Chapter 21
Approach to Polyuria in the ICU

21.1 Introduction

Polyuria, defined as urine output exceeding 3 L per day in adults, is a significant concern in critically ill patients. It can lead to dehydration, electrolyte imbalances, and hemodynamic instability, complicating the management of patients in the Intensive Care Unit (ICU). Polyuria may result from various etiologies, including endocrine disorders, renal dysfunction, fluid imbalances, or as an adverse effect of medications.

A systematic approach to diagnosing and managing polyuria is essential to prevent complications and improve patient outcomes. A critical aspect of this evaluation is classifying polyuria based on urine osmolality, which helps differentiate between water diuresis, solute diuresis, and mixed diuresis. This classification guides further diagnostic testing and management strategies [1, 2] [Ref: Algorithm 21.1].

21.2 Classification of Polyuria Based on Urine Osmolality

1. Water Diuresis (Urine Osmolality<150 mOsm/kg)
2. Solute Diuresis (Urine Osmolality>300 mOsm/kg)
3. Mixed Diuresis (Urine Osmolality 150–300 mOsm/kg)

Diagnostic Approach

1. **Initial Assessment**

- Hemodynamic Stability:
- Assessment: Check for signs of hypotension, tachycardia, or hypovolemia.
- If Unstable:
- Initiate immediate resuscitation with isotonic intravenous fluids (e.g., 0.9% normal saline).

S. B. Mishra et al., *Mastering ICU Care*,
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- Monitor serum sodium and osmolality closely to prevent rapid shifts that can lead to osmotic demyelination or cerebral edema.
- If Stable:
- Proceed with a detailed evaluation of urine output and laboratory investigations.

2. **Quantify Urine Output**

- Urine Output >250 mL/h:
- Confirm polyuria by measuring urine output over several hours.
- Rule out common causes such as excessive fluid administration or diuretic use.

3. **Immediate Laboratory Tests**

- Urine Osmolality:
- <150 mOsm/kg: Suggests water diuresis.
- 150–300 mOsm/kg: Indicates mixed diuresis.
- >300 mOsm/kg: Consistent with solute diuresis.
- Serum Osmolality and Electrolytes:
- Evaluate serum sodium, potassium, calcium, glucose, blood urea nitrogen (BUN), and creatinine.
- Assess plasma osmolality to determine the gradient driving water movement.
- Serum and Urine Glucose:
- Rule out hyperglycemia-induced osmotic diuresis.
- Serum Copeptin Levels:
- Copeptin is a stable surrogate marker for vasopressin (antidiuretic hormone, ADH) and aids in differentiating between CDI and NDI.

4. **Interpretation Based on Urine Osmolality**

A. **Water Diuresis (<150 mOsm/kg).**
Possible Causes:

- Central Diabetes Insipidus (CDI): Deficiency in ADH production.
- Nephrogenic Diabetes Insipidus (NDI): Renal resistance to ADH.
- Primary Polydipsia: Excessive water intake suppressing ADH secretion.

Diagnostic Approach:

- Water Deprivation Test: Gradual water restriction under close monitoring to assess the ability to concentrate urine.

  CDI: Inability to concentrate urine; significant (>50%) increase in urine osmolality after desmopressin administration.
  NDI: Little to no change in urine osmolality after desmopressin.
  Primary Polydipsia: Gradual increase in urine osmolality during deprivation; partial response to desmopressin.

- Copeptin Measurement:

  Low Copeptin Levels: Suggest CDI.
  High Copeptin Levels: Suggest NDI.

- MRI Imaging:

  Perform MRI of the brain to identify structural abnormalities in the hypothalamic-pituitary axis in suspected CDI.

B. **Solute Diuresis (>300 mOsm/kg)**
Possible Causes:

- Hyperglycemia: Uncontrolled diabetes mellitus leading to glucose-induced osmotic diuresis.
- Mannitol Administration: Osmotic diuretic used in cases of increased intracranial pressure.
- High-Protein Diets/Urea Diuresis: Common in ICU patients receiving enteral or parenteral nutrition.
- Radiocontrast Agents: Can cause osmotic diuresis post-imaging studies.

Diagnostic Approach:

- Measure Serum Glucose:

  Hyperglycemia requires prompt insulin therapy to reduce glucose levels and osmotic diuresis.

