CHAPTER 11

PERIANESTHESIA FLUID MANAGEMENT AND RESUSCITATION

Barbara Godden MHS RN CPAN CAPA

Purpose: The perianesthesia nurse will demonstrate knowledge in normal physiology of body water, dynamics of fluid distribution, general fluid imbalances, fluid spacing, perioperative alterations in physiology and nursing assessments and considerations. The perianesthesia nurse will also correctly compute fluid needs and replacement for patients undergoing various surgical procedures.

Competency Statement: The perianesthesia nurse will provide correct and appropriate fluid management and resuscitation for the patient in the perianesthesia period.

Criteria:

1. Explain normal fluid physiology of the body.[1, 2]

Function of Body Fluid

- Transport nutrients and gases through the body
- Help regulate body temperature
- Carry waste to excretion
- Maintain cell shape

Total Body Water (TBW)

- Adults 50-70% of body weight, dependent upon fat ratio, age and sex
- Muscle mass water content is 75%; fat water content is 10%
- Females generally have less water than males
- TBW decreases with aging because adipose tissue replaces muscle mass
- Children: 75-80% of body weight at birth, drops to adult level by age one (1)

Distribution of Water: Two (2) compartments

- Intracellular (ICF): Fluid inside the cells, 25 Liters, 40-55%
- Extracellular (ECF): Fluid outside the cells, 20-35% adult; 20-25% older child

Distribution occurs in three (3) distinct areas:

  - Intravascular: Plasma volume
  - Interstitial: Fluid within an organ or tissue, located between the cells; 12 liters
  - Transcellular: Fluid present in the viscera, nonfunctional, such as CSF, intraocular fluid, gastric fluid

Composition of fluids includes:

- Electrolytes
  - Cations: ICF: Potassium (K^+), Magnesium (Mg^{2+})
    ECF: Sodium (Na^+), Calcium (Ca^{2+})
  - Anions: ICF: Hydrogen phosphate (HPO_4^-)
    ECF: Chloride (Cl^-), Bicarbonate (HCO_3^-)
- Acids, Bases, Salt Buffers
  - pH regulators for Acid-Base balance

Dynamics

- Diffusion: Particles in a fluid move from an area of higher concentration to an area of lower concentration until the concentration of particles is equal (gas or liquid). Little or no energy is required
- Osmosis: Movement of water through a semi-permeable membrane from an area of lesser concentration to an area of higher concentration. The rate of osmosis depends on the concentration of the solute, the temperature of the solution, the electrical charge of the solute and the difference between the osmotic pressures exerted by the solutions. Movement continues across the membrane until the concentrations of the solutions equalize
- Osmotic pressure: The pressure exerted during osmosis
- Osmolality: The osmotic pressure of a solution expressed in osmols or milliosmols per kilogram of water
  - Normal adult serum osmolality is 270-300 mOsm/kg of water

- Osmolarity: The osmotic pressure of a solution expressed in osmols or milliosmols per liter of the solution
  - Isotonic solutions: ECF concentration = ICF concentration
    Do not affect the cell size
    240-340 mOsm/L
    0.9 NS, LR, $D_5$1/4NS
  - Hypertonic solutions: ECF concentration > ICF concentration
    Cause water to move out of the cell
    340 or greater mOsm/L D_5LR, $D_5$1/2, D_{10}W
  - Hypotonic solutions: ECF concentration < ICF concentration
    Cause water to move into the cells
    Less than 240 mOsm/L
    0.45 NS, D_5W
    (In the IV bag D_5W is Isotonic; in the body D_5W is Hypotonic; D_5W=252 mOsm)
- Active Transport: The movement of materials across a cell membrane by means of chemical activity that allows the cell to admit otherwise impermeable molecules against a concentration gradient. Active transport is the means by which the cell absorbs glucose and other substances needed to sustain life and health. Certain enzymes such as adenosine triphosphate (ATP) provide a chemical pump to help move substances across the membrane. Movement occurs from a lower concentration to a higher concentration, requiring the expenditure of energy
- Filtration: The transfer of water and dissolved substances across a pressure gradient through a permeable membrane from a higher to a lower pressure. Water is forced across the thin capillary membranes into the interstitial space

2. Discuss fluid imbalances that can occur in the body, including hypovolemia and hypervolemia.[1-4]

There are two types of fluid imbalances that can occur in the body. These are hypovolemia (extracellular fluid deficit) and hypervolemia (extracellular fluid excess).

