ELECTROLYTES ON WALL STREET:

MANAGING THE HIGHS AND LOWS

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Division of Hospital Medicine

CENSUS

Mr. Millennial

Mrs. Salty

Mr. Farmer

Mrs. Colacey

Mr. Sweaty

Mr. Millennial

24 year old male

Unknown PMH/PSH/Meds

Dropped off at ER. Sweating profusely. Complaining about girlfriend Molly.

Tachycardic (112). Febrile (39). Hypertensive (160/80).

LABS

Lab	Admission
Hemoglobin	14.9
WBC	12.6
Platelets	206
Sodium	120
Potassium	4.1
Bicarbonate	20
Creatinine	1.1
BUN	18
ALT	55
UA	Negative
Glucose	145
ETOH	Negative

ECTASY (MDMA)

*Releases norepinephrine and dopamine and blocks reuptake

*Causes hypertension, hyperthermia, and tachycardia

*Peak effect 2 hours after ingestion lasts 4-6hrs

*Hyponatremia (SIADH, Fluid Intake)

*ABC's and Charcoal if <1hr

*?Coingestions

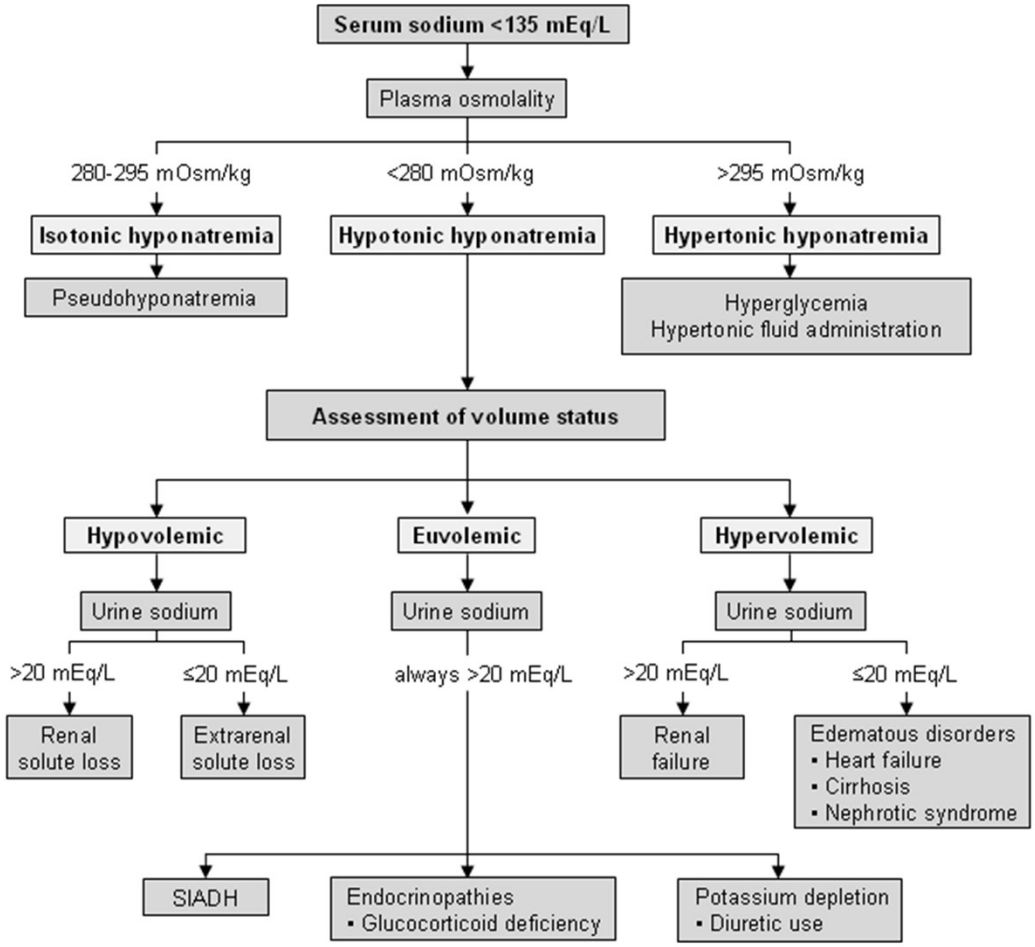
HYPONATREMIA

Hypovolemic
-Sweating, Diarrhea, or Vomiting
-Diuretics (Thiazides, Loop)
-Cerebral Salt Wasting

