frac{Glucose - 5.6}{3.5}\right)$$

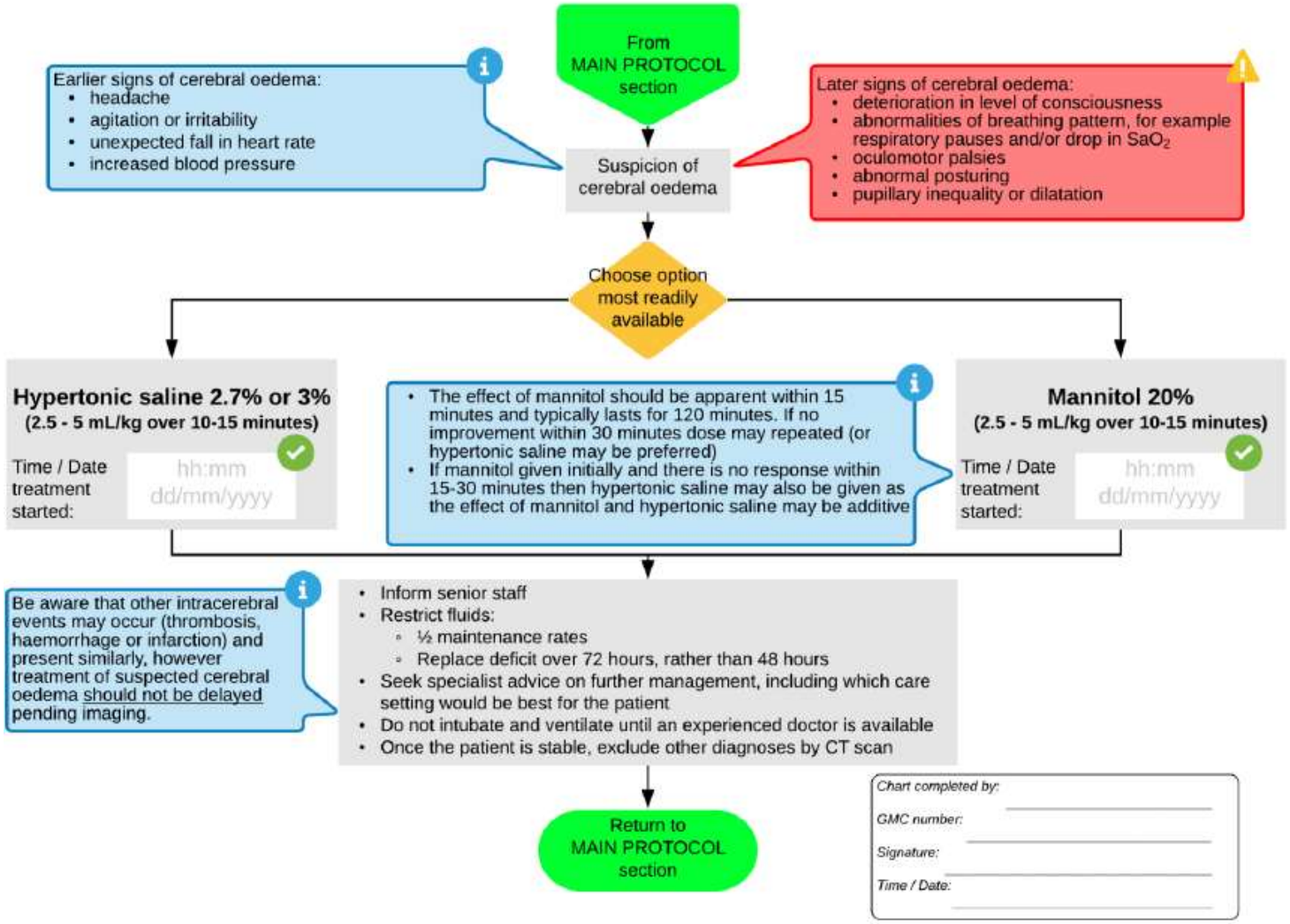


The corrected sodium must rise with therapy at a rate of 0.5-1 mmol/h

Managing complications

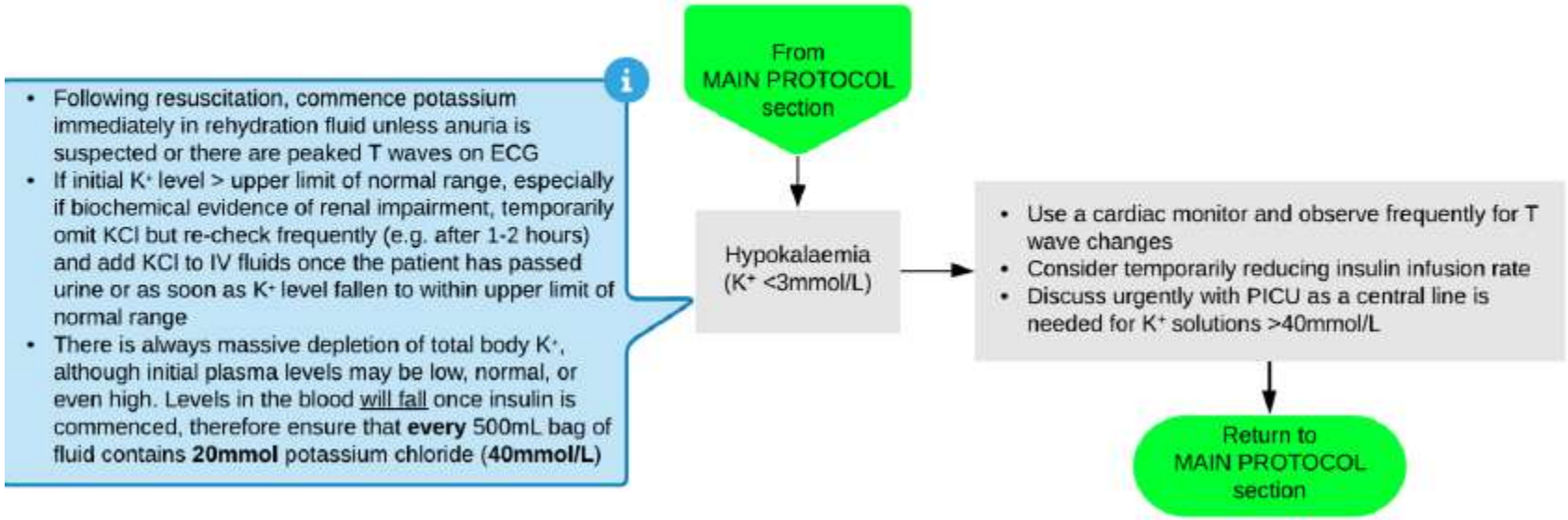


Cerebral oedema



Hypokalaemia

FLOW CHART 9 – HYPOKALAEMIA



Hypoglycaemia

Hypoglycaemia
(Blood glucose <4mmol/L)

Give a bolus of **2 mL/kg of 10% Glucose**

Volume: ml

Started: dd/mm/yy hh:mm

- Increase concentration of glucose in fluids to 10% if not already done
- Reduce insulin infusion rate to 0.05 Units/kg/hour if currently running at a faster rate
- If insulin infusion already running at 0.05 Units/kg/hour, consider temporarily reducing this for 1 hour

Return to MAIN PROTOCOL section

Chart completed by:

GMC number:

Signature:

Time / Date:

Persistent acidosis

- Consideration should be given to calculating the anion gap
- The anion gap is typically 20-30mmol/L in a patient with ketoacidosis.
  An anion gap >35mmol/L may suggest concomitant lactic acidosis due to sepsis or poor perfusion and should prompt a review of the overall clinical picture
- It is not required for routine monitoring but may be helpful if the clinical picture or biochemistry is not improving

Acidosis, ketones or clinical status not improving as expected

Check infusion lines, and the calculation and dose of insulin

Anion gap = Sodium - (Chloride + Bicarbonate) = _____ mmol/L

e.g. 130 - (95 + 10) = 25mmol/L

If acidosis is not correcting, consider the following:

- Insufficient insulin to switch off ketones
- Inadequate resuscitation
- Sepsis
- Salicylate or other prescription or recreational drugs

Once all these causes of acidosis have been excluded, and if ketones are falling gradually, then residual acidosis is likely to be due to hyperchloraemia. This can be left to resolve spontaneously, and does not require any treatment. Acidosis due to hyperchloraemia need not delay the transition to oral fluids and subcutaneous insulin. It needs differentiating from ongoing ketosis.