Hypovolemia (ECF deficit): Occurs when the fluid shifts from the plasma to the interstitium.

Causes:

- A decrease in fluid intake
  - Nothing by mouth (NPO) – for surgery or for lab and diagnostic testing
- Acute loss of fluids
  - Hemorrhage
  - Third spacing
  - Trauma or burns
  - Surgery (trauma)
  - Shock
  - Diuretics
  - Ketoacidosis
  - Diabetes insipidus
  - Wound/fistula drainage
  - Diarrhea
  - Vomiting
  - Intestinal obstruction
  - Prolonged fever
  - Central nervous system (CNS) disorders

- Nasogastric suction
- Laxatives/enemas/bowel preps
- Alcoholism due to poor nutritional status
- Many elderly have altered fluid status due to poor nutritional intake
- Stress
- Vigorous exercise (e.g., 500 ml/hour can be lost during extreme sweating)

Signs and Symptoms:

- Weight loss
- Thirst
- Dry skin and mucous membranes
- Longitudinal furrows in tongue
- Fatigue
- CNS changes
- Decrease in, or absence of, tears
- Increased pulse and respirations
- Decreased blood pressure (especially orthostatic changes)
- Decreased central venous pressure (CVP)
- Decreased urine output/increased specific gravity
- Hemoconcentration (elevated hematocrit)
- Sunken anterior fontanelle in infants

Significance:

- Decreased cardiac output, causing poor perfusion to the brain, kidneys and liver
- Tubular necrosis, renal failure if hypovolemia is severe
- Infants and young children are especially susceptible to fluid imbalances. An infant has a daily water turnover of 25% of their TBW. Adults have a daily water turnover of about 6%

Treatment:

- Treat the underlying cause
- Isotonic fluids

Hypervolemia (ECF excess): Occurs when the fluid shifts from the interstitium to the plasma

Causes:

- Increased oral (po)/IV intake
- Excess sodium intake
- Excess sodium retention
- Increased aldosterone level
- Congestive heart failure (CHF)
- Cirrhosis
- Acute or chronic renal failure
- Remobilization of third (3rd) space fluids

Signs and Symptoms:
- Hemodilution
- Peripheral edema
- Increased blood pressure
- Bounding pulse
- Increased CVP/pulmonary artery (PA) pressures
- Dyspnea/rales (late signs)
- Pleural effusion
- Confusion

Significance:
- Can lead to circulatory overload/CHF
- Can lead to respiratory compromise/pulmonary edema

Treatment:
- Treat the underlying cause
- Give diuretics
- Put patient on fluid restriction

3. Describe fluid spacing.[1, 2, 3]

There are three types of fluid spacing:

First (1st) Spacing: Normal distribution of body fluids

Second (2nd) Spacing: Excess fluid accumulation in the interstitium (edema)

Third (3rd) Spacing: Fluid accumulation from the vascular space/plasma (ECF) into an area normally having minimal to no fluid. Also described as sequestration of fluid into the interstitial space or a body cavity. Generally not visible, causing potential for increased consequences. 3rd spacing can have multisystem involvement or can be localized to a single area or organ. Some 3rd spacing occurs even in simple, uncomplicated surgical procedures

Causes of 3rd spacing include:
- Decrease in plasma proteins
- Increased capillary permeability, such as would occur in direct trauma, radiation, sepsis, allergic reactions or manipulation (as in surgery)
- Lymphatic blockage: the lymph system acts as a route for excess interstitial fluid to flow back into the vascular (ECF) space

Phases of 3rd Spacing: Phase I and Phase II

Phase I Definition: Fluid loss phase
- Occurs immediately after surgery or massive trauma
- Lasts 48–72 hours
- During this phase, there is increased capillary permeability and the fluid and proteins leak into areas of inflammation and trauma/surgical site
- The fluid and proteins shift from the vascular to the interstitial space, because of the fragile and leaky capillaries

