APPENDIX D: PBL Questions and Answers

Fluids, Electrolytes and Acid/Base Balance

PROBLEM 1
Vomiting with Dehydration

A 45 year old man with previously known duodenal ulcer disease presents with complaints of persistent vomiting for the past 36 hours. The vomit is clear-looking and acidic in taste. He has no abdominal pain. Prior to the vomiting, he had difficulty with solid foods causing "fullness" in the stomach and he had been taking only liquids for one week. His heartburn had been aggravated at the time of the "fullness", but antacids did not help and he did not seek medical attention until today. He complains of being dizzy when he stands up. His blood pressure changes from 120/70 when lying to 105/55 when standing, his pulse changes from 100 to 130.

Study Questions:

1. What is the electrolyte composition of gastric contents?
   Na+ 20-120 mEq/L; Cl- 130 mEq/L; K+ 10-15 mEq/L; HCO3- (-); H+ 30-100 mEq/L (KEY CONCEPT: high in Cl-, K+, H+; can rationalize the type of acid-base disturbance observed based on this knowledge)

2. What is the most likely acid-base disturbance in the patient?
   Hypochloremic, hypokalemic metabolic alkalosis

3. What percentage of intravascular volume has been lost?
   Orthostatic--can relate analogously to Class II type shock (15-30% volume loss)--can also see decreased pulse pressure
   Class I shock: typically see no physical exam changes.
   Class III: (30-40%)-marked tachycardia, decreased systolic blood pressure, and oliguria
   Class IV: (>40%)-significantly decreased systolic BP, severe oliguria/anuria; imminently life threatening

4. What intravenous fluid would be most likely to correct the acid/base and volume deficit?
   0.9% NaCL (also replete K+ separately)--leads to decreased reabsorption and increased excretion of HCO3 – Na/HCO3 cotransporter in prox tubules (3:1 ratio) – therefore by replacing sodium with volume you decrease the HCO3 reabsorption here.

5. How much would be needed to replace the intravascular volume deficit?
   TBW=60% (body Weight)
   TBW=2/3 Intracellular Volume (40%); 1/3 Extracellular Volume (20%)
   Extracellular Volume=3/4 Interstitial Fluid; ¼ Plasma Volume (4-5%) of TBW

   In 70 Kg man, the plasma volume is thus about 3 - 3.75 L. (appr. 2L RBC)

   A loss of blood volume of 30% corresponds to an approximate 1.5 L loss (assuming 5L blood volume): 14 L is the Extracellular Volume in a 70-kg person.

   1.5 L x 14 L/3.75 L = 5.6 L

   OR

   Volume deficit = blood volume (66mL/kg males, 60mL/kg females) X %loss BV
   Resuscitation volume = VD x 4
6. What would be the sodium, potassium, and hydrogen ion concentration in the urine (normal, high, low for each)?
Na+ low, K+ high (aldosterone effects); H+ high (paradoxical aciduria)--this latter occurs as hypokalemia worsens and the kidneys try to preserve K+ in exchange for excreting H+.

7. What is the most likely underlying diagnosis?
Gastric outlet obstruction from stricture. Should get EGD/swallow to diagnose once resuscitated.

PROBLEM 3
Excessive Ileostomy Output and Dehydration

A 36 year old man has undergone a total colectomy and proctectomy for ulcerative colitis two years previously, and has an ileostomy which usually drains about 800 cc per day. Two days before coming to the hospital he developed crampy abdominal pain, bloating, and began draining large quantities of liquid from his ileostomy. Because of nausea and two episodes of vomiting he did not take any food or liquids over the past 24 hours.

Study Questions:

1. What is the usual amount of ileum output into the colon each day?
   1-3 L

2. What are the electrolytes of ileostomy output?
   New ostomy: Na+ 130, K+ 20, Cl- 110, HCo3 30
   Adapted ileostomy: Na 50, K+ 5, Cl- 30, HCO3 25
   LR – Na 130, Cl 109, lactate 28, 4mEq K, 3mEq Ca
   pH = 6.5, but is an alkalizing solution (because lactate is converted to bicarb)

3. What would be physical examination evidence of dehydration?
   Dry mucous membranes, tachycardia, low urine output, decreased pulse pressure/systolic pressure (more extreme)

4. What laboratory tests would you order to assess the degree of dehydration and what alterations would you expect?
   Panel 7 (increased BUN/Cr ratio)
   Urine electrolytes (FeNA)--<1%

5. What intravenous fluid would you administer to replace the ileostomy output?
   LR or D51/2 NS c 20 K
PROBLEM 5
Measurement of Fluid Balance

A 65 year old 70 kg man with known congestive heart failure treated with digoxin and a diuretic undergoes an “uneventful” abdominal aortic aneurysm repair with 1,000 cc of blood loss. During the four hours of surgery he is administered 4,000 cc of lactated Ringer's solution. During his first eight hours after surgery he is administered 1,000 cc of lactated Ringer's, has made 250 cc of urine and has drained 200 cc from a nasogastric tube.

