



**Health**  
South Western Sydney  
Local Health District

## Guideline Title    **Management of Diabetic Ketoacidosis**

### **Summary:**

Patients admitted to ICU with DKA (Diabetic Ketoacidosis) will be monitored and managed appropriately.

**Approved by:** ICU Director

**Publication (Issue) Date:** October 2015

**Next Review Date:** October 2018

**Replaces Existing Guideline:** Management of Diabetic Ketoacidosis

**Previous Review Dates:** October 2011

### **Background Information:**

- Diabetic Ketoacidosis is an acute and potentially fatal complication of diabetes typically characterized by hyperglycemia, ketone body formation and metabolic acidosis.
- DKA typically arises in patients with Type 1 Diabetes, but can also occur in those with a diagnosis of Type 2 Diabetes.
- The classic clinical picture of DKA includes a history of polyuria, polydipsia and polyphagia.
- Case definition for DKA is (Blood glucose level) BGL >15mmol/L, pH <7.30, HCO<sub>3</sub> < 18mmol/L, blood capillary ketone (bedside ketone test) or urine ketones positive<sup>1</sup>.
- Resolution of DKA: BGL <11mmol/L, pH >7.3, HCO<sub>3</sub> >18mmol/L<sup>2,6</sup>
- The cause is relative or absolute insulin deficiency, which, in combination with increased levels of stress hormones, stimulates lipolysis resulting in the release of free fatty acids which are converted to ketone bodies- acetoacetate, betahydroxybutyrate and acetone. This results in ketonemia and metabolic acidosis. The relative lack of insulin results in decreased glucose utilization and increased gluconeogenesis. There is also associated glycosuria, with a resulting osmotic diuresis. This leads to the loss of water, sodium, potassium and other electrolytes and can cause significant hypovolemia<sup>6</sup>.

### **1. Introduction contains:**

#### **The risk addressed by this policy:**

Patient Safety and correct management of patient with DKA

#### **The Aims / Expected Outcome of this policy:**

Staff caring for a patient with DKA will have the knowledge and skills required to provide effective and safe care of the patient in accordance with the recommendations of the Emergency, Endocrinology and ICU Medical team.

**Related Standards or Legislation**

NSQHS Standard 1 Governance

**Related Policies**

ICU\_Guidelines\_Pharmacology\_2013\_Actrapid

ICU\_Guidelines\_Clinical\_Guidelines\_2013\_Hyperosmolar\_Hyperglycaemic\_State

**2. Policy Statement:**

- All care provided within Liverpool Hospital will be in accordance with infection prevention/control, manual handling and minimisation and management of aggression guidelines.
- A diagnosis of DKA is made by the Medical team based on the presence of BGL >15mmol/ L, pH <7.30, HCO<sub>3</sub> < 18mmol/L, blood capillary ketone (bedside ketone test) or urine ketones positive<sup>1</sup>. Please refer to table below for DKA diagnostic criteria as per American Diabetes Association.
- As the difference between arterial and venous pH is 0.02 -0.015 and the difference between arterial to venous HCO<sub>3</sub> is 1.88mol/L, venous blood gases can be used if it is difficult to obtain an arterial sample<sup>7</sup>.
- The BGL must be monitored by a blood glucose machine every 1 hour while patient remains on Intravenous Actrapid Insulin Infusion.
- Serum potassium must be measured on admission and repeated every 2 hours. Potassium should always be diluted and NEVER given undiluted through a peripheral line<sup>6</sup>.
- Arterial blood gas analysis, EUC, CMP, blood capillary ketone (bedside ketone test) and urine ketones and osmolality must be measured every 4 hours or more frequently if required by the medical team. In the absence of an arterial line, a venous blood gas analysis can be done.
- An arterial line should be inserted for repeated frequent blood sampling.