Phase I Treatment and Nursing Responsibilities
- Administer fluids 200-1000 ml/hour–crystalloids (Isotonic: LR, NS; or Hypertonic: D_5LR, D_5NS), colloids (Albumin, Hespan)
- Hypertonic solutions are sometimes used prior to the induction of anesthesia to "fill up the tank"
- Isotonic solutions are often used more in the operating room to keep the blood pressure up and increase circulating volume, as the patient is vasodilated from anesthetic agents and may also be starting to "3rd space." Renal perfusion needs to be maintained

- Monitor VS, urine output (UO) and specific gravity, central venous pressure (CVP), pulmonary artery (PA), pulmonary capillary wedge pressure (PCWP) if pressure lines in place
- Monitor K^+, BUN, creatinine
- Auscultate chest for breath sounds/obtain baseline and document

Phase II Definition: Reabsorption

- Capillaries heal and normal permeability returns
- Lymph blockage clears
- Fluid volume shifts back to the vascular space and is excreted by the kidneys

Phase II Treatment and Nursing Responsibilities

- Occurs after the patient leaves the PACU
- Recognize signs and symptoms of the reabsorption phase
  - Increased urine output, decreased specific gravity
  - Output greater than input
  - Weight loss
- Monitor for circulatory overload
  - ECG changes
  - Shortness of breath (SOB)
  - Rales
  - Increased CVP
  - Distended neck veins
  - Possible electrolyte imbalances
- Patients usually unload themselves on the 3rd postop day
- Can give furosemide if severe symptoms, e.g., rales, pulmonary edema

4. Describe alterations in fluid balance that can occur in the perianesthesia period.[1-4]

Pre-existing conditions

- Related to hypovolemia and hypervolemia (as listed under criteria)

Restriction in fluid intake

Third Spacing

- Capillaries damaged from handling in surgery
- Fluid shifts into interstitium. This is fluid that is not available for normal body functions until it is remobilized 48-72 hours later

Fluid Loss during Surgery

- Blood loss
- Evaporative losses (e.g., 1-2 liters/hour of fluid can be lost to evaporation during a long open abdominal case)
- Humidification losses (mouth, ventilator)

Anesthesia

- Inhalation agents vasodilate vessels. Circulating volume is expanded. Need to "fill up the tank" to prevent hypotension upon induction
- Epidurals and spinals also vasodilate. Severe hypotension will occur if volume is not infused prior to the block
- Opioids and barbiturates stimulate ADH output
- Anesthesia also decreases urinary flow by altering renal dynamics

Inadequate Replacement

- Patients may arrive in the PACU with deficits not replaced to the full amount
- One of the most common causes of tachycardia in the PACU is hypovolemia

Stress

- Stress related to surgery, anesthesia, pain and the unknown causes an increase in ADH output

5. Discuss patient information and assessments that the perianesthesia nurse should consider when caring for patients in the postanesthesia period.[1, 2]

Patient information/report from the anesthesiologist and circulator

- Operative procedure
  - Special consideration if neurosurgical procedure: increased fluid increases cerebral edema and also increases intracranial pressure (ICP)
  - Transurethral resection of the prostate (TURP) procedures: fluid can go into cavernous spaces; be alert to the possibility of dilutional hyponatremia
- Patient history: any preexisting conditions related to fluid imbalance, especially decreased kidney or liver function, CHF, inappropriate ADH secretion or decreased activity, such as paralysis (with less activity, less calories are used; therefore, one loses less water)
- Patient medications
- Fluids given
- Estimated blood loss (EBL)
- Any active bleeding
- Vital sign course
- Urine output if urinary catheter in place