Euvolemic
-SIADH (Head trauma, Seizure, CNS disease, Neoplastic, Meds, Illicit Drugs)
-Adrenal Failure
-Hypothyroidism

Hypervolemic
-Congestive Heart Failure
-Cirrhosis
-Polydipsia
-Nephrotic Syndrome
-Renal disease

Pseudo
-Hyperglycemia *FOR EVERY 100 ABOVE 100 ADD 1.6*
-Hypertriglyceridemia
-Paraproteinemia


Serum sodium <135 mEq/L
Plasma osmolality
280-295 mOsm/kg
<280 mOsm/kg
>295 mOsm/kg
Isotonic hyponatremia
Hypotonic hyponatremia
Hypertonic hyponatremia
Pseudohyponatremia
Hyperglycemia
Hypertonic fluid administration
Assessment of volume status
Hypovolemic
Euvolemic
Hypervolemic
Urine sodium
Urine sodium
Urine sodium
>20 mEq/L
≤20 mEq/L
always >20 mEq/L
>20 mEq/L
≤20 mEq/L
Renal solute loss
Extrarenal solute loss
Renal failure
Edematous disorders
▪ Heart failure
▪ Cirrhosis
▪ Nephrotic syndrome
SIADH
Endocrinopathies
▪ Glucocorticoid deficiency
Potassium depletion
▪ Diuretic use

HIS ADMIT LABS

Lab	Admission
Hemoglobin	14.9
WBC	12.6
Platelets	206
Sodium	120
Potassium	4.1
Bicarbonate	20
Creatinine	1.1
BUN	18
ALT	55
UA	Negative
Glucose	145
ETOH	Negative
Urine Sodium	58
Osmo	250

SIADH

- Malignancy (Lung, Brain, GI, GU, lymphoma)
- Pulmonary (Pneumonia, asthma, COPD, Lung CA)
- Intracranial (Trauma, Stroke, Hemorrhage, Infection)
- Drugs (Antipsycotics, Antidepressants, Chemo, Ecstasy)
- Misc (Pain, Nausea, Post Operative)

Diagnosing SIADH

Serum Osmo <275	**Normal Acid Base Status**
Euvolemic	**Normal Adrenal Function**
Urine Osmo >100 Osm/kg	**Normal renal function**
Urine Sodium > 40mEq/L	**Normal Thyroid**

Treatment Pearls

Volume Contraction = Normal Saline

SIADH = Fluid Restrict (800mL per day)

3% Saline = 100mL bolus (2-3meq)

Goal <9meq in 24 hours or <12-14meq in 48 hours

Osmotic Demyelination and Fatal Herniation

Mrs. Salty

PMH
Coronary Artery Disease

PSH:
Cataract Removal

SOCIAL HISTORY:
Single. Nonsmoker. No alcohol.

MEDS:
Aspirin 325mg daily.

ROS:
Nausea. Vomiting. Orthostasis.

******Vomited x1 this morning. "Kinda dark colored" Came to ER******

Lab	**Physical 3 months ago**	**ER Labs**
Hemoglobin	13.3	6.8
Platelets	296	151
Sodium	138	146
Chloride	100	119
Potassium	4.8	3.1
Creatinine	1.0	0.9
BUN	20	16

LABS

Lab	Physical 3 months ago	ER Lab	Floor Lab
Hemoglobin	13.3	6.1	12.6
Platelets	296	171	111
Sodium	138	146	140
Chloride	100	119	101
Potassium	4.8	3.1	5.1
Creatinine	1.0	0.9	1.1
BUN	20	16	21

Drip Arm

Hypernatremia

-Dehydration

-Diabetes Insipidus (Neuro/Nephro)

Hyperchloremia

-Iatrogenic

Next patient is waiting…

Mr. Farmer

PMH

Never been to doctor.

PSH:

SOCIAL HISTORY:

Married. Neversmoker. No ETOH.

MEDS:

None.

