UPTODATE MANAGEMENT OF DKA IN CHILDREN

د أحمد عبدالقادر

Programme

1. Background of DKA
2. Fluids and insulin
3. Electrolytes
4. Monitoring
5. Cerebral edema

General rules

- DKA is the commonest serious complication of diabetes
- It is fatal if not treated
- With proper management it is completely treatable condition
- Consider senior consultation as early as appropriate

The incidence of mortality in DKA in U.S.A is 0.5 %

- **due to :**
  - Dehydration, shock, acidosis.
  - Hypoglycemia.
  - Electrolytes disturbance (Hypokalemia).
  - Aspiration Pneumonia
  - Cerebral oedema.

Mortality is

Unacceptable if it isdue to

Dehydration, acidosis, electrolytes disturbance & hypoglycemia

Cerebral oedema

- is unpredictable
- occurs more frequently in younger children and newly diagnosed diabetes
- has a mortality of around 25%
- causes are not known

Hypokalaemia

- This is preventable with careful monitoring and management

Blood sugar is the 5th vital sign in sick infants and children

- Respiratory rate
- Pulse
- Temperature
- Blood pressure
- Blood sugar

The diagnostic criteria of DKA

Hyperglycemia

BG > 200mg/dl

Acidosis

Venous pH <7.3 and/or bicarbonate <15 mmol/L

Ketosis

Presence of ketones in the blood, urine, or both (BOHB>3.0 mmol/l)

Grading of DKA

Parameters	Mild	Moderate	Sever
Dehydration	3%	5-7%	7-10 (8%)
Consciousness	Alert	Alert/ drowsy	Semi-coma
Glucose mg/dl	300 – 400	400 - 600	>600
BUN	Normal	Normal or ↑	High
PH	7.2-7.3	7.1-7.2	<7.1
Pco2	Normal	Normal or slightly low	Low

Mild DKA

- Children who are alert
- not clinically dehydrated
- not nauseated or vomiting
- do not always require IV fluids, even if their ketone levels are high

Mild DKA

- They usually tolerate oral rehydration and subcutaneous insulin
- but do require monitoring regularly to ensure that they are improving

Moderate and Sever DKA

- Drowsy to semiconscious to comatose

Conscious Level

- Institute hourly neurological observations including Glasgow Coma Score

- conscious level is directly related to degree of acidosis, but signs of raised intracranial pressure suggest cerebral oedema

In the absence of insulin and increase in CRH

- FFA —(B-oxidation)→ keton bodies

Palmatyl Co-A transferase

- Acetone
- Acetoacetate
- B-hydroxybutaric acid(BHOB)

