Urine Analysis to Detect Hypovolemia

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Plan

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  - Types of hypovolemia
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Introduction -1

- **Definition:** Decreased effective circulating blood or plasma volume due to excessive bleeding, diarrhea, vomiting or loss of plasma.
- = Extracellular or salt-loss dehydration / volume depletion

Introduction -2

- Main cause of fluid shortage: Increased fluid loss
- BOTH fluid and electrolyte depletion
- Decreased body fluids
- Serum osmolality: Stable or decrease slightly

Introduction -3

- Hypovolemia → Sustained vasoconstriction → Perfusion of vital organs (heart & brain) → Expense of other organs (gut, liver, kidneys)
- Severe protracted hypovolemia: Impairment in systemic perfusion and microcirculation → Progressive tissue damage → Multiple organ failure

Introduction -4

Types of Hypovolemia

- ***Absolute hypovolemia***
  - Gastrointestinal: Vomiting, diarrhea, bleeding, external drainage
  - Renal: Diuretics, osmotic diuresis, salt-wasting nephropathies
  - Skin: Sweat, burns, others
- ***Relative hypovolemia***
  - Third-space sequestration: Intestinal obstruction, crush injury, burns, fractures, acute pancreatitis, sepsis, liver disease, heart failure, anaphylaxis

Signs and Symptoms -1

- Initial symptoms of hypovolemia:
  - Dry mucous membranes
  - Loss of skin elasticity
  - Thirst
  - Oliguria

Signs and Symptoms -2

- Signs and symptoms of severe hypovolemia:
  - Peripheral cyanosis, cold and clammy extremities
  - Changed level of consciousness or alertness
  - Chest pain/tightness/pressure
  - Palpitations, tachycardia
  - Tachypnea
  - Decreased pulse pressure, hypotension
  - Decreased jugular venous pressure
  - Anuria

Diagnostic Workup -1

- **Hypovolemia** – A clinical diagnosis
  - **Bedside ultrasound**
  - **Central venous pressure**

Diagnostic Workup -2

- **Serum Sodium Concentration**
  - Primary water loss (insensible losses or diabetes insipidus) → Hypernatremia
  - Salt and water loss → Volume depletion → Release of ADH → Water retention → ≈ Hyponatremia

Diagnostic Workup -3

- **Acid Base Balance:**
  - Normal extracellular pH / metabolic alkalosis / metabolic acidosis
    - Vomiting, nasogastric suction, diuretics → Hydrogen ion loss → Metabolic alkalosis
    - Diarrhea → Bicarbonate loss → Metabolic acidosis
    - + Shock → Lactic acidosis

Diagnostic Workup -4

- **Hematocrit and serum albumin concentration:**
  - RBCs and albumin: Limited to the vascular space
  - Reduction in the plasma volume → Elevation in the hematocrit (relative polycythemia) and serum albumin concentration
  - ‘Underlying hypoalbuminemia and/or anemia’

Diagnostic Workup -5

- **Blood Urea Nitrogen (BUN) and Serum Creatinine (Cre_s):**
  - Normal BUN/Cre_s: 10:1.
  - Hypovolemia → increased urea reabsorption → elevation in BUN/Cre_s
  - Urea reabsorption: Linked to the reabsorption of sodium and water.
  - Increased sodium reabsorption → Increased urea reabsorption → Decreased urea excretion & elevation of BUN/Cre_s (Frequently to >20:1)

Diagnostic Workup -6

Urinary Tests

- **Urine Specific Gravity and Urine Osmolality**
- **Urine Sodium Concentration and Fractional Excretion of Sodium**
- **Fractional excretion of Urea and Chloride**
- **Urine Sediment Microscopy**

Diagnostic Workup -7

- **Urine Specific Gravity and Urine Osmolality**
  - **Urine Specific Gravity**
  - The density of urine relative to the density of water
  - Normal range: 1.005 to 1.030

Diagnostic Workup -8

- **Urine Specific Gravity and Urine Osmolality**
  - **Urine specific gravity** >1.030 ≈ hypovolemia
  - Urine specific gravity: Affected by the number and size of particles
  - Large molecules invalidate the results.
  - **Urine osmolality:** More accurate

Diagnostic Workup -9

- **Urine Specific Gravity and Urine Osmolality**
  - **Urine Osmolality**
  - Normal range: 50 to 1200 mosm/kg
  - >500 mOsm/kg ≈ hypovolemia
  - Impaired concentrating ability: Osmolality may not rise as expected
    - Kidney disease, diuretics, osmotic diuresis, diabetes insipidus
  - **High urine osmolality ≈ Hypovolemia**
  - **Isosmotic urine does not exclude hypovolemia.**

Diagnostic Workup -10

- **Urine Na Concentration and Fractional Excretion of Na**
  - **Urine Na Concentration**
  - Low urinary Na: Common in hypovolemic patients
    - Kidneys attempt to conserve Na and water to expand the extracellular volume.
  - Urine sodium concentration in hypovolemia: <20 mEq/L
    - May be as low as 1 mEq/L.

Diagnostic Workup -11

- **Urine Na Concentration and Fractional Excretion of Na**
  - **False (+)s of Low Urine Sodium Concentration**
    - ATN → Impaired concentrating ability → Decreased water reabsorption → Dilution → Lower urine sodium concentration
    - Heart failure, cirrhosis, nephrotic syndrome

Diagnostic Workup -12

- **Urine Na Concentration and Fractional Excretion of Na**
  - **False (-)s of Low Urine Na Concentration**
    - Salt-wasting states (diuretics, underlying kidney disease)
    - Selective renal ischemia (acute glomerulonephritis, bilateral renal artery stenosis)
    - Accompanying high rate of water reabsorption
    - Excretion of Na with an anion
      - Metabolic alkalosis → High filtered bicarbonate load
      - The urine chloride concentration remains <20 mEq/L.

Diagnostic Workup -13

- **Urine Na Concentration and Fractional Excretion of Na**
  - **Fractional excretion of sodium (FENa)**
  - An alternative to the urine Na concentration
  - FENa **<1% ≈ volume depletion**

Diagnostic Workup -14

- **Urine Na Concentration and Fractional Excretion of Na**
  - **Limitations of Fractional Excretion of Na**
  - Same as urine Na concentration
    - Not affected by changes in urine volume
    - Diuretics
      - Fractional excretion of urea: <35% in hypovolemia

Diagnostic Workup -15

- **Urine Sediment Microscopy**
  - Not helpful in hypovolemia
  - Urine color, pH, glucose etc.: No use
  - Urine color: Affected by lots of substances
  - pH and glucose: Measure in blood sample

Take Home Messages

- Hypovolemia is a clinical diagnosis.
- No fully reliable urinary test exists.
- Urine specific gravity greater than 1.030
- Urine osmolality greater than 500 mOsm/kg
- Urine sodium/chloride concentration less than 20 mEq/L
- Fractional excretion of sodium less than 1%
- Fractional excretion of urea less than 35%

suggest hypovolemia.

- Urine microscopy, color, pH, glucose etc. are not helpful.

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