# Diabetic Ketoacidosis

# Introduction

- **DKA is a serious acute complications of Diabetes Mellitus. It carries significant risk of death and/or morbidity especially with delayed treatment.**
- **The prognosis of DKA is worse in the extremes of age, with a mortality rates of 5-10%.**
- **With the new advances of therapy, DKA mortality decreases to > 2%. Before discovery and use of Insulin (1922) the mortality was 100%.**

# Epidemiology

- DKA is reported in 2-5% of known type 1 diabetic patients in industrialized countries, while it occurs in 35-40% of such patients in Africa.
- DKA at the time of first diagnosis of diabetes mellitus is reported in only 2-3% in western Europe, but is seen in 95% of diabetic children in Sudan. Similar results were reported from other African countries .

# Consequences

- The latter observation is annoying because it implies the following:
  - The late diagnosis of type 1 diabetes in many developing countries particularly in Africa.
  - The late presentation of DKA, which is associated with risk of morbidity & mortality
  - Death of young children with DKA undiagnosed or wrongly diagnosed as malaria or meningitis.

# Pathophysiology

- **Secondary to insulin deficiency, and the action of counter-regulatory hormones, blood glucose increases leading to hyperglycemia and glucosuria. *Glucosuria* causes an osmotic diuresis, leading to water & Na loss.**
- **In the absence of insulin activity the body fails to utilize glucose as fuel and uses fats instead. This leads to ketosis.**

# Pathophysiology/2

- **The *excess of ketone bodies* will cause metabolic acidosis, the later is also aggravated by *Lactic acidosis* caused by dehydration & poor tissue perfusion.**
- **Vomiting due to an ileus, plus *increased insensible water losses* due to tachypnea will worsen the state of dehydration.**
- **Electrolyte abnormalities are 2ry to their loss in urine & trans-membrane alterations following acidosis & osmotic diuresis.**

# Pathophysiology/3

- **Because of acidosis, K ions enter the circulation leading to hyperkalemia, this is aggravated by dehydration and renal failure.**
- **So, depending on the duration of DKA, serum K at diagnosis may be high, normal or low, *but the intracellular K stores are always depleted.***
- **Phosphate depletion will also take place due to metabolic acidosis.**
- **Na loss occurs secondary to the hyperosmotic state & the osmotic diuresis.**

# Pathophysiology/4

- The dehydration can lead to decreased kidney perfusion and acute renal failure.
- Accumulation of ketone bodies contributes to the abdominal pain and vomiting.
- The increasing acidosis leads to acidotic breathing and acetone smell in the breath and eventually causes impaired consciousness and coma.

# Precipitating Factors

- New onset of type 1 DM: 25%
- Infections (the most common cause): 40%
- Drugs: e.g. Steroids, Thiazides, Dobutamine & Turbutaline.
- Omission of Insulin: 20%. This is due to:
  - Non-availability (poor countries)
  - fear of hypoglycemia
  - rebellion of authority
  - fear of weight gain
  - stress of chronic disease

# DIAGNOSIS

- ***You should suspect DKA if a diabetic patient presents with:***

- **Dehydration.**
- **Acidotic (Kussmaul's) breathing, with a fruity smell (acetone).**
- **Abdominal pain &\or distension.**
- **Vomiting.**
- **An altered mental status ranging from disorientation to coma.**

# DIAGNOSIS/2

***To diagnose DKA, the following criteria must be fulfilled :***

1. **Hyperglycemia: of > 300 mg/dl & glucosuria**
2. **Ketonemia and ketonuria**
3. **Metabolic acidosis: pH < 7.25, serum bicarbonate < 15 mmol/l. Anion gap >10.**

**Anion gap= [Na]+[K] – [Cl]+[HCO3].**

**This is usually accompanied with severe dehydration and electrolyte imbalance.**

# Management

**The management steps of DKA includes:**

- **Assessment of causes & sequele of DKA by taking a short history & performing a scan examination.**
- **Quick diagnosis of DKA at the ER.**
- **Baseline investigations.**
- **Treatment, Monitoring & avoiding complications.**
- **Transition to outpatient management.**

# Assessment

- **History:**

**Symptoms of hyperglycemia, precipitating factors , diet and insulin dose.**

- **Examination:**

- **Look for signs of dehydration, acidosis, and electrolytes imbalance, including shock, hypotension, acidotic breathing, CNS status…etc.**
- **Look for signs of hidden infections (Fever strongly suggests infection) and If possible, obtain accurate weight before starting treatment.**

# *Quick Diagnosis*

- Known diabetic children confirm D hyperglycemia, K ketonuria & A acidosis.
- Newly diagnosed diabetic children be careful not to miss because it may mimic serious infections like meningitis.
- **Both Hyperglycemia (using glucometer) glycosuria, & ketonuria (with strips) must be done in the ER and treatment started, without waiting for Lab results which may be delayed.**

# Baseline Investigations

***The initial Lab evaluation includes:***

- **Plasma & urine levels of glucose & ketones.**
- **ABG, U&E (including Na, K, Ca, Mg, Cl, PO4, HCO3), & arterial pH (with calculated anion gap).**
- **Venous pH is as accurate as arterial (an error of 0.025 less than arterial pH)**
- **Complete Blood Count with differential.**
- **Further tests e.g., cultures, X-rays…etc , are done when needed.**

# *Pitfalls in DKA*

- **High WCC: may be seen in the absence of infections.**
- **BUN: may be elevated with prerenal azotemia secondary to dehydration.**
- **Creatinine: some assays may cross-react with ketone bodies, so it may not reflect true renal function.**
- **Serum Amylase: is often raised, & when there is abdominal pain, a diagnosis of pancreatitis may mistakenly be made.**

# Treatment

## Principles of Treatment:

- Careful replacement of fluid deficits.
- Correction of acidosis & hyperglycemia via Insulin administration.
- Correction of electrolytes imbalance.
- Treatment of underlying cause.
- Monitoring for complications of treatment.
- Manage DKA in the PICU. If not available it can be managed in the special care room of the pediatric inpatient ward.

