**Guidelines on Diagnosis and Management of Common Electrolyte Abnormalities:**

**Prepared by:**

Dr. Hormaz Dastoor. MD, FASN, ABIM, CCST (UK)

Chief of Nephrology

Al Rahba Hospital- Abu Dhabi, United Arab Emirates

Email: hodastoor@seha.ae

**Urology and Kidney Disease Council Members:**

Dr. Samra Abouchacra , Chairperson SEHA Kidney and Urology Council

Dr. Nick Richards, SEHA Dialysis Services

Dr. Zubaida Al Ismaili, SEHA Dialysis Services

Dr. Mohsen El Mekresh, Chair- Urology, Mafraq Hospital

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Dr. Basam Bernieh, Tawam Hospital

Dr. Abraham George, Tawam Hospital

Dr. Hormaz Dastoor, Al Rahba Hospital

Dr. Ayman Al Madani, Mafraq Hospital

Dr. SalahEldin Essa Physician Al-Gharbia Hospitals

**Scope:**

This guideline has been developed to improve the treatment of acute electrolyte disorders and reduce the risk of complications associated with their diagnosis and management.

These guidelines are recommendations based on the best available evidence on the appropriate treatment and care of specific electrolyte disorders.

The Guideline applies to all Medical Practitioners in all SEHA Business Entities (including Ambulatory Health Services-AHS), requiring treatment of Acute Electrolyte Disorders.

**Guideline development:**

This guideline is a publication of the Renal Service Line Group at SEHA. The team consists of experts in the field of Nephrology from various SEHA Business Entities. The group has met in February 2016 and agreed on the scope for the guidelines.

**Guideline Objectives:**

1. Correct electrolyte imbalances that are essential to maintain normal physiological function. Hospitalised patients may not be able to eat and drink normally and often have depleted fluid levels and/or an electrolyte imbalance. Intravenous provision of fluid and electrolytes is therefore often needed to maintain or restore balance.
2. Intravenous fluid and electrolyte therapy may also be needed to correct imbalances from losses of red blood cells, plasma, water or electrolytes beyond the normal losses in urine, stool and sweat and maintain in red blood cells, plasma, water or electrolytes. Causes of abnormal losses include blood loss; plasma or fluid loss from burns; fluid loss from diarrhoea, vomiting or surgical drains; and abnormal leakage of fluid from the circulation into the interstitial space.
3. There are many issues to consider when prescribing intravenous fluids and electrolytes. It is imperative that the amount and type is correct for the patient. Inadequate fluid and electrolyte provision can lead to hypovolemia and poor organ perfusion, and excessive provision can result in hypervolemia, oedema and heart failure. Under or over provision of electrolytes can also lead to potentially serious disturbances of intracellular or extracellular electrolyte balance, particularly in patients with reduced kidney or liver function.
4. Intravenous fluid and electrolyte therapy spans many medical and surgical disciplines. Inappropriate fluid therapy is rarely documented as being responsible for patient harm, but it is widely accepted that errors in prescribing, leading to insufficient or excessive provision.
5. Prescribing errors are particularly likely to arise in emergency departments, acute admission units and general ward areas, where initiation and prescription of intravenous fluids and electrolytes may be undertaken by less expert staff. In higher dependency and critical care units more expertise is available and fluid and electrolyte status can be more closely monitored.

**Current practice:**

1. Prescribers are not always aware of the specific constituents of the various intravenous replacements therapies and as such, many fluid and electrolyte prescriptions provide too little or too much fluid or electrolytes to restore and maintain fluid balance. There is little formal training and education in intravenous fluid and electrolyte management to support correct prescribing.
2. There is a wide variation in the type of charts used to record fluid and electrolyte status in practice. Monitoring of patients is often suboptimal, with fluid and electrolyte status not being recorded accurately. Changes to patients’ requirements are often not assessed. There is often insufficient attention by clinical staff to ensure that appropriate identification, treatment and monitoring of changes in fluid and electrolyte status is maintained and documented.
3. There is considerable debate about the efficacy of some specialised intravenous fluids in seriously ill patients, and consequent variation in clinical practice.
4. There is a need for a standardised approach to the clinical assessment of patients’ fluid and electrolyte status and the prescription of intravenous fluid and electrolyte therapy. This guidance represents a major opportunity to improve patient safety.

**Review of Evidence:**

The literature was reviewed using a multiple database search - The Cochrane Library (1995-2016), Ovid MEDLINE (1946-2016), PubMed (1960-2013), Up-to-Date (2016), for human studies published in English pertaining to the treatment of these electrolyte disorders in adults.

The modules are presented in algorithmic form to assist diagnosis in a systematic manner, and are followed by current recommendations on treatment of the specific electrolyte disorder.