**Diagnostic Criteria for DKA<sup>6</sup>**

	DKA		
	Mild	Moderate	Severe
Plasma Glucose (mmol /L)	>15	>15	>15
Arterial pH	7.25-7.30	7.00-7.24	<7.00
Serum Bicarbonate (mEq/L)	15-18	10 to 15	<10
Urine Ketones	Small	Moderate	Large
Blood capillary ketones	0.5 – 0.9mmol/L	1.9 -2.9mmol/L	3.3 -5.3mmol/L
Effective serum osmolality (formula below)	Variable	Variable	Variable
Alteration in sensorial or mental obtundation	Alert	Alert / drowsy	Stupor /coma

**3. Principles / Guidelines****Precipitants to DKA<sup>1,6</sup>:**

- Infection

- Inadequate Insulin doses, missed insulin doses, non compliance (psycho-social factors)
- Acute medical illnesses – eg: Acute myocardial infarction, CVA, trauma, sepsis
- Protracted vomiting

### Clinical Features of DKA<sup>1,2,6,7</sup>

- History of acute symptoms developing over 24 hours, sometimes symptoms may be present for a few days before the development of ketoacidosis.
- Main symptoms are increasing polyuria, polyphagia and polydipsia.
- Weight loss and weakness.
- Drowsiness, decreased level of consciousness leading to DKA induced coma.
- Signs of dehydration and hypovolemia (tachycardia, hypotension).
- Presence of Kussmaul ventilation (abnormally deep, very rapid sighing respirations characteristic of diabetic ketoacidosis, it is hyperventilation due to respiratory compensation for metabolic acidosis) and detectable odour of acetone on the patients breath.
- Nausea, vomiting, abdominal pain, elevation of serum amylase and liver enzymes.
- Elevated blood glucose levels and metabolic acidosis. Blood capillary ketones are positive.
- Measured serum sodium concentration is usually decreased because of the osmotic flux of water from the intracellular to extracellular space, which occurs in the presence of hyperglycemia.
- Serum potassium concentration may be elevated because of an extracellular shift of potassium caused by insulin deficiency, hypertonicity and acidemia.

### Management of DKA:

The management of DKA is aimed at stopping the ketogenesis, which will consequently correct the acidosis, replacing fluid deficits and monitoring and supplementing potassium to maintain normal serum levels (Potassium  $K^+$  – 3.5 -5mmol/L).

#### DKA Case Definition<sup>1</sup>:

BSL >15mmol/L  
Arterial pH < 7.30  
 $HCO_3^-$  < 18mmol /L  
Bedside capillary or urine ketones positive

#### Resolution of DKA<sup>6</sup>:

BSL < 11mmol/L  
Arterial pH > 7.3  
 $HCO_3^-$  > 18mmol /L

#### Anion Gap<sup>2</sup>:

(Serum Sodium + Potassium) – (Serum Chloride + Bicarbonate)  
Normal Anion Gap is – 8 to 16mmol/L

#### Serum Osmolality<sup>8</sup>

2 x measured serum sodium + serum glucose + serum urea  
Normal Serum osmolality is – 280 -300mmol/kg

#### Corrected Sodium<sup>3</sup>:

Glucose /3 + measured serum sodium

### IV Fluid Therapy<sup>1,2</sup>

- Fluid therapy is directed at expansion of intravascular and extravascular volume and restoration of renal perfusion.

- Assess volume status – this is assessed using static or dynamic measures of assessment (refer to Appendix 1).
- If severe hypovolaemia present, administer 0.9% Sodium Chloride 15-20ml/kg/hr ( $\approx$  1L /hr). Closely monitor volume status until severe hypovolaemia is corrected.
- If Mild dehydration present – Check Corrected Na.  
**Corrected Na<sup>+</sup> = Glucose /3 + measured serum sodium.**
- If **Corrected Na<sup>+</sup> < 145mmol/L** – administer 0.9% Sodium Chloride. Use table below as guide to fluid replacement:

1 <sup>st</sup> liter 0.9% Normal Saline	▪ over 1 hour (1000 ml/hr)
2 <sup>nd</sup> liter .9% Normal Saline	▪ over 2 hours (500 ml/hr)
3 <sup>rd</sup> liter 0.9% Normal Saline	▪ over 4 hours (250 ml/hr)
4 <sup>th</sup> liter 0.9% Normal Saline	▪ over 4 hours (250 ml/hr)
5 <sup>th</sup> liter 0.9% Normal Saline	over 6 hours (167 ml/hr)

**NOTE:** above table is a guide, clinical assessment of response to fluids should be done frequently. More cautious fluid replacement is indicated in young people aged 18-25 years, elderly, pregnant patients & patients with heart or renal failure.

- If **Corrected Na<sup>+</sup> > 145mmol/L** – administer 0.45% Sodium Chloride  $\approx$  250-500ml/hr.
- Fluid replacement strategies should take into account ongoing clinical assessment of volume status as well as age, presence of co-morbidities and electrolyte status.
- When BGL < 15mmol/L change to 5% Glucose  $\approx$  100 – 150ml/hr and 0.9% Sodium Chloride  $\approx$  100ml/hr.