***Transferred from OSH for femur fracture after falling off tractor and being rolled over.

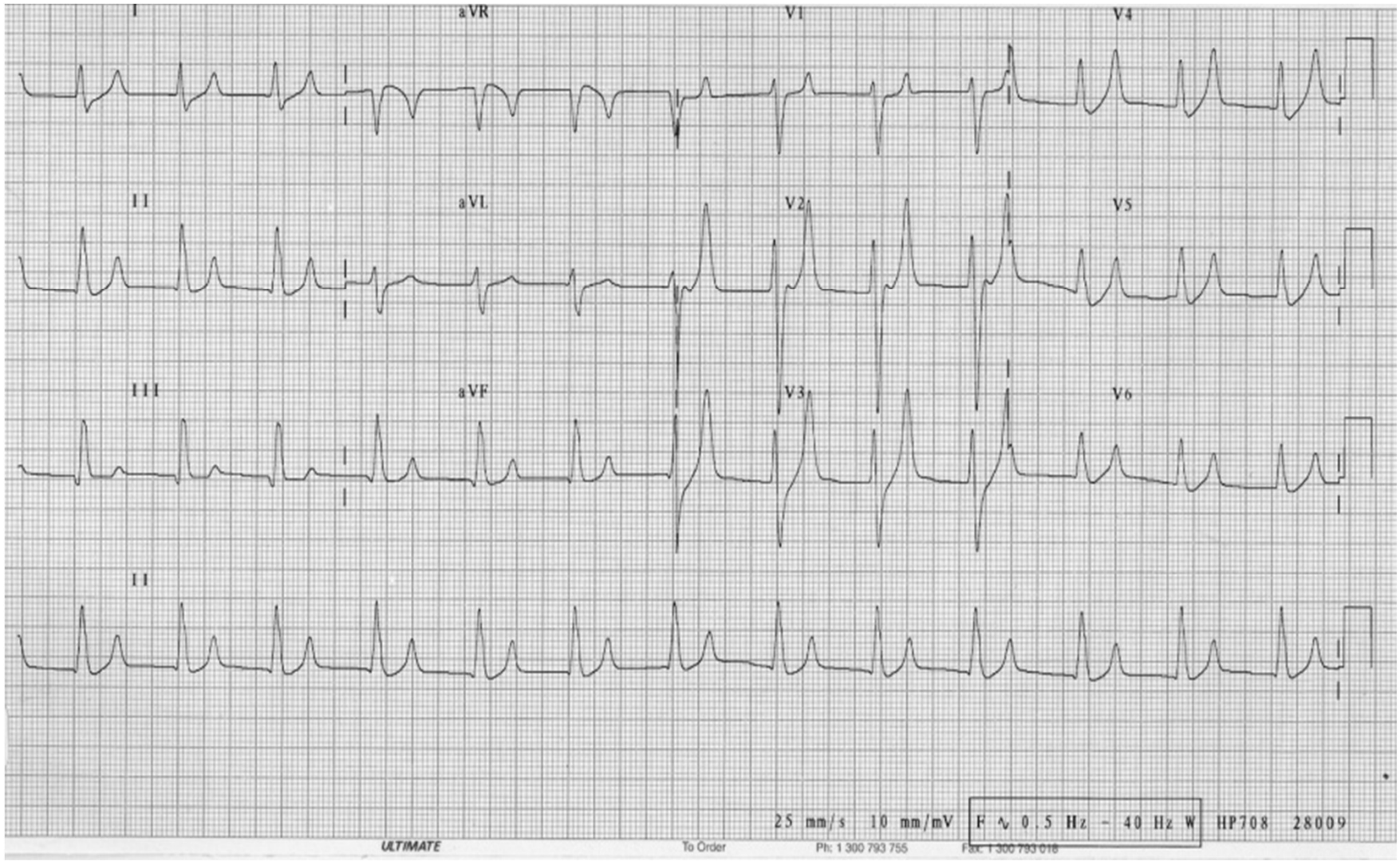
Lab	Admission
Hemoglobin	11.7
White Blood Cells	11.8
Platelets	392K
Creatinine	1.0
Potassium	4.9

Fentanyl PCA, normal saline, Western movie channel

Lab	Admission	Hospital Day 2
Hemoglobin	11.7	10.1
White Blood Cells	11.8	11.1
Platelets	392K	421K
Creatinine	1.0	2.9
Potassium	4.9	6.8

	ADMIT LABS	DAY 2
Hemoglobin	11.7	10.1
Potassium	4.8	**6.8**
Sodium	144	141

Potassium 6.8


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
25 mm/s 10 mm/mV F ∿ 0.5 Hz - 40 Hz W HP708 28009
ULTIMATE
To Order
Ph: 1 300 793 755
Fax: 1 300 793 018

Potassium	5.4
CK	19,526

Rhabdomyolysis

Traumatic	Nontraumatic Exertional	Nontraumatic Nonexertional
Crush Syndrome Immobilization	Marked exertion Hyperthermia	Drugs Toxins Infections