**Clinical guidelines:**

Guidelines that will be covered include:

1. Hyponatremia
2. Hypernatremia
3. Hypokalemia
4. Hyperkalemia
5. Hypocalcemia
6. Hypercalcemia
7. Hypomagnesemia
8. Hypermagnesemia
9. Hypophospatemia
10. Hyperphosphatemia

The modules are presented in algorithmic form to assist diagnosis and avoid diagnostic variations. They are followed by current recommendations on treatment of the specific electrolyte disorder.

**HYPONATREMIA:**

**Adrogue- Madias Formula**

Δ Na=(infusate Na+ infusate K)- Serum Na

Total Body Water + 1

This formula calculates the anticipated rise in serum Na after the administration of 1 liter of selected fluid. Total Body Water = 0.6 \* Body Weight

**Volume (liter)= Desired Δ (Na) e**

**Δ (Na) s (with 1 liter)**

**This formula calculates how much volume of the selected fluid should be given based on the desired rise in serum sodium and the calculated rise in serum sodium using the formula in upper panel (with 1 liter). For example if the anticipated rise in serum sodium with 1 liter of 3% Nacl is 10 mmol/l, and the desired rise in serum sodium is only 5 mmol/l , then 5/10= 0.5 liter of the infusion should be administered based on current recommended correction limits**

**Treatment:**

**General Guidelines:**

* Aim for a 5-6 mmol/l per 24-h increase in serum sodium concentration.
* Limit the increase in serum sodium concentration to 10 mmol/l in the first 24 h and 8 mmol/l during every 24 h there- after, until a serum sodium concentration of 130 mmol/l is reached.
* Check the serum sodium concentration after 1, 6 and 12 h.

**Symptomatic Hyponatremia:**

**Acute (<48 hours) Severe (coma, inability to communicate, seizures) Symptomatic Hyponatremia (Pna< 120 mmol/l):**

* 100 ml of 3% Saline bolus – will raise Pna by 1.5 mmol/l in men and 2.0 mmol/l in women.
* If symptoms persist or worsen repeat the bolus x2 over 10 minute intervals.
* If symptoms have resolved but the rise in serum sodium is substantially less than the 24-hour goal, further therapy in addition to fluid restriction may consist of a slow infusion of hypertonic saline (e.g., 10 to 30 mL per hour) with careful monitoring of the serum sodium.
* The rationale behind the bolus is to rapidly increase Pna by 4-6 mmol/l, which can reverse seizures.

**Mild- Moderate (dizziness, gait, lethargy, confusion)**

* Less severe symptoms seen in Pna < 120 mmol/l that develop over more than 48 hours, or less severe Hyponatremia which develop in less than 48 hours and in patients with chronic moderate Hyponatremia (Pna – 120 to 129 mmol/l)
* Hypertonic saline to raise Pna 1 mmol/l per hour in first 3-4 hours justified with distressing symptoms (confusion, lethargy), followed by maintenance treatment with fluid restriction and salt intake.
* Patients with less severe symptoms can be treated with fluid restriction and oral salt tablets.

**As a rule 1 ml/kg of 3% Saline= 1 mmol/l increase in Pna**

**Investigations:**

**Urine:**

Na, Urea, Uric Acid, creatinine, osmolality

**Blood:**

Osmolality, Glucose, Lipids, Thyroid Function, Adrenal Profile, Renal Function, Serum and Urine Protein Electrophoresis

**Hypernatremia:**

**Treatment:**

* Water Deficit: 0.6 x Ideal Body Weight x ((Pna/140)-1)
* Infusion Rate: Replace half the deficit over 24 hours, remainder over 1-2 days.
* In chronic Hypernatremia, rate of correction is <0.5 mmol/l/hour or < 10-12 mmol/day.
* In Acute Hypernatremia, rate of correction may be increased to 1 mmol/l/hour.
* 0.45% NS, 0.225% NS or D5W may be used.
* 0.9% NS is avoided unless severe volume depletion.

**Investigations:**

**Urine:** Na, Osmolality, Specific Gravity, 24-hour urine Na-K-Creatinine.

**Blood:** Basic chemistry and metabolic profile, Osmolality, ADH, Plasma renin

**Hypokalemia:**

**Investigations:**

**Urine:** K, Na, Ca2+, Chloride, Mg2+, Creatinine, pH, 24-hour urine Potassium

**Blood:** Magnesium, Renin, Aldosterone and Ratio

**Treatment:**

* Total Body K deficit= 100-150 mmol for every 1 mmol/l drop in Plasma K
* Correct Hypomagnesaemia, alkalosis, Volume depletion
* For K < 2.0 mmol/l or < 3.0 mmol/l with EKG abnormalities or symptoms give IV KCL 20-40 mmol/ hour via central line with EKG monitoring
* Otherwise, give oral KCl 20-40 mmol po Q4-24 hours
* Consider K sparing diuretics like Amiloride, Spironolactone

**Hyperkalemia:**

**Investigations:**

**Urine:** Potassium, Creatinine, 24 hour Potassium, pH, Sodium, Specific gravity

**Blood:** Renin, Aldosterone, CBC, Basic chemistry and metabolic panel, magnesium

**Treatment:**

**Mild (K < 6.0 mmol/l):**

IV Lasix 40-80 mg

Ca Resonium 30 grams Po

**Moderate (K :6.0-7.0 mmol/l):**

Sodium Bicarbonate 50 mmol IV over 5 minutes

D50 (50 grams) plus Insulin 10 units IV over 15 mns.