### Insulin Therapy<sup>1,2,6,7</sup>

Prepare Intravenous Actrapid infusion: Dilute 50units actrapid to 50mL sterile 0.9% Sodium Chloride, to give a concentration 1unit/mL.

- Confirm K<sup>+</sup> is > 3.3mmol/L
- Commence actrapid IV continuous infusion @ **0.1units /kg/hr** (usual starting rates may range from 4 to 10 units / hour). Aim for BGL reduction of **2- 3 mmol/ hr**.
- If BGL does not drop by > 3mmol/hr in the first hour, double the rate of the infusion.
- If BGL drops by > 3 but <6mmol /hr, continue actrapid infusion @0.1units /kg/hr.
- IF BGL drops by >6mmol /hr, seek medical advice. If the acidosis is resolving, may consider decreasing actrapid infusion to 0.05 units/kg/hr, if marked acidosis is still present this may not be ideal.
- When BGL <15mmol/L, reduce the actrapid infusion rate to 0.05 – 0.1units/kg/hr. DO NOT STOP INSULIN. If required give / increase glucose intake (persisting ketosis is a sign of inadequate glucose administration), e.g change to 10% glucose.
- Keep BGL between 8-11 mmol/L until DKA is resolved. (Resolution criteria - BSL<11mmol/L, Arterial pH > 7.3, HCO<sub>3</sub> > 18mmol /L).
- Once DKA has resolved if patient is nil by mouth continue intravenous insulin infusion and fluid replacement.
- NOTE:** Consider starting daily subcutaneous Long Acting Insulin (eg Lantus) at the same time as use of insulin infusion after discussion with Intensivist or Endocrinology team. This aims to facilitate the transition to subcutaneous therapy when the insulin infusion is ceased at a later time.

### Subcutaneous Insulin Therapy<sup>6,7</sup>

- When the patient is able to eat, a multiple dose schedule should be started that uses a combination of short or rapid acting insulin and intermediate or long acting insulin. This should be done in consultation with the endocrinology team.
- There must be an overlap between the intravenous insulin infusion and the subcutaneous insulin dose. The intravenous insulin infusion should not be discontinued for at least 30-60 minutes after the administration of the subcutaneous dose. This is critical for preventing worsened control and hyperglycemia.

- Estimating the Total Daily Dose (TDD) of insulin<sup>7</sup>: this is based on patient's sensitivity to insulin degree of glycemic control, insulin resistance, weight and age.

**TDD = Patients weight in kg x 0.5 to 0.7units**

0.7 units is used for those thought to be more insulin resistant (teens, obese)

Eg: 72 kg patient TDD = 75 x 0.5 units = 36 units in 24hrs.

- The basal QDS regime for subcutaneous insulin: Give 50% of the TDD with the evening meal in the form of long acting insulin such as Lantus. Divide the remaining dose equally between pre-breakfast, pre-lunch and pre-evening meal in the form of rapid acting insulin.

**Electrolyte Replacement – Potassium & Phosphate<sup>1,2</sup>.**

**Potassium:**

- Maintain serum potassium (K<sup>+</sup>) between 4-5mmol/L.
- Potassium chloride can be drawn up undiluted in a 50ml syringe and administered via syringe driver when central venous access available. For peripheral access 40mmol potassium chloride can be added to a 1L bag of IV Fluid. It is compatible with sodium chloride, glucose and compound sodium lactate solutions.
- Refer to table below for suggested potassium infusion rates according to serum K level and access.

Serum K Aim to maintain serum K 4.0-5.0 mmol/L	Potassium infusion rate if replacement via peripheral line	Potassium infusion rate if replacement via central access	Additional note: re: insulin therapy
K < 3.3 mmol/L	20 mmol/hr	30 mmol/hr	Hold insulin therapy until K > 3.3 mmol/L
K 3.4 –4.0 mmol/L	10 mmol/hr	20 mmol/hr	
K 4.1-5.0 mmol/L	10 mmol/hr	10 mmol/hr	
K 5.1-5.5 mmol/L	5-10 mmol/hr	5-10 mmol/hr	
K > 5.5 mmol/L	Do not replace K, wait for next K result, recheck within 2 hours	Do not replace K, wait for next K result, recheck within 2 hours	