# Fluids replacement

- ***Determine hydration status*:**

**A. Hypovolemic shock:**

**administer 0.9% saline, Ringer's lactate or a plasma expander as a bolus dose of 20-30 ml/kg. This can be repeated if the state of shock persists. Once the patient is out of shock, you go to the 2nd step of management.**

# Fluids replacement/2

## B- Dehydration without shock:

1. **Administer 0.9% Saline 10 ml/kg/hour for an initial hour, to restore blood volume and renal perfusion.**
2. **The remaining deficit should be added to the maintenance, & the total being replaced over 36-48 hours. To avoid rapid shifts in serum osmolality 0.9% Saline can be used for the initial 4-6 hours, followed by 0.45% saline.**

# Fluids replacement/3

- When serum glucose reaches 250mg/dl change fluid to 5% dextrose with 0.45 saline, at a rate that allow complete restoration in 48 hours, & to maintain glucose at 150-250mg/dl.
- Pediatric saline 0.18% Na Cl should not be used even in young children.

# Insulin Therapy

- start infusing regular insulin at a rate of 0.1U/kg/hour using a syringe pump. Optimally, serum glucose should decrease in a rate no faster than 100mg/dl/hour.
- If serum glucose falls < 200 prior to correction of acidosis, change IV fluid from D5 to D10, but don't decrease the rate of insulin infusion.
- The use of initial bolus of insulin (IV/IM) is controversial.

# Insulin Therapy/2

***Continue the Insulin infusion until acidosis is cleared:***

- **pH > 7.3.**
- **Bicarbonate > 15 mmol/l**
- **Normal anion gap 10-12.**

# Correction of Acidosis

- **Insulin therapy stops lipolysis and promotes the metabolism of ketone bodies. This together with correction of dehydration normalize the blood PH.**
- **Bicarbonate therapy should not be used unless severe acidosis (pH<7.0) results in hemodynamic instability. If it must be given, it must infused slowly over several hours.**
- **As acidosis is corrected, urine KB appear to rise. Urine KB are not of prognostic value in DKA.**

# Insulin Therapy/3

- If no adequate settings (i.e. no infusion or syringe pumps & no ICU care which is the usual situation in many developing countries) Give regular Insulin 0.1 U/kg/hour IM till acidosis disappears and blood glucose drops to <250 mg/dl, then us SC insulin in a dose of 0.25 U/kg every 4 hours.
- When patient is out of DKA return to the previous insulin dose.

# Correction of Electrolyte Imbalance

- **Regardless of K conc. at presentation, total body K is low. So, as soon as the urine output is restored, potassium supplementation must be added to IV fluid at a conc. of 20-40 mmol/l, where 50% of it given as KCl, & the rest as potassium phosphate, this will provide phosphate for replacement, & avoids excess phosphate (may precipitate hypocalcaemia) & excess Cl (may precipitate cerebral edema or adds to acidosis).**

# Potassium

- **If K conc. < 2.5, administer 1mmol/kg of KCl in IV saline over 1 hour. Withhold Insulin until K conc. becomes> 2.5 and monitor K conc. hourly.**
- If serum potassium is 6 or more, do not give potassium till you check renal function and patients passes adequate urine.

# Monitoring

**A flow chart must be used to monitor fluid balance & Lab measures.**

- **serum glucose must be measured hourly.**
- **electrolytes also 2-3 hourly.**
- **Ca, Mg, & phosphate must be measured initially & at least once during therapy.**
- ***Neurological & mental state must examined frequently*, & any complaints of headache or deterioration of mental status should prompt rapid evaluation for possible cerebral edema.**

# Complications

- Cerebral Edema
- Intracranial thrombosis or infarction.
- Acute tubular necrosis.
- peripheral edema.

# Cerebral Edema

- **Clinically apparent Cerebral edema occurs in 1-2% of children with DKA. It is a serious complication with a mortality of > 70%. Only 15% recover without permanent damage.**
- **Typically it takes place 6-10 hours after initiation of treatment, often following a period of clinical improvement.**

# Causes of Cerebral Edema

**The mechanism of CE is not fully understood, but many factors have been implicated:**

- **rapid and/or sharp decline in serum osmolality with treatment.**
- **high initial corrected serum Na concentration.**
- **high initial serum glucose concentration.**
- **longer duration of symptoms prior to initiation of treatment.**
- **younger age.**
- **failure of serum Na to raise as serum glucose falls during treatment.**

# Presentations of C. Edema

**Cerebral Edema Presentations include:**

- **deterioration of level of consciousness.**
- **lethargy & decrease in arousal.**
- **headache & pupillary changes.**
- **seizures & incontinence.**
- **bradycardia. & respiratory arrest when brain stem herniation takes place.**

# Treatment of C. Edema

- Reduce IV fluids
- Raise foot of Bed
- IV Mannitol
- Elective Ventilation
- Dialysis if associated with fluid overload or renal failure.
- Use of IV dexamethasone is not recommended.

The End