Study Questions:

1. **What methods would you use to evaluate the intravascular volume status in this patient eight hours after surgery?**
   BP, HR, Urine output, CVP, SG catheter, Urine electrolytes (FENA), physical exam findings -edema etc. Can also consider bedside echo to evaluate right heart filling and IVC collapse.

2. **What is considered an adequate urine output for this patient?**
   0.5-1 cc/kg/hr

3. **What methods could you use to evaluate the total body fluid status of this patient?**
   Physical exam—edema, Serum Na

PROBLEM 8
Hyponatremia

A 55 year old woman with alcoholic cirrhosis and ascites is admitted for upper intestinal bleeding. Upper endoscopy reveals gastritis which is not actively bleeding. She is admitted and given an intravenous of 5% dextrose and 0.2% NaCl at 125 cc/hr. Over the next 24 hours her abdomen becomes tense and her urine output is 15 to 20 cc per hour. Her serum sodium has decreased from 132 on admission to 122 and she is less responsive to verbal stimuli.

Study Questions:

1. **What are possible etiologies of hyponatremia?**
   Pseudohyponatremia (protein, lipids)
   Dilutional hyponatremia (hyperglycemia, mannitol)
   True Hyponatremia--
   Decreased ECF volume: (plasma, GI skin, renal losses)
   NI ECF volume: (SiADH, psychogenic, hypothyroidism, hypoadrenalism)
   Expanded ECF volume: CHF, cirrhosis, nephritic syndrome, malnutrition

2. **What is the most likely etiology in this patient?**
   Cirrhosis (expanded ECF volume)

3. **What happens to urine sodium concentrations with the several etiologies listed above?**
   Psychogenic (100)
   SiADH (>100)
   Heart Failure (Low Urine Na+)
   Renal Failure (High Urine Na+)

4. **What is the treatment of hyponatremia in this patient?**
   Free water restrict; + Na restrict (loop diuretic)
PROBLEM 12
Acute Renal Failure

A 64 year old man has surgical resection of an abdominal aortic aneurysm with graft interposition. The operation is difficult and six units of packed cells are infused during the surgery. The patient’s blood pressure twice fell to 70 systolic during the four-hour operation. Eight liters of crystalloid were administered, 500 cc of fresh frozen plasma, and 1,000 cc of Hetastarch. The patient came to the intensive care unit with a systolic blood pressure of 60 mmHg. Three additional units of blood were given before his pressure is over 100 mmHg systolic. The patient made 100 cc of urine output during the case but in the ICU is noted to be oliguric, with 5 to 10 cc of urine output during the first four postoperative hours. Mannitol, which was given in the operating room, was repeated with no increase in urine output. During the next twelve hours six liters of crystalloid and 500 cc of packed red cells are administered resulting in 75 cc of dark yellow urine. By this time his hemoglobin and hematocrit have stabilized at 9.6 gms and 27.8%.

Laboratory values are:

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<th>Parameter</th>
<th>Value</th>
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<tr>
<td>WBC</td>
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<tr>
<td>BUN</td>
<td>55 mg/dl</td>
</tr>
<tr>
<td>Creatinine</td>
<td>2.1 mg/dl</td>
</tr>
<tr>
<td>Na+</td>
<td>134 mEq/1</td>
</tr>
<tr>
<td>K+</td>
<td>5.8 mEq/1</td>
</tr>
</tbody>
</table>

Urinalysis:

- sp. gr. 1.010
- urine osmolarity 300 mOsm/L
- 0 rbc/hpf
- 0 wbc/hpf
- 0 pigmented granular casts
- protein 2+
- urine Na+ 45 mEq/1

Study Questions:

1. What is the differential diagnosis of the oliguria? The most likely diagnosis?
   Pre-renal; Intra-renal; Post-renal

2. What is the most likely etiology?
   ATN

3. What is the natural history of this disease?
   The disease typically lasts 1-3 weeks as tubular cells regenerate after ischemic insult, but course may be quite variable depending upon extent of initial insult.

4. What are the principles of management of this disease?
   IV hydration
   Cease nephrotoxic drugs
   Optimize oxygen delivery to organ systems
   Potentially Dialysis

5. Instead of recovering, this patient develops aspiration pneumonia in the intensive care unit, progresses to multi-system organ failure, and expires on post-op day 17. This patient’s case is presented at the weekly morbidity and mortality conference, and the attending comments that this patient had a high expected mortality, so it shouldn’t have an impact on the hospital’s O/E ratio. What does he mean by the “O/E” ratio? How is this metric used?
   The “O/E” ratio is the “Observed to Expected” mortality rate. It is a risk-adjusted measure of a hospital’s mortality rate, and is used as a metric of the quality of care that a hospital provides. The “observed” component is the actual number of patients that died in a certain hospital in a given period of time. The “expected” component is the expected average of hospitalized patient deaths with a particular condition (or who underwent a certain operation) adjusted for comorbidities. An O/E=1 means that the observed=expected. An O/E<1 means the hospital is doing better than expected (fewer people are dying than are expected to.) An O/E >1 means that a hospital is doing worse than expected (more people are dying than are expected to.)

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