**Phosphate<sup>6</sup>:**

- Studies have failed to show any beneficial effect of phosphate replacement. However to avoid cardiac and skeletal muscle weakness and respiratory depression due to hypophosphatemia, careful phosphate administration may be indicated in patients with cardiac dysfunction, anemia or respiratory depression and in those with serum phosphate level <0.32mmol/L<sup>6</sup>.
- Preparation: Potassium Di-Hydrogen phosphate – each ampoule of 10ml contains 10mmol potassium ions, 10mmol phosphate ions and 20mmol hydrogen ions.
- Add 20mmol Potassium Di-Hydrogen phosphate to the IV replacement fluid and monitor levels in those patients who require phosphate replacement. .
- It is compatible with sodium chloride and glucose solutions. It is incompatible with compound sodium lactate solutions.

**Bicarbonate Replacement<sup>1,6</sup>**

- **If pH >7.0** sodium bicarbonate administration is usually not required.
- At a pH > 7.0, insulin administration blocks lipolysis and resolves ketoacidosis without bicarbonate administration.
- **If pH <6.9**, then give 100mmol sodium bicarbonate 8.4% over 2 hours. This is to prevent cardiovascular depression associated with severe acidosis.

- **If pH 6.9 -7.0**, and there is evidence of cardiac instability and the risk of lowering potassium has been managed, then give 50mmol of sodium bicarbonate 8.4% over one hour<sup>6</sup>. This is an option that is to be considered by the medical team
- Monitor pH every 2 hours until >7.0.
- Sodium Bicarbonate is compatible with sodium chloride and glucose solutions. It is incompatible with compound sodium lactate solutions.

#### Clinical Issues<sup>1,2,7</sup>:

- **On admission:**
  - Measure BGL with blood glucose meter. If the BGL is elevated off the meter send for urgent formal BGL from the lab.
  - Measure blood capillary ketones with a ketone meter.
  - Measure Arterial blood gas, EUC, CMP, FBC, serum lactate, LFT, HbA<sub>1c</sub>. If indicated attend blood cultures.
  - Test urine for glucose, ketones, nitrates. If indicated attend urine cultures and drug screen.
  - Perform other tests as clinically indicated, such as a septic screen, thyroid function tests, pregnancy test, troponin levels, lipase, CRP, ECG, Chest X-ray. Measure creatinine kinase levels if rhabdomyolysis is suspected.
- Vital signs are continuously monitored.
- Closely monitor patients level of consciousness and GCS – watch for signs of cerebral edema.
- Monitor *BGL every hour* with a blood glucose meter.
- *Arterial blood gases* need to be attended *every 2 hours* until pH >7.0.
- Calculate Anion gap. An anion gap <16, indicates a resolving ketoacidosis.
- *EUC, CMP and serum and urine ketones* need to be attended *every 4 hours*.
- Patient may be switched from intravenous to subcutaneous insulin once the DKA has resolved and they are able to eat normally.
- Endocrine team should be involved for patient follow-up and education.
- DVT Prophylaxis is necessary for these patients as per the DVT Prophylaxis guideline.

#### Complications of DKA.

- **Cerebral Edema:** This is a rare but potentially fatal complication of DKA. Studies suggest that cerebral hypoperfusion followed by subsequent reperfusion could be the causative mechanism. This can be prevented by the gradual correction of glucose and serum osmolality. Clinically cerebral edema is characterised by deterioration in the level of consciousness, with lethargy, decrease in arousal and headache. Neurological deterioration may be rapid with seizures, pupillary changes, bradycardia and respiratory arrest.
- **Pulmonary Edema:** This is rare with DKA. The cause and prevention strategies are the same as with cerebral edema. The elderly and those with impaired cardiac function are particularly at risk and fluid resuscitation should be carefully monitored in these patients.
- **Hypokalemia and hyperkalemia:** Serum potassium must be measured on admission and repeated every 2 hours. These are two life threatening complications that can be prevented by close monitoring of potassium levels.
- **Hypoglycemia:** this can result from excess administration of insulin. Hypoglycemia can cause cardiac arrhythmias and acute brain injury.

#### 4. Performance Measures

All incidents are documented using the hospital electronic reporting system: IIMS and managed appropriately by the NUM and staff as directed.

