Fluid Replacement Therapy
and Perioperative Management

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Objectives:

- **Physiology of body fluids**
- **Fluid therapy**
- **Fluid maintenance**
- **Fluid replacement**
- **Perioperative Considerations**
- **Conclusion**

Fluid therapy during surgery is dependent upon appropriate understanding of the normal physiology of body fluids. The body is divided into two major fluid components:

1) Intracellular fluid, and
2) Extracellular fluid

Although these compartments are separated by membranes; water, oxygen, electrolytes and nutrients cross these barriers.

Water accounts for 45-50 percent of the body weight of adult females and 55-60 percent in adult males. The lower water content in females is due to a larger percentage of adipose tissue which contains less water than muscle.

Abstract

Fluid management is a vital component of the perioperative management of every patient. The operating room nurse should be familiar with the dynamics of body fluids and its clinical significance. Having an understanding of fluid therapy and the individual patient's needs will enhance and assist in building the teamwork approach of care with the anesthetist.

Total body water is distributed between two major fluid compartments:

- **Extracellular** (20% of body weight)
  - Interstitial
  - Circulating blood volume
- **Intracellular** fluid (40% of body weight)

The movement of water between different fluid compartments is determined by:

- **Hydrostatic pressure**

Water will move from a compartment of high hydrostatic pressure to one of low pressure.

- **Osmotic pressure**

The prime determinant of water distribution in the body. The osmotic pressure of a solution depends upon the number of molecules in the solution. Normally, intra and extracellular fluids are in an equilibrium. **Sodium (Na^+)** is the electrolyte that acts to hold water in the extracellular space. **Potassium (K^+)** is the electrolyte in the intracellular compartment. Cell membranes are permeable to Na^+ and K^+ ions which are restricted to their compartments by the Na^+/K^+ pump. Larger molecules such as plasma proteins, (particularly **albumin**), are confined to the circulating blood volume. Plasma proteins create a major osmotic force preventing excessive fluid loss from capillaries. This effect is called the oncotic pressure.

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During a normal day, water intake equals water output.

Water loss: Insensible - vaporization from skin and lungs (12-15ml/kg) or about 900 mls in a 70 kg man. This can increase by a rise in temperature and ventilation with dry anesthetic gases and active sweating.

Urinary losses - average 1ml/kg/hr or 1600 mls in a 70 kg man.

Fecal - less than 100ml/24 hr period. The replacement of these losses can be termed the **maintenance fluids.**

Normally, daily water losses are not associated with loss of electrolytes. However, gastric suctioning, vomiting, bowel obstruction, and diarrhea may be associated with electrolyte losses which must be replaced in addition to water replacement.

Abnormalities of fluid balance can easily be categorized into three classes:

1. volume changes
2. concentration
3. composition

Volume Changes

The most common disturbances in the preoperative patient are those of the ECF compartment. Withholding fluids before surgery causes depletion of ECF because of continuous losses.

The diagnosis of severe volume depletion is demonstrated clinically by tachycardia and hypotension.

In third space loss, fluid is registered into a nonfunctional space from the extracellular compartment. This may occur with ascites, burns, massive crush injuries, and GI inflammation or obstruction.

Nonfunctional losses can also occur from surgical manipulation and tissue trauma.

Estimating fluid deficits can best be accomplished by evaluating clinical signs.

A mild deficit represents approximately 4%, a moderate deficit 6-8%, and a severe loss 10% of the body weight.

Orthostatic hypotension can occur with a deficit of 6-8%.

Signs of ECF loss are tachycardia, dry mucous membranes, hypotension, furrowed tongue, apathy, oliguria, collapsed veins, poor skin turgor, cool and dry skin, and subnormal temperatures.

Treatment is restoration of the ECF balance and adequate urinary output. Urinary output should be 30-50 ml/hr or 0.5-1 ml/kg/hr.

Concentration changes

The two primary factors involved in concentration changes are the serum sodium concentration and the serum osmolality. concentration abnormalities can be corrected slower than volume deficits. A volume deficit is often associated With an increased serum sodium. This is due to a decrease of extracellular electrolyte free water and an increase of dissolved substances in the plasma. This can be corrected by hypotonic solutions.