Albuterol Nebulizer 10-20 mg over 15 mns

Dialysis if Renal Failure

**Severe (> 7.0 mmol/l)**

Calcium Gluconate (Peripheral IV 10-30 ml of 10% solution given IV over 2-5 minutes)

Dialysis if Renal Failure

**Hypocalcemia:**

**Treatment of Acute Symptomatic Hypocalcemia:**

-20 ml of 10% Calcium Gluconate in 100 ml D5W over 15 minutes, then 60 ml in 500 ml NS over 6 hours.

- Each 10 ml of Calcium Gluconate will increase Serum Ca2+ by 0.125 mmol/l

- Give empiric 2 grams MgSo4 IV unless in Renal Failure

**\* 10% Calcium Gluconate = 93 mg Elemental Calcium/10 ml**

**\* 10% Calcium Chloride = 272 mg Elemental Calcium/ 10 ml**

**Chronic Hypocalcemia:**

- Calcium Carbonate 600 mg po BID-TID

- Ergocalciferol 50,000 units q 7 days

- Calcitriol 0.25 mcg daily, titrate to 0.5- 2 mcg qid

**Investigations:**

**Urine:** 24 hour Urine Ca2+ with Ca2+- Creatinine Ratio

**Blood:** Ionized Ca2+, Mg2+, Po4, albumin, iPTH, Renal Function

**Hypercalcemia:**

**Investigations:**

**Urine:** 24-hour urine Ca2+, Urine Ca2+, Creatinine

**Blood:** Total and Ionised Ca2+, albumin, Mg2+, PO4, iPTH, Basic Chemistry, Basic metabolic panel, alkaline phosphatase, 1,25 (OH)2 Vit D, 25 OH Vit D, PSA, CEA

**Treatment of Acute Symptomatic Hypercalcemia:**

- NS 250 ml/hour IV, when volume deficit is corrected add Furosemide 20-40 mg IV q2-4 hour to maintain euvolemia.

- Etidronate 7.5 mg/kg/day in 250 ml NS infusion over 2 hours. Can repeat in 3 days.

- Pamidronate 60-90 mg IV over 4-6 hours

- Calcitonin 4-8 IU/kg IM/SQ q 12 hrs x 4 doses

- IV Glucororticoids: Prednisolone 20-40 mg daily for lymphoma/malignancy.

- Consider Dialysis if intolerance to fluids in CHF/ Renal Failure

**HypoMagnesemia:**

**Treatment:**

**Symptomatic:**

- Magnesium Sulfate 1-2 gram IV over 15 minutes (2-4 ml of 50% solution)

- Magnesium deficit = 0.2 x kg weight x desired increase in Mg concentration

**Asymptomatic:**

-Oral Magnesium oxide 200-400 mg po BID-QID

**Investigations:**

**Urine:** Mg2+, Ca2+, Creatinine, 24-hour urine magnesium

**Blood:** Magnesium, calcium basic metabolic and Chemistry profile

FeMg= UMg X Pcr

0.7 x PMg x Ucr

**Hypermagnesemia:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Hypermagnesemia** | | | |
| **Causes:** | -Increased Magnesium Intake  - Renal Insuffiency  - Lithium  - Familial Hypocalciuric Hypercalcemia  - Milk Alkali Syndrome  - Hypothyrodism  - Addisons Disease | | |
| **Manifestations** | Mild | 1.5- 4.5 mmol/l | - Prolonged QT  - Hyporeflexia  - Hypotonia |
|  | Moderate | 5-7 mmol/l | - Muscle paralysis  - Hypotension  - Hypoventilation  - AV conduction Abnormalities |
|  | Severe | >7 mmol/l | - Respiratory Depression  - Complete heart Block  - Coma |
| **Treatment** | - Stop offending Agent  - Saline diuresis 0.9% saline infused at 100-150 ml/hour to replace urine loss  - Calcium chloride 1-3 gram added to saline ( 10% solution , 1 gramper 10 ml amp) to run at 1 gram/hour AND  - Lasix 20-40 mg IV q4-6 as needed  - Magnesium > 4.5 mmol/l – requires stat Hemodialysis because of risk of respiratory failure | | |