#### 5. References / Links

1. Abbas, EK & Burton, DR, May 2011. Accessed from <http://www.uptodate.com> on 7/8/2011
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3. Protocol for the management of DKA, Campbelltown ICU Guidelines
4. Wallace, TM & Matthews, DR 2004, Recent advances in the monitoring and management of diabetic ketoacidosis, *QJ Med*, 97:773-780
5. Medical Calculator, <http://www.medcalc.com/body> accessed on 7/8/11
6. American Diabetes Association 2001, Hyperglycemic Crisis in Patients with Diabetes Mellitus, *Diabetes Care*, vol 24 (11): 1988-1996.
7. Joint British Diabetes Societies Inpatient Care Group 2010, The Management of Diabetic Ketoacidosis in adults, accessed from <http://www.bsped.org.uk/professional/guidelines/docs/DKAGuideline.pdf> on 10/10/2011
8. <http://www.syndpath.stvincents.com.au/tests/Osmolality> , viewed on 10/10/11

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**Reviewers:** ICU – CNC, CNE, NM, NUM, Staff Specialists, CNS 's , Emergency Staff Specialists

**Endorsed by:** Prof M. Parr, Director ICU.

### Appendix 1

#### Assessment of Volume Status.

**Dynamic evaluation:** has greater specificity and is considered more useful than static evaluation. Dynamic methods should be used as a guide during administration of a fluid challenge.

- Respiratory variations in arterial pressure or stroke volume (during mechanical ventilation in the absence of ventilatory dyssynchrony or arrhythmias).
- Pulse pressure variation or stroke volume variation with the respiratory cycle
- Positive response to fluid challenge.

Static Evaluation: **has limited sensitivity and specificity.**

*Signs of dehydration:*

- Diminished skin turgor
- Thirst
- Dry mouth
- Hypernatraemia, hyperproteinaemia, elevated haemoglobin and haematocrit.

*Circulatory signs of hypovolaemia:*

- Tachycardia (refer to 'goals to be achieved' section below).
- Arterial hypotension (MAP  $\leq$ 65mmHg)
- Increased serum lactate
- Decreased peripheral temperature

*Decreased renal perfusion:*

- Concentrated urine output < 0.5mL/kg/hr (refer to 'goals to be achieved' section below)
- Increased blood urea nitrogen relative to creatinine concentration.
- Persistent metabolic acidosis.





**Protocol For The Management of DKA**

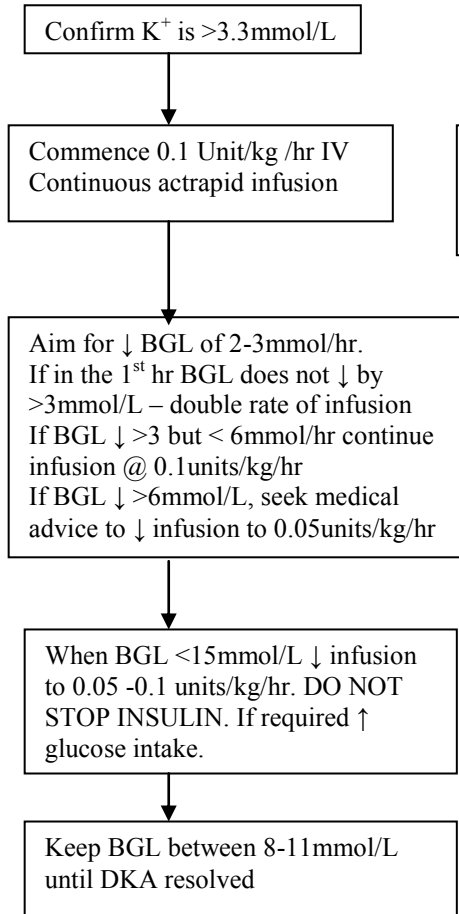
**DKA Case Definition:**  
BSL >15mmol/L, Arterial pH < 7.30  
HCO<sub>3</sub> < 18mmol/L, Blood capillary  
or urine ketones positive