Hyponatremia can occur in patients with normal, increased or decreased ECF volumes. With a normal ECF volume, the treatment is detection of the cause of sodium loss. This may develop from failure of the kidneys to conserve sodium.

Hypervolemia/hyponatremia is caused by excessive water retention. This is a concern in transurethral resections, and antidiuretic administration where water is retained. The treatment is hypertonic solutions.

Hypovolemia/hyponatremia often occurs when there is a fluid loss through the GI tract. This condition may be corrected by hypotonic solutions.

Composition abnormalities

Composition abnormalities are imbalances in electrolytes and blood gases. The electrolyte disturbance most frequently encountered in the preoperative patient is hypokalemia, which can be corrected by the administration of potassium chloride. Acid base balance should also be considered throughout the perioperative period.

Maintenance/Replacement Therapy

The selection of parental solution should be based on the needs of the individual patient. The type and amount of the solution should be carefully reviewed and estimated according to the physical status, weight, and cardiovascular status of the patient; daily maintenance requirements based on weight or body surface area; and the present fluid status of the patient.

Maintenance Fluids provide replacement of normal fluid loss such as loss via the lungs, urine, and skin. Maintenance fluids are isotonic, e.g.: D_5W, D_5NaCl 0.45.

Replacement Fluids correct an abnormal loss of isotonic fluid from the body (e.g..edema ascites).

Replacement fluids are: Ringer's Lactate, 0.9%NaCl, Plasmalyte.

The rate of fluid administration varies depending on the type of loss, severity of loss, and the cardiac and renal status of the patient. Patients who have cardiovascular and/or renal disease will not tolerate fluid shifts as well as a healthy patient.

The majority of surgical patients have been fasting for 8-10 hours prior to surgery. Patients coming to surgery are depleted of solutes and water as a result of normal body function.

Adults should have their intravenous started before induction to replace these losses and to provide access to the circulatory system. Imbalances Should be corrected before entering the O.R.

Guidelines for Routine Fluids on the Day of Surgery

1. Start I.V. - replace insensible losses with main tenance type solution e.g. D_5W, D_5NaCl 0.45

Hourly: 4 ml/kg/hr....for the first 10 kg
2 ml/kg/hr....11-20 kg
1 ml/kg/hr....21 kg and up
multiplied by the number of hours NPO

An example would be:
60 kg fe male (100mls/hr) for Total Abdominal Hysterectomy, NPO x 8 hrs = 800 mls
(400 mls first hour, 200 mls the second & third)
plus each hour to replace once IV insitu = 100 mls

2. Change to replacement fluid intraop.
e.g. R/L, 0.9%NaCl
60 kg = 100 mls/hr

3. Estimate surgical trauma, add appropriate volume of replacement:
- minimal: add 4 ml/kg/hr
- moderate: 6 ml/kg/hr
- extreme: 8 ml/kg/hr

60 kg x 6 = 360 mls/hr
TOTAL: first hour = 860 mls,
second & third = 660 mls

4. Give appropriate colloid solution for each volume of blood lost > 20% of EBV (70mls/kg = 4200 mls 20% = 840 mls)

Losses: crystalloid can be used with a hct> 30% at 3 ml/1 ml of blood

5. Monitor V/S and output. Adjust fluid to urine output at 1ml/kg/hr

Intraoperative Fluid Management

Preoperatively, patients require the appropriate replacement of fluid and electrolytes to circumvent a hypotensive episode during induction of anaesthesia. The preop fluid loss can be as great as 1.5-2 ml/kg/hr for an adult (for children the loss is greater).

The ECF loss should be replaced before induction with a hypotonic crystalloid solution.

The loss of fluids during anaesthesia must be assessed. Unhumidified gases, high flows, evaporation, surgical trauma, and fever all contribute to the loss of fluids in the surgical patient.

Replacement of Blood Loss

There is a great deal of controversy as to when to replace blood loss. In a normal circumstance a person can tolerate a loss of 500 mls or 10% of the estimated blood volume (EBV). However, a loss of 15% can be considered the limit for replacement therapy.

The hematocrit level is often the indicator used for assessing the need for replacement. There is also controversy regarding this level as well. A rule of thumb for estimating allowable blood loss based on 30% hematocrit as the accepted low level.