- Medication Review:

  Identify and adjust medications like mannitol or diuretics contributing to solute diuresis.

- Electrolyte-Free Water Clearance:

Calculation:
Osmolar Clearance (Cosm) : C = UV/P
Free Water Clearance (C) : CH2O = V × [1 − (Uosm/Posm)]
Electrolyte − Free Water Clearance : E — Ch2O = VE — Cosm
V—Total urinary volume per unit time, U—Urinary concentration of the substance, P—plasma concentration of the substance, Uosm—Urine osmolality, Posm—Plasma osmolality.

Clinical Application:

- Guides fluid management in patients with hypernatremia due to osmotic diuresis.
- Aids in preventing rapid correction of sodium levels, which can be harmful.

Management of Iatrogenic Causes:

- Adjust nutritional support to prevent excessive protein intake.
- Limit use of osmotic agents when possible.

C. **Mixed Diuresis (150–300 mOsm/kg).**
Possible Causes:

- Partial Diabetes Insipidus: Partial deficiency or resistance to ADH.

- Concurrent Solute Overload with Water Diuresis: Combination of factors causing both solute and water loss.

Diagnostic Approach:

- Detailed History and Examination:
- Assess for conditions that may cause partial DI or solute overload.

Laboratory Evaluation:

- Evaluate serum and urine electrolytes, glucose, and other solutes.
- Assess for medications or conditions contributing to mixed diuresis.

Water Deprivation Test and Copeptin Levels:

- May help identify partial CDI or NDI.

5. **Common ICU Causes of Polyuria**
   - Resolving Acute Tubular Necrosis (ATN):
     - Description: During the diuretic phase of ATN recovery, patients may have high urine output.
     - Management: Careful fluid and electrolyte replacement to match losses.
   - Post-Obstructive Diuresis:
     - Description: Significant diuresis following relief of urinary tract obstruction.
     - Management: Monitor and replace fluid and electrolyte losses to prevent hypovolemia.
   - Medication-Induced Diuresis:
     - Description: Use of diuretics or other medications leading to increased urine output.
     - Management: Review and adjust medications as necessary.
6. **Further Diagnostic Tests**
   - Hypertonic Saline Infusion Test:
     - Purpose: Assesses arginine vasopressin (AVP) release in response to increased plasma osmolality.
     - Usefulness: Helps distinguish between CDI and NDI when the water deprivation test is inconclusive.
   - MRI Imaging:
     - Purpose: Detects structural abnormalities in the hypothalamus or pituitary gland in suspected CDI.
   - Renal Function Tests:
     - Purpose: Evaluate for intrinsic renal diseases contributing to polyuria.

