FLUID AND ELECTROLYTE BALANCE--2

DR MOHSIN

Acid-Base Balance

- The pH of body fluids is maintained within a narrow range despite the ability of the kidneys to generate large amounts of HCO_3^- and the normal large acid load produced as a by-product of metabolism.
- Important Buffers Include
  1. Proteins
  2. Phosphates
  3. Bicarbonate–carbonic acid system.

- Changes in ventilation in response to metabolic abnormalities are mediated by **Hydrogen Sensitive Chemoreceptors** found in **The Carotid Body And Brain Stem.**
- Acidosis stimulates the chemoreceptors to increase ventilation, whereas alkalosis decreases the activity of the chemoreceptors and thus decreases ventilation.
- The kidneys provide compensation for respiratory abnormalities by either increasing or decreasing bicarbonate reabsorption in response to respiratory acidosis or alkalosis, respectively.

- The major acid-base buffering system in the blood involves carbon dioxide and bicarbonate anion.

$$H^+ + HCO_3^- \leftrightarrow H_2C0_3 \leftrightarrow CO_2 + H_2O$$

- The relationship between the species that define pH is known as the **Henderson-Hasselbalch Equation:**

$$\boxed{pH = 6.1 + \log HCO_3^- / 0.03 \times PaCo_2}$$

Metabolic Derangements

Metabolic Acidosis

Respiratory Acidosis

Metabolic Alkalosis

***Respiratory* Alkalosis**

Compensation for acid-base derangements

1. Respiratory Compensation for metabolic derangements
2. Metabolic Compensation for respiratory derangements

Metabolic Acidosis

- Metabolic acidosis results from an increased intake of acids, an increased generation of acids, or an increased loss of bicarbonate.

Etiology of metabolic acidosis

Increased Anion Gap

1. Exogenous acid ingestion
    1. Ethylene glycol
    2. Salicylate
    3. Methanol
2. Endogenous acid production
    1. Ketoacidosis
    2. Lactic acidosis
3. Renal insufficiency

Normal Anion Gap

1. Acid administration (HCl)
2. Loss of bicarbonate
3. GI losses (diarrhea, fistulas)
4. Ureterosigmoidostomy
5. Renal tubular acidosis
6. Carbonic anhydrase inhibitor

The body responds by several mechanisms

1. producing buffers (extracellular bicarbonate and intracellular buffers from bone and muscle)
2. increasing ventilation (Kussmaul's respirations)
3. increasing renal reabsorption and generation of bicarbonate.
4. The kidney also will increase secretion of hydrogen and thus increase urinary excretion of NH4 + (H+ + NH3 + = NH4 +).

- Evaluation of a patient with a low serum bicarbonate level and metabolic acidosis includes determination of the anion gap (AG), an index of unmeasured anions.

$$AG = (Na) - (Cl + HCO3)$$

- The normal AG is <12 mmol/L and is due primarily to the albumin effect, so that the estimated AG must be adjusted for albumin (hypoalbuminemia reduces the AG).*

$$\text{Corrected AG} = \text{actual AG} - [2.5(4.5 - \text{albumin})]$$

* Gluck SL. Acid-base. *Lancet.* 1998;352:474.

Treatment

- The treatment is to restore perfusion with volume resuscitation rather than to attempt to correct the abnormality with exogenous bicarbonate.

Metabolic Alkalosis

- Metabolic alkalosis result from either an increase in bicarbonate generation or impaired renal excretion of bicarbonate.

- The majority of patients also will have hypokalemia, because extracellular potassium ions exchange with intracellular hydrogen ions and allow the hydrogen ions to buffer excess HCO3.

Etiology of metabolic alkalosis

Increased bicarbonate generation

- 1. Chloride losing (urinary chloride >20 mEq/L)
    - i. Mineralocorticoid excess
    - ii. Profound potassium depletion
- 2. Chloride sparing (urinary chloride <20 mEq/L)
    - i. Loss from gastric secretions (emesis or nasogastric suction)
    - ii. Diuretics
- 3. Excess administration of alkali
    - i. Acetate in parenteral nutrition
    - ii. Citrate in blood transfusions
    - iii. Antacids
    - iv. Bicarbonate
    - v. Milk-alkali syndrome

Impaired bicarbonate excretion

1. Decreased glomerular filtration
2. Increased bicarbonate reabsorption

Treatment

- Replacement of the volume deficit with isotonic saline and then potassium replacement once adequate urine output is achieved.

Respiratory Derangements

- Under normal circumstances blood Pco2 is tightly maintained by alveolar ventilation, controlled by the respiratory centers in the pons and medulla oblongata.
  1. Respiratory Acidosis
  2. Respiratory Alkalosis

Respiratory Acidosis

- Respiratory acidosis is associated with the retention of CO_2 secondary to decreased alveolar ventilation.