The estimated blood volume is obtained as:

EBV = 70 ml/kg
(e.g. 70kg x 70 = 4900 mls)

Next we must calculate the estimated red cell mass (ERCM.

ERCM = EBV x preop. Hct
(e.g. 70 kg, Hct 40% (.40) 4900 x .40 = 1960)

The estimated red cell mass desired ($ERCM_d$) by multiplying the EBV with the acceptable low Hct

$ERCM_d$ = EBV x .30
(eg. 4900 x .30 = 1470)

Allowable red cell loss (ARCL) is the difference between ERCM and $ERCM_d$
(e.g. 1960 - 1470 = 490)

Allowable blood loss (ABL) is twice the ARCL
(e.g.490 x 2 = 980mls)

Keep in mind that the blood loss seen on the operative field is only a portion of the loss. One must add another 15-40%.

When replacing blood with crystalloids the rate is 3 mls for every ml of blood lost.

The advantages of using a crystalloid over a colloid are that it is less expensive, increases urinary flow, replaces interstitial fluids and it is synthetic and not derived from blood donor products. The disadvantages are that of fluid overload, improvement is short-lived and peripheral as well as pulmonary edema can occur.

Blood Products

Some blood products must be compatible with the patients blood group.

Recipients Blood Group:	Donors Blood Group:
0	0,A,B,AB
A	A,AB
B	B,AB
AB	AB

There are different blood products available which are used for specific purposes.

1. Packed Red Blood Cells 250-300mls.

Very viscous and do not transfuse quickly. Effective for chronic anemias not rapid blood loss.

To reduce viscosity add 200 mls of NaCl. To increse Hgb 1 gram, 3 ml/kg/gm of packed cells or 6 ml/kg/gm of "reconstituted" are required. Packed cells may be transfused. Packed cells **do not** contain platelets, albumin or coagulation proteins.

2. Fresh Frozen Plasma (FFP) 200 mls.

Plasma contains both coagulation factors and plasma proteins. It contains the clotting factors V and VIII. Stored plasma contains a limited amount of these factors. Plasma is labelled for ABO but not the RH group.

Stored plasma is effective in treating patients requiring volume expansion and protein replacement.

FFP should be administered to patients with coagulation abnormalities. It **does not** contain platelets.

3. Platelets 50 mls.

Unlike plasma and packed cells, platelets cannot be stored for long periods of time and must be administered within 72 hours of collection. They cannot be refrigerated after thawing.

Platelets are used for the treatment of thrombocytopenia and serum levels of 50,000mm³ should be present to prevent bleeding during major surgery. Six units of platelets will raise the platelet count by 30,000 in a 70 kg male.

4. Cryoprecipitate 5-15 mls.

This is a concentrate of factor VIII and is effective in treating hemophilia. The administration of 1 unit/6 kg body weight will raise the factor VIII level 15-20%.

5. Albumin 50, 250, 500 mls.

The 5% solution is osmotically equivalent to an equal amount of normal plasma. The 25% solution is equivalent to five times the volume of plasma. Albumin is used as a volume expander or to replace protein loss as occurs with extensive burns or ascites.

6. Autologous Blood 300mls.

Patients can donate their own blood preoperatively. The disadvantage of this blood is the increased amount of volume provided for the amount of cells present. It is useful for bleeding in which volume is required, however it may not elevate the Hct level adequately enough on its own.

7. Synthetic colloids

There are synthetic agents available for blood volume expansion including dextran, gelatin, and hydroxyethel starch.

All of these preparations can produce incompatibility reactions, but it is rare. The symptoms range from histamine release to anaphylaxis. These may be considered, however, in patients refusing blood products or in polycythemia and thrombocytopenia.

In summary, careful evaluation must take place to meet the individual fluid management needs of each patient. Continual assessment of hypovolemia (e.g. heartrate, blood pressure and CVP) is important as well as the maintenance of the appropriate levels of fluid intravenously. This eliminates the need to play "catch-up" and volume overload after the fact. Careful assessment of urinary output and bloodloss is important intraoperatively, as well as an understanding of the different types of fluid therapy required will enable the perioperative nurse to competently assist in the care of the patient in the operating room.

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