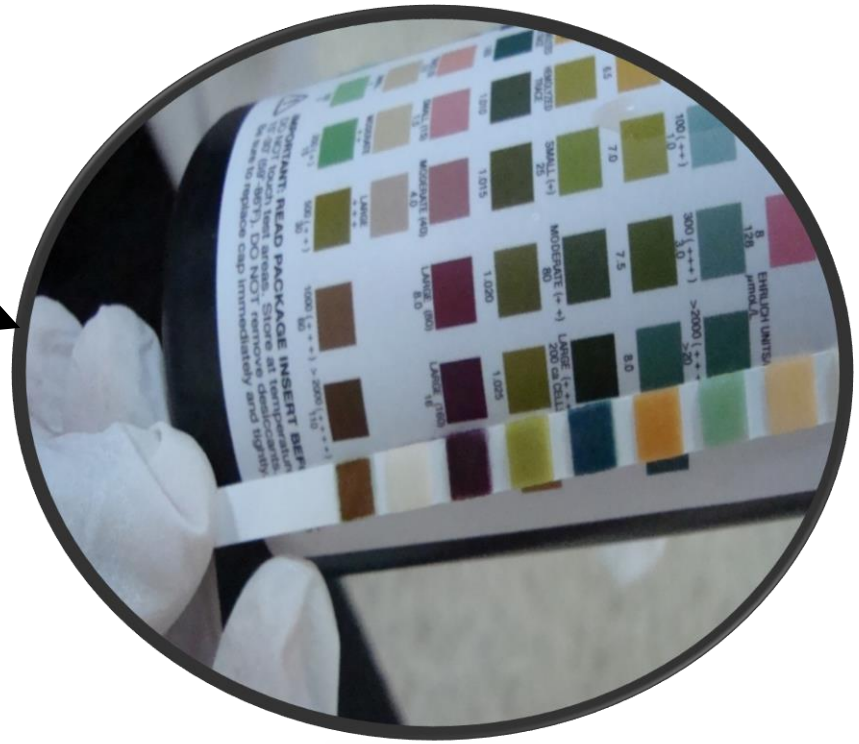
Very acidic

The main ketone in DKA is

- **B-hydroxybutaric acid(BHOB)** (the ratio 10/1)

- Acetoacetate

- Acetone



Use a near-patient testing method

- beta-hydroxybutyrate level for the diagnosis and monitoring of the treatment of DKA

If a near-patient testing method is not available

use urinary ketone levels to make the diagnosis, but they are not useful for monitoring

Testing Ketones

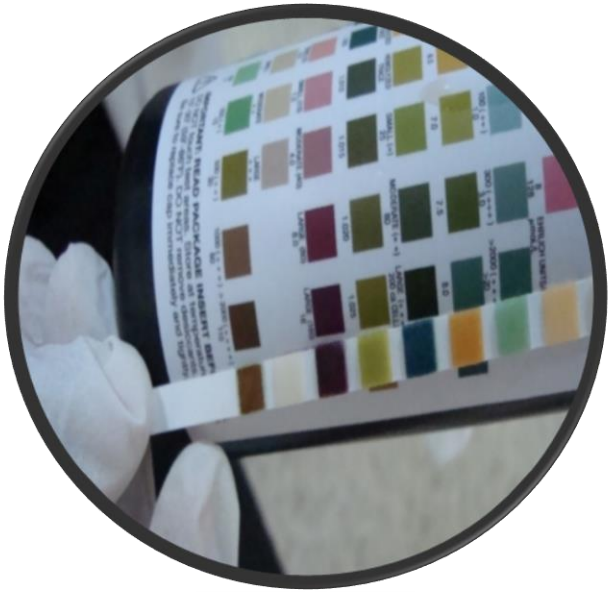
Urine

Capillary blood

urine dipstick

- for diagnosis and assessment of severity

Not for follow up after starting DKA Rx



If a child is

- hyperosmolar
- very high BG level >30 mmol/l (540 mg)
- with little or no acidosis or ketones

HHS

this is a Hyperosmolar Hyperglycaemic State

and requires DIFFERENT treatment

Discuss this with the senior doctor– these children can be very difficult to manage

Metabolic acidosis in DKA

Usually corrected spontaneously by fluid and insulin

Bicarbonate : generally is not recommended

Suspect sepsis(in DKA) if there is

- **Fever**

- Hypothermia
- Hypotension
- Refractory acidosis
- Lactic acidosis
- Insulin resistance

- Blood culture
- Urine R/E & culture
- CXR-cough or chest findings
- LP if there is meningeal signs
  - 3rd generation cephalosporins or Ampi-genta

Causes/Precipitating Factors of DKA

- Missed insulin injections
- Intercurrent illness/infection

Full Examination – looking particularly for

- cerebral oedema
- infection
- ileus

cerebral oedema

Headache

Irritability

slowing pulse

rising blood pressure

reducing conscious level

N.B. papilloedema is a late sign

Calculations in DKA

Serum Osmolality:

$2[Na] + (glucose/18)$

Corrected Na =

Measured Na + (**1.6**)(glucose - 100)/100

Anion Gap:

$Na - (Cl + HCO_3)$ Normally <12

Corrected Na =

- Measured Na + [(serum glucose as mg/dl−100)/100] × 1.6

- Example
- BG=600 measured Na = 130
- 130 + [600−100)/100] × 1.6
- 130+{500/100 }× 1.6
- 130+ 5 × 1.6
- 130+8=138
- Corrected Na=138

Risk factors of developing CE

Younger children

New onset T1DM presenting with DKA

Low Pco2

Increased BUN

Sever dehydration and acidosis

Treatment related risk factors of CE

- Early use & bolus insulin
- Use of bicarbonate
- Rapid hydration
- Use of diluted fluid

In the emergency room and after

Document the initial GCS score for use as a baseline

Obtain an accurate weight

Fluid requirement in DKA

Deficit(plus-minus bolus)

Maintenance

Ongoing losses X

Bolus only if shocked

- poor peripheral pulses
- poor capillary filling with tachycardia
- and/or hypotension

Bolus only if shocked

- **give 10 ml/kg 0.9% sodium chloride as a bolus**

- ***(There is no evidence to support the use of colloids or other volume expanders in preference to crystalloids)***

Type of fluid is normal saline

No place for 20cc/kg in DKA

If in shock(BP is low) 10/kg as fast as possible.
repeat till BP normalize-max-three

If in BP is N+ poor perfusion

5-10cc over 1hr

sever DKA with N-BP & normal perfusion
no bolus

If DKA patient in shock and not responding to two boluses

- **What are the possible causes?**

- Sever acidosis
- Sepsis

- Be careful with fluid bolus
- Bolus only if in shock

DKA patient rarely shocked

Sever DKA (High risk for CE)

- Correct hyperosmolarity slowly over 48hrs

- By reducing glucose slowly(50-80mg/dl/hr)

- By rehydration slowly(48hrs) by hypertonic fluids(N/S)

- Monitor carefully for complication of Rx(CE)

Management Goals

- Fluid resuscitation & slow correction of dehydration(48hrs)
- Reversal of the acidosis and ketosis (by insulin & IVF)
- Reduction in the plasma glucose concentration to normal

Management Goals

- Replenishment of electrolyte (sodium & potassium)
- Identification the underlying cause (infection)
- Monitor for complications of DKA and its treatment

  (Hypokalemia, hypoglycemia and CE)

DKA treatment

- ABC
- Monitoring
- Specific treatment
  - Fluids
  - Potassium
  - Insulin
- Management of complications

EMERGENCY MANAGEMENT

- 1. General Resuscitation: A, B, C. Airway Ensure that the airway is patent and if the child is comatose, insert an airway. +(urinary catheter)

- If consciousness reduced or child has recurrent vomiting, insert N/G tube, aspirate and leave on open drainage.

Initial Investigations

- ☐ blood glucose
- ☐ urea and electrolytes (electrolytes on blood gas machine give a guide until accurate results available)
- ☐ blood gases (venous or capillary)

Initial Investigations

- near patient blood ketones (beta-hydroxybutyrate) if available (superior to urine ketones)
- other investigations only if indicated e.g full blood count (leucocytosis is common in DKA and does not necessarily indicate sepsis), CXR, CSF, throat swab, blood culture, urinalysis, culture and sensitivity etc

Fluid requirement

5% for mild to moderate DKA and 10% for severe DKA, based on pH

X

BSPED Guidelines August 2015

Mild 3%	Only just clinically detectable
Moderate 5%	Dry MM, reduced skin turgor
Severe 8%	Above with sunken eyes, drousy
+shock	Severely ill, poor perfusion, thready pulse

Over estimation of dehydration is Dangerous: DO NOT USE MORE THAN 8%

Fluid requirement

Deficit + maintenance - bolus

- Ongoing losses generally are not calculated

Fluid requirement

Deficit + maintenance - bolus

Fluid Calculation in sever DKA

- Deficit 8%
- Add two maintenance
- Divide over 48 hrs
- Giving the total volume **evenly** **over the next 48 hrs. As hourly rate**
- **hrly rate = (deficit) + 2*maintenance / 48hr**

- Deficit=% dehydration * 10 * wt
- Use 3-5% for moderate DKA
- 7-9% for sever DKA **average 8%**

What is the duration of rehydration for sever DKA?