**Hypophosphatemia:**

|  |  |
| --- | --- |
| **Treatment of Severe Hypophosphatemia** | |
| **PO4 Level (mmol/l)** | **IV PO4 Dose (mmol/kg)** |
| 1.6-2.4 | 0.08 |
| 1.2-1.5 | 0.08-0.15 |
| 0.8-1.1 | 0.15-0.2 |
| <0.8 | 0.2-0.3 |

**Investigations:**

**Urine:** 24 hour PO4, Po4, Creatinine, Urinalysis

**Blood:** Metabolic Panel, PTH, Calcidiol

**Hyperphosphatemia:**

**Treatment:**

**Severe Hyperphosphatemia**

* Volume expansion with 0.9% Saline 1-2 L over 1-2h
* Dialysis

**Moderate Hyperphosphatemia**

* Restrict dietary phosphate to 900 mg/day
* Sevelemer 800-1600 mg 3 times/day with meals

**Investigations:**

**Urine:** PO4, Creatinine, FePO4

**Blood:** K, Creatinine, PTH, 25 OH Vit D, Corrected Ca2+, CPK, LDH

FePO4<5%= Non Renal cause

FePO4>5%= Renal or HypoParathyrodism

**Appendix:**

**Converting between weight, valency and molarity**

**A. Number of milligrams in 1 milliequivalent or 1 millimole**

|  |  |  |
| --- | --- | --- |
| Substance | 1 mEq | 1 mmol |
| Na+ | 23 | 23 |
| K+ | 39 | 39 |
| Ca2+ | 20 | 40 |
| Mg2+ | 12 | 24 |
| P (Phosphorus) |  | 31 |
| Chloride | 35.5 | 35.5 |
| Bicarbonate | 61 | 61 |

**B. Changing milligrams to milliequivalents or millimoles – Na+, K+, HCO3-**

1. 1 gram NaCl= 1000 mg/ (23+35.5) mg= 17 mEq or mmol of Na+

2. 1 gram Na= 1000 mg / 23 mg= 43 mEq or mmol of Na+

3. 1 gram KCl= 1000 mg/ 74.5 mg= 14 mEq or mmol of K+

4. 1 gram K= 1000 mg/ 39 mg= 26 mEq or mmol of K+

5. 1 gram NaHCO-3= 1000 mg/ 84 mg= 12 mEq or mmol of Na+ or 12 mEq or mmol of HCO-3

**C. Changing milligrams to milliequivalents or millimoles – Calcium**

Normal Calcium level = 10 mg/dl = 100 mg/L= 100/ 20 mEq/L (since 20 mg = 1 mEq)

= 5 mEq/L= 5/2 mMol (since 2 mEq= 1 mmol)= 2.5 mmol/l

**D. Changing milligrams to milliequivalents or millimoles – Magnesium**

Normal Mg level = 2.4 mg/dl= 24 mg/L= 24/ 12 mEq/L (since 12 mg= 1 mEq)

= 2 mEq/L= 2/2 mMol (since 2mEq= 1 mMol)= 1 mmol/l

**E. Changing milligrams to milliequivalents or millimoles – Phosphorus**

Normal P level= 2.5 to 4 mg/dl= 25 to 40 mg/L=(25/31 or 40/31) mMol (since 1mMol of P= 31 mg)

= 0.8 to 1.3 mmol/l

**F. Estimating Dietary Na (sodium) and NaCl (salt intake ) to check Dietary Compliance**

1 gram Na = 43 mmol Na and 1 gram NaCl= 17 mmol Na

If Spot Urine Na= 86 mmol/l and estimated 24 Urine Volume = 1.5 L/day, then Urine Na= (86 /43 or 86/17) x 1.5 L= 3 grams Na or 7.5 grams NaCl Intake /day

**Guideline Sponsor:**

SEHA Kidney and Urology Council

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**Guideline Development Committee:**

Dr. Hormaz Dastoor MD

Chief of Nephrology, Al Rahba Hospital

Email: [hodastoor@seha.ae](mailto:hodastoor@seha.ae)

Dr. Samra Abouchacra MD

Chairman, SEHA Kidney and Urology Council

Email: [sabouchacra@seha.ae](mailto:sabouchacra@seha.ae)

**DISCLAIMER:**

This Clinical Practice Guideline document is based on the best information available. It is designed to provide information and assist decision-making. It is not intended to define a standard of care, and should not be construed as one, nor should it be interpreted as prescribing an exclusive course of management.

Variations in practice will inevitably and appropriately occur when clinicians take into account the needs of individual patients, available resources, and limitations unique to an institution or type of practice. Every health-care professional making use of these recommendations is responsible for evaluating the appropriateness of applying them in the setting of any particular clinical situation. The recommendations for research contained within this document are general and do not imply a specific protocol.