Hyperkalemia

-Decreased excretion (renal dx)

-Tissue Catabolism (rhabdo, hemolysis, GI bleed)

-Cell shift (acidosis, lack of insulin)

-Excessive intake (IV, PO, KCl salt substitute)

-Blood transfusion

-Medications (ACE/ARB, K+ sparing, cyclosporine, NSAIDS)

-Pseudo (hemolysis, elevated WBC (> 50K) platelets (>1million))

-Heparin Induced Hypoaldosteronism (2-4d after admin)

Hyperkalemia: Treatment

Intervention	Mechanism	Onset and Duration	Dose	Remember
Calcium Gluconate	Stabilize cardiac membrane.	Immediate Onset, transient	1000mg (10mL of 10% solution)	Can repeat X1 if EKG changes persist. Can exacerbate dig tox.
Albuterol	Shift potassium into cells	20-30 minutes, Transient	10-20mg in 4ml nebulized solution ever four hours.	Beta agonist
Insulin D50	Shift potassium into cells.	10-20minutes, transient	10units of regular insulin with D50	Monitor blood sugar closely.
Furosemide	Increases urinary potassium excretion	Onset: 5 - 30 mins Duration: 2 - 6 h	20 – 40 mg IV q12 – 24 h	Use only after hydration, Useful in volume overload, heart failure
Kayexalate	Increase potassium excretion.	1-2 hours	15-30grams orally	Do not give to post op or renal transplant pts
Dialysis	Potassium removal	Immediate	n/a	Marked tissue breakdown, ESRD on HD,

MS. COLACEY

PMH/PSH

Obesity

PSH:

Right Total Knee

SOCIAL HISTORY:

Single. Wheelchair bound. Resides in SNF.

MEDS:

Fentanyl patch. MiraLAX.

ROS:

“Confusion, back pain, Can’t poop!!!”

*****Family notes she is not eating and losing lots of weight*****

ADMIT LABS

Lab	Admission
Hemoglobin	10.2
MCV	86
Platelets	214,000
Sodium	133
Potassium	4.8
Bicarbonate	23
Creatinine	1.5
BUN	48
Alk Phos	586
ALT	38
Bilirubin	1.0
ABG	Normal
UA	Negative

Type	Frequency	Bone metastasis	Causal agent	Tumors
Humoral hypercalcemia of malignancy	80%	Minimal, absent	PTHrP	Squamous cell ca (head/neck, esophagus),cervix, renal, endometrial, ovarian, breast, HTLV- lymphoma
Local osteoclastic hypercalcemia	20%	Extensive, common	Cytokines, chemokines, PTHrP	Breast, multiple myeloma, lymphoma
1-25 Di-OH D secreting lymphoma	< 1 %	Variable	Vitamin D analogues	Lymphomas

Prostate (1.5%)

Breast

Kidney

Thyroid

Lung

Multiple Myeloma (9.5%)

Hypercalcemia

-Primary Hyperparathyroidism
-Malignancy (PTH peptide, Bone Mets)
-Sarcoidosis
-Drugs (HCTZ, Lithium, Theophylline, Vitamin D)
-Vitamin D intoxification
-Hyperthyroidism
-Immobilization

Hypercalcemia: Treatment

Intervention	Mechanism	Duration of action	Dose	Remember
Normal saline	Restores volume, promotes calcium excretion	Hours	200-300 ml/hr IV to maintain UOP 100-150 cc/hr	Caution in heart failure
Bisphosphonates	Block osteoclast mediated bone resorption	Onset: 1 – 3 d Duration: 2 - 4 wk.	Pamidronate IV 60-90mg (2 - 4 h) Zoledronic acid IV 4 - 8 mg (15 min)	Caution in renal failure Rare: Osteonecrosis of the jaw, esp. with repeated doses
Calcitonin	Increases calcium excretion Decreases Ca reabsorption	Onset: 1 – 4 h Duration: 6 – 12 h	4 - 8 IU/Kg q12h SQ/IV	Safe Tachyphylaxis limits use
Furosemide	Increases urinary Ca excretion	Onset: 5 - 30 mins Duration: 2 - 6 h	20 – 40 mg IV q12 – 24 h	No longer 1st line Rx, Use only after hydration, Useful in volume overload, heart failure
Corticosteroids	Inhibit cytokine mediated inflammation, vit D analog	Onset: 1-5 d Duration: 2-4 wks.	Prednisone 40-60 mg/d	Useful in lymphoma, granulomatous disease

Tachyphylaxis:

Definition:

rapid development of tolerance or immunity to the effects of a drug

Denosumab

- Bisphosphonate refractory HCM or renal impairment
- Human monoclonal antibody
- Inhibits formation, function, survival of osteoclasts
- 120mg every four weeks
- Nausea, dyspnea, headache, edema, vomiting

Total vs Ionized?