12 hours

24 hours

36 hours

48 hours

72 hours

The conventional maintenance therapy calculation

APLS **maintenance** fluid

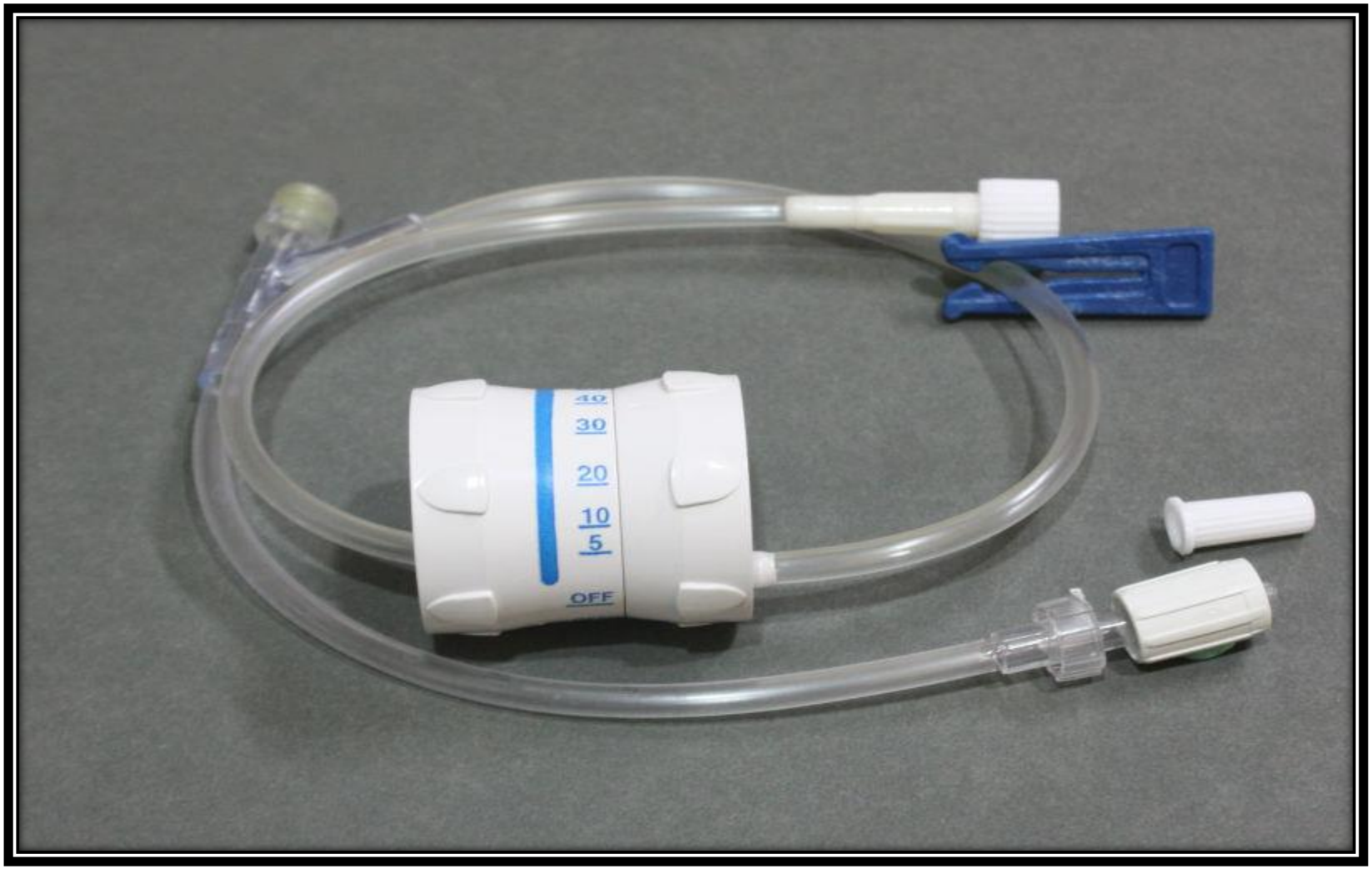
100ml/kg /day……for the 1st 10 kg body weight.