**Resolution of DKA:**  
BSL < 11mmol/L, Arterial pH > 7.3  
HCO<sub>3</sub> > 18mmol/L

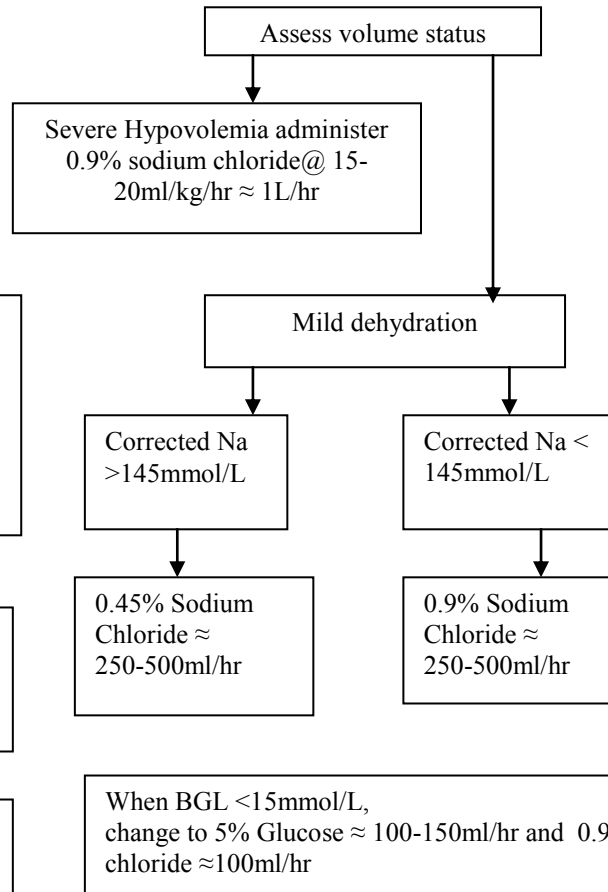
**Anion Gap<sup>2</sup>:**  
(Serum Na<sup>+</sup> + K<sup>+</sup>) – (Serum Cl<sup>-</sup> + HCO<sub>3</sub>)  
**Serum Osmolality<sup>8</sup>**  
2 x measured serum sodium + serum  
glucose + serum urea

**Corrected Sodium:**  
Glucose /3 + measured  
serum sodium

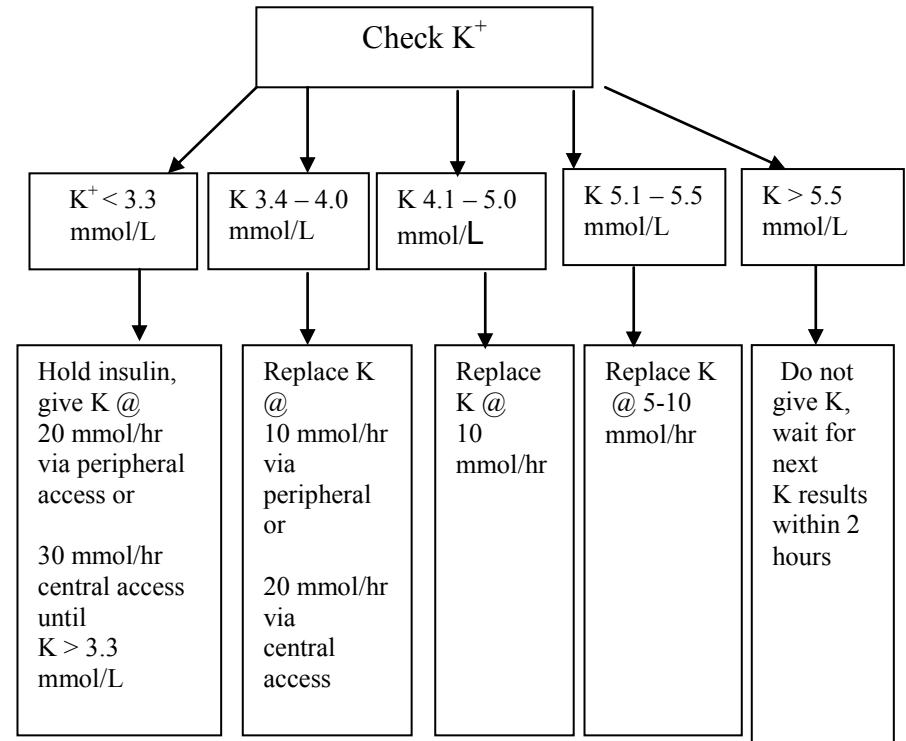
**INSULIN**



**IV FLUIDS**



**POTASSIUM\*\***



**\*\*Note: When administering K<sup>+</sup> at rate of > 20mmol/hr – hourly level of K<sup>+</sup> should be measured**