Electrolyte Emergencies
- Hyponatremia/hypernatremia
- Hypokalemia/hyperkalemia
- Hypocalcemia/hypercalcemia
- Hypomagnesemia/hypermagneseemia
- Hypophosphatemia/hyperphosphatemia
Hyponatremia

• Symptomatic: headaches, nausea, vomiting, decreased mental status, seizures, coma, brain herniation, neurogenic pulmonary edema, respiratory arrest, death
• Risk is higher in premenopausal females, children
• Sodium usually <120mEq/L
Treatment

- Correction can be life threatening especially in chronic hyponatremia (hyponatremia > 48 hours)
- Replete potassium first, remember potassium is an exchangeable cation
- Use hypertonic saline in symptomatic hyponatremia
- Patients with seizures and coma should get 2ml/kg bolus infusions or 100ml of 3% saline up to 2 times
- Do not correct by more than 8mEq/l in 24 hours or 15-20mEq/l in 48 hours.
- Check sodium q 2 hours
- Change Na for 1 Liter of IVF= [(infusate Na+ infusate K)-serum Na]/TBW +1
Hypernatremia

• Symptomatic: Cerebral dehydration leads to demyelinization, cerebral bleeding, coma and death.
• Na> 158-160mEq/L
• Acute or Chronic
• Don’t correct >8-10mEq/l in 24 hours
• Provide 50% of the water deficit in the first 12-24 hours and the rest over the next 24 hours
• Check sodium q2 hours
• [(Desired Na+/serum Na+) -1]xTBW
Hypokalemia

- Symptomatic: tachyarrhythmia, muscle weakness
- K<3mEq/l
- IV repletion, 20mEq-40mEq/hour via CVC, 10mEq/hour via PIV
- Continuous EKG monitoring
- No use of dextrose in IV solutions
- Make sure magnesium is replete
Hypokalemia: long QT interval, ST depression, low T waves, TU wave fusion
Hyperkalaemia  
$S[K]^+ > 5.0 \text{ mmol/l}$

Pseudohyperkalaemia, $P[K]^+ 0.3 \text{ mmol/l} > S[K]^+$?
- Leukocytosis $> 70,000/\text{cm}^3$
- Thrombocytosis $> 1,000,000/\text{cm}^3$
- Familial disordered cation transport on erythrocyte membranes
- Factitious?
  - Improper isolation of serum before clotting
  - Long, tight tourniquet time

Increased potassium input?
- Potassium supplements and salt substitutes
- Stored packed red blood cells
- Penicillin G potassium

Reduced potassium secretion?
- Renal failure
- Drugs
  - ACE inhibitors, angiotensin-II blockers, spironolactone, amiloride, triamterene, non-steroidal anti-inflammatory drugs, cyclosporine and tacrolimus, heparin, trimethoprim, pentamidine, mitomycin C
- Addison's disease
- Type IV renal tubular acidosis
  (hyporeninaemic hypoaldosteronism)
- Type II pseudohypoaldosteronism
  (Gordon's syndrome)
- Hyperkalaemic type I (distal) renal tubular acidosis
- Urinary tract obstruction
- Sickle cell disease
- Ureteroejunctostomy
- Lupus nephritis
- Acute transplant rejection

Increased potassium release from cells?
- Cell and tissue catabolism
  - Haemolysis
  - Rhabdomyolysis
  - Tissue damage in trauma
  - Tumour lysis syndrome
- Transcellular potassium shifts
  - Acidosis
  - Exercise
  - Insulin deficiency
  - Hyperosmolality
  - Mutated sodium channel in hyperkalaemic familial periodic paralysis
- Drugs
  - Beta-adrenergic blockade
  - Digitalis overdose
  - Succinylcholine
  - Intravenous amino acids (lysine, arginine, epsilon-aminocapric acid)
  - Cyclosporine and tacrolimus
  - Rebound after barbiturate coma
  - Somatostatin administration
Hyperkalemia

- Symptomatic: fatigue, weakness, paresthesias, paralysis, palpitations
- K>6mEq/l
- Treatment: IV Calcium to restore membrane excitability toward normal
- Fastest-insulin/D50, Beta agonists
- Furosemide, sodium polystyrene sulfate +sorbitol
- Bicarbonate?
- Renal Replacement Therapy: IHD, then continuous therapies
Normal tracing (plasma K+ 4–5.5 meq/L). PR interval = 0.16 s; QRS interval = 0.06 s; QT interval = 0.4 s (normal for an assumed heart rate of 60).

Hyperkalemia (plasma K+ ≥7.0 meq/L). The PR and QRS intervals are within normal limits. Very tall, slender peaked T waves are now present.