50 ml/kg/day ……added for 2nd 10 kg body weight.

20ml /kg /day……..added for each kg above 20kg.

Infusion pump is the best for IVF and insulin infusion in treatment of DKA

IVF regulators



When to shift from N/S to ½ NS?

For all sever DKA patient continue normal saline for the 12hrs

After 12hrs look at measured sodium

Sodium rising

→ Shift to 1/2N/S

Sodium is not rising or decreasing

→ Continue 0.9N/S

With or without dextrose depending on BG

Oral Fluids

- ☐ Do not give oral fluids to a child or young person who is receiving intravenous fluids for DKA until ketosis is resolving and there is no nausea of vomiting.
- ☐ NGT may be necessary in the case of gastric paresis.
- ☐ If oral fluids are given before the 48hr rehydration period is completed, the IV infusion needs to be reduced

Fluid Losses

- If a massive diuresis continues for several hours fluid input may need to be increased
- If large volumes of gastric aspirate continue, these will need to be replaced with 0.45% saline with KCl

POTASSIUM

- Ensure that all fluids (except any initial bolus) contain 40 mmol/l potassium chloride, unless there is evidence of renal failure

POTASSIUM

- Potassium is mainly an intracellular ion, and there is always massive depletion of total body potassium although initial plasma levels may be low, normal or even high

- Levels in the blood will fall once insulin is commenced

General rules during Rx of DKA

- Reduce glucose slowly

(50-80mg/dl/hr)

- Keep BG between 150-250 mg/dl

(200-300mg/dl accepted)

Two important rules in DKA Rx

Fluid replacement should begin before starting insulin therapy

Start insulin after 1hr with potassium

Insulin in DKA

- Start at least one hour after starting IVF
- No initial bolus
- Regular or rapid acting insulin
- 0.1 unit/kg/hr infusion enough for all patient

(0.05U/kg/hr is recommended for)

- Younger age(<5yrs) & newly diagnosed
- Hypokalemia at presentation
- Euglycemic DKA & HHS
- Pts with high risk factors for CE??

Once BG <300mg/dl

change from N/S to N/S with D5

Once BG <300mg/dl

Don't reduce insulin
insulin needed to
switch off ketogenesis

If the BG falls below 150mg/dl

- □ increase the glucose concentration of IVF infusion

- □ if there is persisting ketosis, continue to give insulin at a dosage of least 0.05 units/kg/hour

If the BG falls below 80mg/dl

- give a bolus of 1-2 ml/kg of 10% glucose and increase the glucose concentration of the infusion

Hypoglycemia during DKA management

- Allowing BG to drop to hypoglycemic levels is a common mistake that usually results in a rebound ketosis derived by counter-regulatory hormones

- Rebound ketosis necessitates a longer duration of treatment

Lantus during DKA treatment

- For **children who are already on long-acting insulin (especially insulin glargine (Lantus)), you may wish to continue this at the usual dose and time throughout the DKA treatment, in addition to the IV insulin infusion, in order to shorten length of stay after recovery from DKA.**

Continuing acidosis is usually caused by

- Insufficient fluids
- Insufficient insulin
- Sepsis

If after 4-6 hours

- the blood glucose rises out of control, or the pH level is not improving consult senior medical staff and re-evaluate
- possible sepsis, insulin errors or other condition
- consider starting the whole protocol again

If within 6–8 hours

- the blood ketone level is not falling
- think about increasing the insulin dosage to 0.1 units/kg/hour or greater