Return to MAIN PROTOCOL section

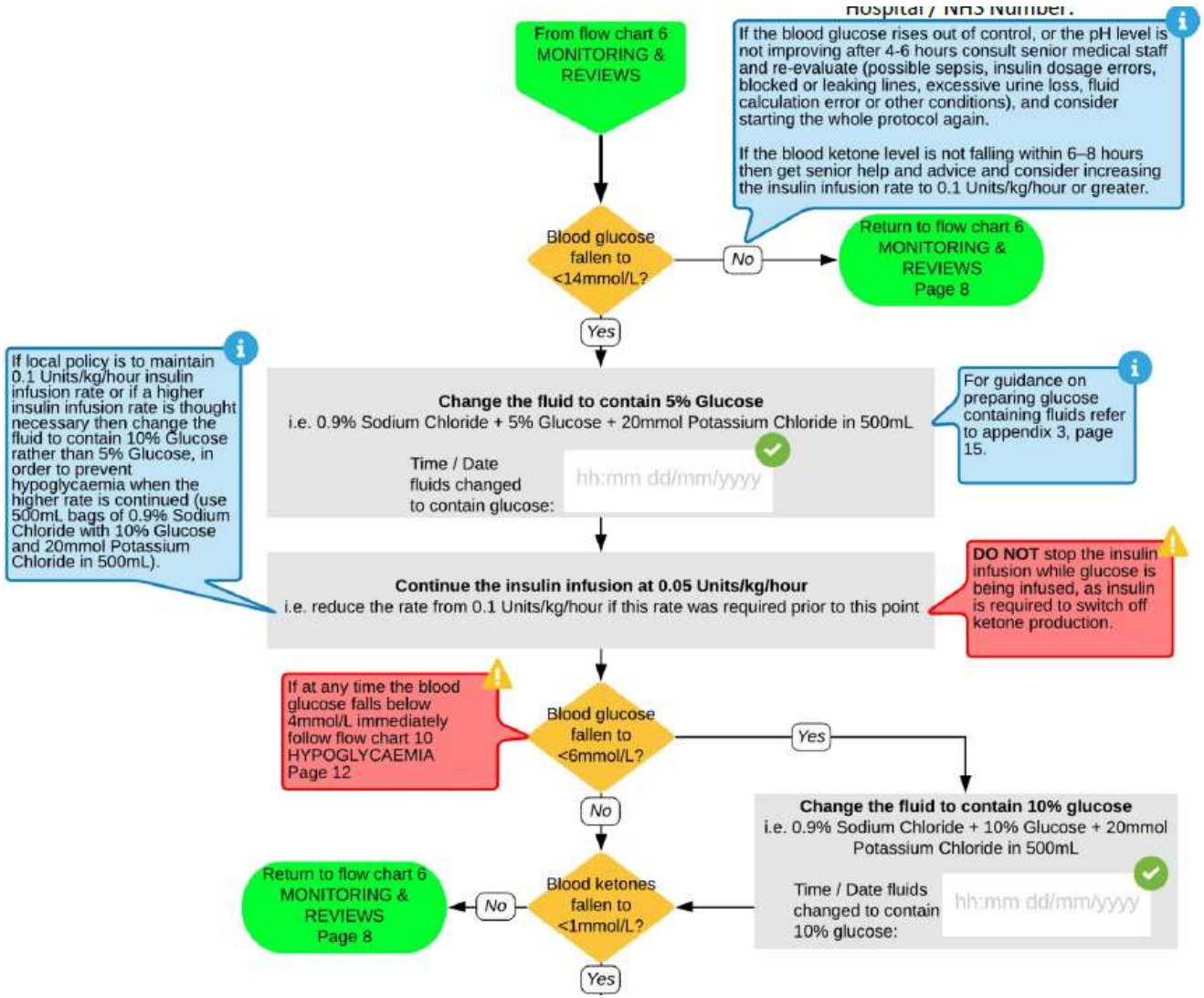
Chart completed by: _____

GMC number: _____

Signature: _____

Time / Date: _____

Ongoing care



Converting to subcut insulin

If ketones <1 and patient tolerating oral fluids

Consider switching from intravenous to subcutaneous insulin

Start **rapid-acting** subcutaneous insulin **at least** 30 minutes before stopping intravenous insulin.

Time / Date SC insulin started: hh:mm dd/mm/yyyy

Time / Date IV insulin stopped: hh:mm dd/mm/yyyy

Subcutaneous insulin should be started according to local protocols for the child with newly diagnosed diabetes, or the child should be started back onto their usual insulin regimen at an appropriate time (discuss with senior staff).

For a child or young person with DKA who is using insulin pump therapy, restart the pump at least 60 minutes before stopping intravenous insulin. Change the insulin cartridge and infusion set, and insert the cannula into a new subcutaneous site.

Ongoing education and management as per local guidelines.

If blood glucose and ketones are not controlled following switch to SC insulin, consider re-starting DKA pathway.

Do not change from IV insulin to SC insulin until ketosis is resolving (i.e. blood ketones below 1.0 mmol/L) and the patient is alert and tolerating oral fluids without nausea or vomiting.

Could this episode of DKA have been prevented? (i.e. earlier presentation not managed correctly?)

Yes ☐ No ☐

If YES then feedback appropriately such as completing incident form or contacting GP.

End of DKA Pathway

Chart completed by:

GMC number:

Signature:

Time / Date:

Case

This 10 year old boy presented with severe dehydration and vomiting. There was a preceding history of polyuria, polydipsia and weight loss.

Name the 3 most important blood investigations you would perform.

Why do children in DKA look so unwell?

What are the principles of management?

References

https://www.dka-calculator.co.uk/

BSPED Interim Guideline for the Management of Children and Young People under the age of 18 years with Diabetic Ketoacidosis
https://www.bsped.org.uk/media/1739/dka-guideline-jan-2020.pdf

https://dontforgetthebubbles.com/diabetic-ketoacidosis/