Corrected Calcium = Calcium + 0.8(4.0-Albumin)

Calcium

Hyperalbuminemia

Hypoalbuminemia

Chronic Kidney Disease

Ionized

$$$$$$$$$$$$$$$$$$$$$$$$$

Acid Base disorders

Hyperparathyroidism

Hyperphosphatemia

Mr. Sweaty

PMH
Diabetes
Chronic Kidney Disease

PSH:
Appendectomy

SOCIAL HISTORY:
Single. Significant alcohol and tobacco use.

MEDS:
NPH 15u BID, ASA 325mg Qday, Metoprolol 50mg BID, Norvasc 5mg BID

ROS:
Nausea, vomiting, weight loss. Night sweats.

ADMIT LABS

Lab	Admission
Hemoglobin	8.2
WBC	1,900
Platelets	54,000
Sodium	133
Potassium	6.3
Bicarbonate	23
Creatinine	1.5
LDH	645
Phosphorus	8.6
Calcium	6.8
Uric Acid	9.6

Tumor Lysis Syndrome

- Caused by massive release of intracellular contents by cancer cells, either spontaneously or after tumor death with recent chemotherapy
- More commonly seen in aggressive hematologic malignancies i.e. high grade lymphoma, acute leukemia
- Also seen after treatment of active solid tumors, i.e. small cell lung cancer, germ cell tumors and melanomas
- Severe metabolic derangements may be life threatening

Cairo-Bishop classification

LABORATORY TUMOR LYSIS SYNDROME
Uric acid ≥ 8mg/dL (≥ 476µmol/L) or 25% increase from baseline
Potassium ≥ 6mEq/L (≥ 6mmol/L) or 25% increase from baseline
Phosphorus ≥ 6.5mg/dL (≥ 2.1mmol/L) or 25% increase from baseline
Calcium ≤ 7mg/dL (≤ 1.75mmol/L) or 25% decrease from baseline

CLINICAL TUMOR LYSIS SYNDROME
Creatinine > 1.5 times the upper limit of normal
Cardiac arrhythmia or sudden death
Seizure

Why emergency?

Hyperuricemia

- Uric acid can crystallize in renal tubules and lead to acute renal failure

Hyperkalemia

- Life-threatening arrhythmias

Hyperphosphatemia

- Leads to hypocalcemia, tetany, seizures, arrhythmias

ADMIT LABS

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Creatinine	1.5
LDH	645
Phosphorus	8.6
Calcium	6.2
Uric Acid	9.6

Problem	Intervention	Dosage	Comments
Renal insufficiency	IV fluids	Normal saline, 3L/m2 daily	Caution if history of CHF
Hyperuricemia	Allopurinol (xanthine oxidase inhibitor) inhibits uric acid production Rasburicase (recombinant urate oxidase) Converts uric acid into water soluble allantoin	100 mg/m2 divided in 3 doses (every 8 hours) Commonly 600 mg initially followed by 300 mg/d (prophylaxis) IV 0.15-0.2 mg/kg/d (can be given up to 5 days)	Reduce dose in renal failure. Only effective in prophylaxis. Not recommended if uric acid level above 7.5 mg/dl For severe hyperuricemia. Contraindicated in pregnancy, G6PD deficiency Expensive
Hyperphosphatemia	Phosphate binders Dialysis	50-150 mg/kg daily	Low phosphorus diet Dialysis if refractory to therapy
Hyperkalemia	Insulin (Regular) Dextrose (50%) Calcium gluconate (10%) Kayexalate Sodium bicarbonate Albuterol Dialysis	10 units IV 5 ml Dextrose 50% IV push 1000 mg IV 20 mg nebulized	If hyperkalemic ECG changes Dialysis if refractory to therapy
Hypocalcemia	Calcium gluconate (10%)	1000 mg IV (no faster than 200mg IV/minute)	Use only if symptomatic, Caution with severe hyperphosphatemia

Questions?

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