Hyperkalemia (plasma K+ ≥8.5 meq/L). There is no evidence of atrial activity; the QRS complex is broad and slurred and the QRS interval has widened to 0.2 s. The T waves remain tall and slender. Further elevation of the plasma K+ level may result in ventricular tachycardia and ventricular fibrillation.
Hypocalcemia

• Symptomatic: tetany, muscle weakness, myalgia, cramps, parasthesia in hands and feet, circumoral numbness, dysphagia, biliary, intestinal colic, laryngospasm, bronchospasm, seizures, papilloedema, CHF from decreased myocardial contractility, hypotension, anxiety, psychosis, confusion, dementia, depression

• Ionized ca <0.7mmol/l or Ca 7-7.5mg/dl
Hypocalcemia: QT prolongation, T wave inversion
Treatment

• Replete Magnesium
• IV replacement
• Caution with digoxin?
• Caution in high phosphorus states >6mg/dl
Hypercalcemia

- Symptomatic: fatigue, weakness, anxiety, depression, anorexia, n/v, abdominal pain, constipation, peptic ulcers, nephrogenic DI, Type 1 RTA, nephrolithiasis, acute pancreatitis, hypertension, confusion, psychosis, coma, shortening of QT wave-no clinical importance

- Calcium > 12mg/dl or ionized Ca 3.0mmol/l

- Measure ionized ca
Hypercalcemia: Short QT interval, Osborn waves
Treatment

- Hydration to a euvoletic to slightly hypervolemic state, then diuresis with loop diuretic
- Inhibition of osteoclast activity in the bone
- Avoid immobilization
- Cinacalcet
S\-[Mg]^{2+}\ <\ 0.75\ mmol/l

**Gastrointestinal losses**
- Nasogastric suctioning
- Acute or chronic diarrhoea
- Malabsorption syndromes
- Steatorrhoea
- Short-bowel syndrome
- Malnutrition
- Intestinal fistula
- Acute pancreatitis
- Primary intestinal hypomagnesaemia (selective defect in Mg\(^{2+}\) adsorption)

**Renal losses**
- Alcohol
- Osmotic diuresis in diabetes mellitus, uraemia, after mannitol
- Post-obstructive diuresis, renal transplantation and recovery from acute tubular necrosis
- Correction of chronic systemic acidosis
- Hypercalcaemia and hypercalciuria
- Hypocalcaemia, phosphate depletion
- Hungry bone syndrome
- Hyperaldosteronism
- Chronic parenteral fluid nutrition and volume expanded status
- Diuretics
- Nephrotoxic drugs (aminoglycoside, cisplatin, amphotericin B, cyclosporin, foscarnet, pentamidine)
- Theophylline, β-agonists
- Primary renal magnesium wasting (Gitelman’s syndrome, Paracellin-1 mutation, Na-K-ATPase mutation)
Hypomagnesemia

• Symptomatic: respiratory muscle weakness, fasciculations, cramps, tetany, convulsions, coronary artery vasospasm, atrial tachyarrhythmias, supraventricular, ventricular arrhythmias, torsades de pointes

• IV repletion at 1-2g of magnesium sulfate over a 10 minute period, up to 10grams a day

• Aim to keep above 1.0mg/dl
Torsade de pointes
Hypermagnesemia

• Symptomatic: confusion, depressed level of consciousness, N/V, weakness, paralysis with absence of reflexes, respiratory depression, hypotension, bradycardia, complete AV block

• PR, QT and QRS intervals are increased, decreased P wave voltage

• Mg>4.8mg/dl

• Treatment: Calcium, RRT
Hypophosphatemia

- Symptomatic: granulocyte dysfunction, arrythmias, respiratory muscle weakness, reduced oxygen delivery to tissues
- Phosphorus $<1.0$mg/dl
- Treatment: IV replacement with 15-30mmol over 2 hours potassium phosphate or sodium phosphate, cannot replace in the same line with calcium
- Watch out for resulting hypocalcemia
$[\text{PO}_4^{3-}] > 1.6 \text{ mmol/l}$

**Pseudohyperphosphataemia**
- Multiple myeloma
- Waldenström macroglobulinaemia
- Monoclonal gammopathy
- Extreme hypertriglyceridaemia
- In vitro haemolysis
- Hyperbilirubinaemia

**Massive acute phosphate load**
- Rhabdomyolysis
- Tumour-lysis syndrome (Burkitt's lymphoma, Non-Hodgkin's lymphoma, leukaemias)
- Haemolysis
- Malignant hyperthermia
- Ischaemic bowel
- Lactic acidosis, ketoacidosis
- Hyperglycaemia
- Vitamin D intoxication
- Large amounts of phosphate salts (oral/rectal laxatives, enemas, intravenous phosphate)