Nursing Assessments in the PACU

- Vital signs
  - Decreased blood pressure, increased heart rate and respirations can be a sign of hypovolemia
- Urine output
  - If the patient has a urinary catheter, monitor output; decreased output can be a sign of hypovolemia
  - In 3rd spacing Phase I, the urine output will be less than the fluid intake
- Monitor hemodynamic parameters if the patient has central lines
  - CVP, PA, PCWP, Cardiac Output (CO)
  - These will all be decreased if the patient is hypovolemic
- Monitor breath sounds
  - Obtain baseline upon admission to the PACU and document
  - Monitor breath sounds at regular intervals to note for any changes and document
  - Be alert to broncho-vesicular sounds, as well as rales that increase in intensity
- Monitor lab work if ordered.
  - Hemoglobin and/or hematocrit
  - Electrolytes
  - ABGs
  - Urine specific gravity
  - Serum osmolality
  - Glucose, especially in infants
- Monitor mental status.
  - Decreasing mentation can be a sign of fluid imbalance

6. Apply standard formulas to calculate the fluid needs of the perianesthesia patient.[1]

- **Adult Fluid Replacement[1,2,5]**
  - Four part formula for calculating fluid to be replaced intraoperatively

1. Deficit: Defined as the time the patient is NPO to the time surgery begins

- Formula is the maintenance rate X the number of hours the patient has been NPO
- Also account for fluid losses from NG suctioning and bowel preps

2. Maintenance: Defined as the time of incision to closure

- Based on the 4 – 2 – 1 formula
  - 4 ml/kg/hr for 0-10 kg weight
  - 2 ml/kg/hr for the next 10 kg weight
  - 1 ml/kg/hr for each kg greater than 20
- Example:
  - Weight in kg = 70
  - 4 ml/kg/hr for the first 10 kg = 40
  - 2 ml/kg/hr for the next 10 kg = 20
  - 1 ml/kg/hr for each kg greater than 20 = 50
  - 40 + 20 + 50 = 110 ml/hr
- A shortcut for patients weighing greater than 20 kg is weight in kg + 40
- Example:
  - Weight in kg = 70 + 40 = 110 ml/hr

3. Surgical losses

- Blood
  - Replace 3-4 ml crystalloid/ml blood loss or 1 ml colloid/1 ml blood loss
  - Replace blood at 1 ml/1 ml loss + crystalloid or colloid
- Evaporation from open wound
- Third-spacing from fluid redistribution

4. Estimation of Evaporation and Third-Space Losses – additional maintenance fluid based on amount of tissue trauma[3, 4, 5, 7]

- Minimal procedure, e.g., herniorrhaphy, 2-4 ml/kg/hr
- Moderate procedure, e.g., cholecystectomy, 4-6 ml/kg/hr
- Major procedure, e.g., bowel resection, 6-8 ml/kg/hr

Schedule for Replacement During the Surgical Procedure[3, 4, 5, 6, 7]

- First hour
  - ½ the deficit + maintenance + replacement for blood loss
- Second hour
  - ¼ the deficit + maintenance + replacement for blood loss
- Third hour
  - ¼ the deficit + maintenance + replacement for blood loss
- Example:
  - 80 kg patient scheduled for total hip replacement, NPO for 10 hours
  - Deficit = 10 hours NPO X 120 = 1200 ml
  - Maintenance = 120 ml/hr
  - Blood loss replacement (EBL = 300 ml) = 3 ml crystalloid X 300 = 900 ml
- 1st hour = 600 (1/2 the deficit + 120 (maintenance*) + 300 ml LR (blood loss replacement) = 1020 ml

- 2nd hour = 300 (1/4 the deficit) + 120 (maintenance*) + 300 ml LR (blood loss replacement) = 720 ml
- 3rd hour = 300 (1/4 the deficit) + 120 (maintenance*) + 300 ml LR (blood loss replacement) = 720 ml
- Total = 2460 ml

** Additional fluid may be added to the hourly maintenance to account for evaporation and tissue trauma losses*

Estimated Adult Blood Volumes

- Male = 70-75 ml/kg
- Female = 55-67 ml/kg[1]
- Crystalloids[3, 4, 6, 7]
  - Isotonic.
    - Expand ECF volume
    - Improve circulatory dynamics and renal function
    - NS, LR, $D_5$1/4NS
  - Hypertonic:
    - Shift the ECF from the interstitial space to the plasma in anticipation of 3rd spacing
    - Sodium replacement should precede potassium replacement
    - D_5LR, D_5NS, D_{10}W
  - Hypotonic:
    - Shift the ECF from the plasma into the interstitial space
    - 0.45 NS, 0.25 NS
- Blood Replacement
  - ml/ml for blood replacement + 3 ml/ml crystalloid to estimated blood loss
  - Colloids
  - Whole blood
  - Whole blood components
    - PRBCs
    - Albumin/Plasmanate
    - Fresh frozen plasma (FFP)
    - Platelets
  - Synthetic colloids[3, 4, 6]
    - Dextran
    - Hetastarch (Hespan)
- Urinary Output:

  Should range from 30-50 ml/hr to indicate adequate fluid volume and renal perfusion (or 1 ml/kg/hr of surgical time). Potassium should not be added to any IV solutions until adequate urine output is certain

Pediatric Fluid Replacement[5, 8, 9, 10]

Deficit:

Very dependent on the child's preoperative condition

A general rule is 10-20 ml/kg of isotonic solution over 1-2 hours

Hourly Maintenance Fluid Requirements for Infants and Children

BODY WEIGHT (KG)	HOURLY REQUIREMENT
1-10 kg	4 ml/kg/hr for each kg body weight
11-20 k. 11-20 kg	40 ml/hr + 2 ml/kg/hr for each kg
> 20 kg	60 ml + 1 ml/kg/hr for each kg > 20 kg

Based on 1 ml of fluid per 1 kcal of caloric expenditure

Estimated Blood Volume (EBV)

Infant 80-90 ml/kg

Child 70-80 ml/kg

Maximal allowable blood loss should not exceed 20% of EBV, depending on pre-op hematocrit[1]

Example: A 9 year old male, 31 kg, scheduled for tympanoplasty. Hourly fluids required:

1st 10 kg = 4x10 = 40 ml

2nd 10 kg = 40+2x10 = 60 ml

Last 11 kg = 60+1x11 = 71 ml

Hourly fluids required 171 ml/hr

7. Communicate and document all pertinent information per institution/unit specific policy/protocol.

References

1. Malina DP. Fluid and electrolytes. In: Odom-Forren J, ed. *Drain's PeriAnesthesia Nursing: A Critical Care Approach.* 6th ed. St. Louis, MO: Saunders; 2013:194-206.
2. Noble KA. Fluid, electrolyte, and acid-base balance. In: Schick L, Windle PE, eds. *PeriAnesthesia Nursing Core Curriculum: Preprocedure, Phase I and Phase II PACU Nursing.* 2nd ed. St. Louis, MO: Saunders; 2010:379-404.
3. Peng ZY, Kellum JA. Perioperative fluids: A clear road ahead? *Curr Opin Crit Care.* 2013; 19(4):353-358.
4. Bundgaard-Nielsen M, Secher NH, Kehlet H. 'Liberal' vs. 'restrictive' perioperative fluid therapy – A critical assessment of the evidence. *Acta Anaesthesiol Scand.* 2009; 53: 843-851.
5. Beagley L, Lopez J, eds. *Redi-Ref for Perianesthesia Practices.* Cherry Hill, NJ: ASPAN; 2010.
6. Corcoran T, Rhodes JE, Clarke S, Myles PS, Ho KM. Perioperative fluid management strategies in major surgery: A stratified meta-analysis. *Anesth Analg.* 2012; 114(3):640-651.
7. Kleespies A, Thiel M, Janch KW, Hartl WH. Perioperative fluid retention and clinical outcome in elective, high-risk colorectal surgery. *Int J Colorectal Dis.* 2009; 24:699-709.
8. American Heart Association. *Pediatric Advanced Life Support.* Dallas, TX: American Heart Association. 2012.
9. Najafi N, Veyckemans F. Belgian recommendations on perioperative maintenance fluid management of surgical pediatric population. *Acta Anaesth.Belg.* 2012; 63:101-109.
10. Schnur M, Talbot K. The pediatric patient. In: Schick L, Windle PE, eds. *PeriAnesthesia Nursing Core Curriculum: Preprocedure, Phase I and Phase II PACU Nursing.* 2nd ed. St. Louis, MO: Saunders; 2010:133-187.