Once the BG has fallen to 250 mg/dl

- add glucose to the fluid and think about the insulin infusion rate, as follows

If ketone levels are less than 3 mmol/l

- ☐ change the fluid to contain 5% glucose; use 500 ml bags of 0.9% sodium chloride with 5% glucose and 20 mmol potassium chloride in 500ml which are available from Pharmacy.
- ☐ reduce to or maintain at an insulin infusion rate of 0.05 units/kg/hr

If ketone levels are above than 3 mmol/l

- maintain the insulin infusion rate at 0.05 to 0.1 units/kg/hour to switch off ketogenesis

- change the fluid to contain 10% glucose rather than 5% glucose, in order to prevent hypoglycaemia when the higher dose of insulin is continued

Bicarbonate use in DKA

- **Rarely needed if ever**
- **Hyperkaelemia** at presentation
- The only important role of bicarbonate is to improve **cardiac contractility** caused by sever acidosis usually <6.9 resulting in shock that is not responding to IV N/S bolus

Bicarbonate in DKA

- multiple studies suggest that bicarbonate therapy may cause paradoxical intracellular acidosis, worsening tissue perfusion and increase the risk of **hypokalemia, and cerebral edema**

MONITORING

Ensure full instructions are given to the senior nursing staff

MONITORING

- hourly capillary blood glucose
- Do not rely on any sudden changes but check with a venous laboratory glucose measurement
- capillary blood ketone levels every 1-2 hours (if available)

MONITORING

- **urine** testing for **ketones** used only at beginning for diagnosis (only needed if blood ketone testing not available)
- hourly **BP** and basic observations
- hourly level of **consciousness** initially, using the modified Glasgow coma score

MONITORING

- half-hourly neurological observations, and heart rate, in children under the age of 2, or in children and young people with a pH less than 7.1, because they are at increased risk of cerebral oedema

MONITORING

- headache
- slowing of pulse rate
- any change in conscious level
- or behaviour

If cerebral oedema is suspected, treat immediately

- mannitol (20% 0.5-1 g/kg over 10-15 minutes) or
- hypertonic saline (2.7% or 3% 2.5-5 ml/kg over 10-15 minutes).

If cerebral oedema is suspected, treat immediately

- deterioration in level of consciousness
- abnormalities of breathing pattern, for example respiratory pauses
- oculomotor palsies
- abnormal posturing
- pupillary inequality or dilatation.

If cerebral oedema is suspected, treat immediately

- fluids should be restricted to ½ maintenance rates
- **inform senior staff immediately.**
- After starting treatment for cerebral oedema with mannitol or hypertonic saline immediately seek specialist advice on further management

If cerebral oedema is suspected, treat immediately

- ☐ do not intubate and ventilate until an experienced doctor is available
- ☐ once the child is stable, exclude other diagnoses by CT scan - other intracerebral events may occur (thrombosis, haemorrhage or infarction) and present similarly

If cerebral oedema is suspected, treat immediately

- a repeated dose of Mannitol may be required after 2 hours if no response
- document all events (with dates and times) very carefully in medical records

MONITORING

- reporting any changes in the **ECG** trace, especially signs of hypokalaemia, including ST-segment depression and prominent U-waves
- ☐ **twice daily weight**; can be helpful in assessing fluid balance
- **Start recording all results and clinical signs on a flow chart.**

Medical reviews

- At 2 hours after starting treatment, and then at least every 4 hours, carry out and record the results of the following blood tests -
- ☐ glucose (laboratory measurement)
- ☐ blood pH and pCO2
- ☐ plasma sodium, potassium and urea
- ☐ blood ketones (beta-hydroxybutyrate).

The golden role during management of DKA

In any neurological manifestation hypoglycaemia should be excluded

Change to SC INSULIN

1. Fully conscious
2. Well hydrated
3. No acidosis
4. PH more than 7.3
5. No GIT. Symptom
6. S.k+ and s. Na+ (normal)


Thank
you