**Renal failure (GFR < 20 – 25 ml/minute)**
- Increased tubular re-absorption
- Hypoparathyroidism
- Pseudohypoparathyroidism
- Vitamin D intoxication
- Acromegaly
- Thyrotoxicosis
- Glucocorticoid withdrawal or deficiency
- Tumoral calcinosis syndrome
- Bisphosphonates
- Magnesium deficiency
Hyperphosphatemia

• Acute can be life threatening secondary to hypocalcemia, hyperkalemia: CaPhos product > 60-72mg/dl results in precipitating calcium, decreasing serum calcium levels and causing AKI

• Symptoms: those of associated hypocalcemia and hyperkalemia

• Treatment: insulin/D50, IVF, carbonic anhydrase inhibitor, RRT
A 71-year-old woman who has had nocturia for several years is admitted to the hospital secondary to increasing weakness and frequency of urination. She has been well until 2 days ago, when she felt weak and could not climb the stairs to her apartment. She has a history of duodenal ulcer many years ago that responded to intensive antacid therapy. She currently takes calcium carbonate for treatment of osteoarthritis, and she takes bicarbonate of soda for heartburn. She has a 40 pack-year history of smoking.

On physical examination, she is frail and oriented only to person. Pulse is 106/min, and BP is 110/80 supine and 90/70 mmHg sitting. The remainder of the examination is normal.

Laboratory studies reveal the following: Hematocrit 41, Na 152 mmol/L, K 3.0 mmol/L, Cl 100 mmol/L, HCO3 39 mEq/L, BUN 98 mg/dl, creatinine 7.1 mg/dl, Ca 14.4 mg/dl, phosphate 6.3 mg/dl, serum 1,25-dihydroxyvitamin D 30 pg/ml (35 to 85 pg/ml), parathyroid hormone 16 pg/ml (30 to 50 pg/ml).

Urinalysis shows specific gravity of 1.007, trace protein, Na of 49 mmol/L, creatinine of 70 mg/dl, and urine osmolality of 260 mOsm/kgH2O.

Renal ultrasound shows normal-sized kidneys and no hydronephrosis.

The clinical and laboratory findings are MOST consistent with which ONE of the following?

A. Vitamin D intoxication.
B. Chronic kidney disease as a result of longstanding hypertension.
C. Multiple myeloma.
D. Milk-alkali syndrome.
E. Primary hyperparathyroidism.
A 54 y/o woman comes for a follow-up examination. She was discharged from the hospital 7 days ago after hospitalization for severe SOB. During her hospitalization, a large pleural effusion was found and pleurodesis was performed. At today’s visit, she feels tired. She has not had nausea, headache, or irritability and has not vomited. She was diagnosed with met small cell lung CA 13 months ago and was treated with palliative chemo with a good response. Previous surgeries include 2 cesarean sections. She also has a 75 pack year tob hx.

On physical exam her T is 36.8, P 84 RR 18 BP 126/84. She appears cachectic. Cardiac exam is normal. On pulm exam there are diminished breath sounds in the R base. There is no pedal edema.

Labs: Glc 114
  bun 10
  cr 0.6
  Na 112
  K 3.2
  Cl 84
  bicarb 21
  phos 3.1
  alb 3.2
  serum osm 243
  urine osm 542
  urine Na 120
  urine K 24

Which of the following is the most appropriate therapy?
A) 3% saline via infusion pump
B) Demeclocycline
C) Fluid restriction <1L/d
D) Sodium Chloride tabs, 2 grams TID
E) HCTZ
A 37y/o male with longstanding ETOHism is admitted to the ICU with severe pancreatitis. His friends state that for the last several weeks he has been drinking beer all day and has been eating very little except for salty snacks. Over the next 3 days, he develops sepsis and a pancreatic abscess that requires drainage. 2 days later, he remains on mechanical ventilation and vasopressor support.

Labs obtained on hospital day 6:
Glc 96
Bun 5
Cr 0.7
Na 136
K 4.3
Cl 105
Bicarb 22
Alb 2.9
Ca 7.1
Phos 2.4
Mg 2.2

He is started on TPN with 2000 total calories, 20% from fat; 120 meq of Na and 80meq of K. The total volume is 2L.

Which of the following conditions does this patient have high risk for after TPN is started?
A) Rhabdomyolysis
B) Leukopenia
C) Torsade de pointes
D) Cerebral edema
E) Fulminant liver failure