7. **Management Tailored to the ICU Setting**

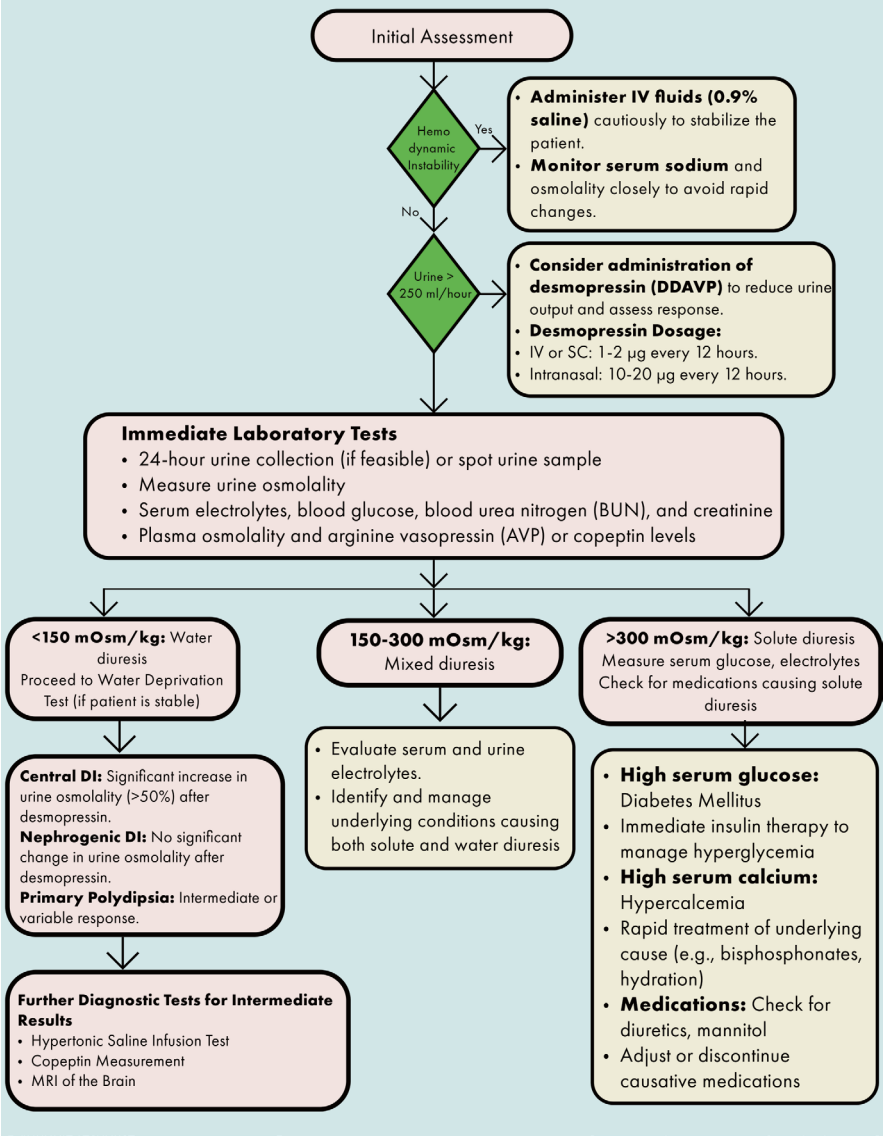
- Fluid Balance:
  - Monitoring: Accurate recording of intake and output is essential.
  - Adjustment: Modify fluid administration to match losses, prevent dehydration, and maintain hemodynamic stability.
- Medication Adjustments:
  - Review: Identify and modify medications contributing to polyuria.
  - Desmopressin Administration:
  - Indication: Used in CDI to reduce urine output.
- Dosage:
  - IV or SC: 1–2 μg every 12 h.
  - Intranasal: 10–20 μg every 12 h.
  - Monitoring: Observe for response and monitor for hyponatremia.
  - Electrolyte and Osmolality Monitoring:
  - Frequency: Regular checks of serum electrolytes and osmolality.
  - Goal: Detect and correct imbalances promptly; avoid rapid sodium correction.
- Nutritional Support:
  - Adjustment: Modify protein intake to prevent urea-induced osmotic diuresis.
  - Balance: Ensure appropriate caloric and electrolyte intake.
- Patient Safety:
  - Prevent Complications: Implement measures to avoid hypotension, acute kidney injury, and electrolyte disturbances.
  - Education: Inform the healthcare team about the importance of monitoring and timely intervention.

21.3 Conclusion

Managing polyuria in the ICU requires a thorough and systematic approach to diagnose and treat underlying causes promptly. Classifying polyuria based on urine osmolality into water diuresis, solute diuresis, or mixed diuresis is fundamental in guiding further investigations and management. Essential diagnostic tools include urine and serum osmolality measurements, water deprivation tests, copeptin levels, and imaging studies.

Tailored management strategies in the ICU emphasize fluid balance, careful monitoring of electrolytes and osmolality, medication adjustments, and addressing the underlying cause. Early recognition and appropriate intervention are crucial to prevent complications such as dehydration, electrolyte imbalances, and hemodynamic instability, ultimately improving patient outcomes in the critical care environment.

Algorithm 21.1 Approach to polyuria in the ICU



Bibliography

1. Lamas C, del Pozo C, Villabona C. Clinical guidelines for management of diabetes insipidus and syndrome of inappropriate antidiuretic hormone secretion after pituitary surgery. Endocrinol Nutr. 2014;61(4):e15–24.
2. Ramírez-Guerrero G, Müller-Ortiz H, Pedreros-Rosales C. Polyuria in adults. A diagnostic approach based on pathophysiology. Rev Clin Esp (Barc). 2022;222(5):301–8.