Etiology of respiratory acidosis: hypoventilation

1. Narcotics
2. CNS injury
3. Pulmonary: significant
   i. Secretions
   ii. Atelectasis
   iii. Mucus plug
   iv. Pneumonia
   v. Pleural effusion
4. Pain from abdominal or thoracic injuries or incisions
5. Limited diaphragmatic excursion from intra-abdominal pathology
   i. Abdominal distention
   ii. Abdominal compartment syndrome
   iii. Ascites

Treatment

- Because compensation is primarily a renal mechanism, it is a delayed response.
- Treatment of acute respiratory acidosis is directed at the underlying cause.
- Measures to ensure adequate ventilation are also initiated.
- In the chronic form of respiratory acidosis, the partial pressure of arterial CO_2 remains elevated and the bicarbonate concentration rises slowly as renal compensation occurs

Respiratory Alkalosis

- ***Respiratory Alkalosis*** In the surgical patient, most cases of respiratory alkalosis are acute and secondary to alveolar hyperventilation.
- **Causes** Include pain, anxiety, and neurologic disorders, including central nervous system injury and assisted ventilation.
- Drugs such as salicylates
- Fever
- Gram-negative bacteremia
- Thyrotoxicosis
- Hypoxemia

- Acute hypocapnia can cause an uptake of potassium and phosphate into cells and increased binding of calcium to albumin, leading to symptomatic hypokalemia, hypophosphatemia, and hypocalcemia with subsequent arrhythmias, paresthesias, muscle cramps, and seizures.

Treatment

- Treatment should be directed at the underlying cause, but direct treatment of the hyperventilation using controlled ventilation may also be required.

FLUID AND ELECTROLYTE Therapy

Goals of maintenance fluids

- Prevent dehydration
- Prevent electrolyte disorders
- Prevent ketoacidosis
- Prevent protein degradation

From Greenbaum LA. Pathophysiology of body fluids and fluid Therapy: maintenance and replacement Therapy. In: Berhman R, Kliegman R, Jenson H, editors. Nelson textbook of pediatrics. 17th edition. Philadelphia: Elsevier Science; 2004. p. 242–5.

Maintenance water rate

0 – 10 kg: 4 mL/kg/h

10– 20 kg: 40 mL/h + 2mL/kg/h (weight 10 kg)

- >20 kg: 60 mL/h + 1 mL/kg/h (weight20 kg)
- The maximum fluid rate normally is 100 mL/h.

- From Greenbaum LA. Pathophysiology of body fluids and fluid Therapy: maintenance and replacement Therapy. In: Berhman R, Kliegman R, Jenson H, editors. Nelson textbook of pediatrics. 17th edition. Philadelphia: Elsevier Science; 2004. p. 242–5.

FLUID AND ELECTROLYTE Therapy

Solutions	Electrolyte composition (mEq/L)						
	Na	Cl	K	HCO_3^-	Ca	Mg	mOsm
Extracellular fluid	142	103	4	27	5	3	280–310
Lactated Ringer's	130	109	4	28	3		273
0.9% Sodium chloride	154	154					308
D5 0.45% Sodium chloride	77	77					407
D5W							253
3% Sodium chloride	513	513					1026

Alternative resuscitative fluids

Solution	Molecular wt	Osmolality mOsm/L	Sodium mEq/L
Hypertonic Saline 7.5%	_	2565	1283
Albumin 5%	70,000	300	130-160
Albumin 25%	70,000	1500	130-160
Dextran 40	40,000	308	154
Dextran 70	70,000	308	154
Hetastarch	450,000	310	154
Hextend	670,000	307	143
Gelofusine	30,000	NA	154

Crystalloids and colloids

	Crystalloid	Colloid
Intravascular persistence	Poor	Good
Haemodynamic stabilisation	Transient	Prolonged
Required infusion volume	Large	Moderate
Risk of tissue oedema	Obvious	Insignificant
Enhancement of capillary perfusion	Poor	Good
Risk of anaphylaxis	Nil	Low to moderate
Plasma colloid osmotic pressure	Reduced	Maintained
Cost	Inexpensive	Expensive

5% Dextrose Solution

- It's is an isotonic solution, which supplies calories, but not ectrolytes.
- This solution is particularly used in the immidiate postoperative period when sodium excretion is considerable diminished by renal conservation.
- Prolonged administration of this solution will obviously result in hyponatraemia.
- It may cause thrombosis of the vein.

Dextrose 10%	Dextrose anhyd. 10% w/v. Water for injection q.s.	-Prevention and correction of hypoglycemia.
Dextrose 25%	Dextrose anhyd. 25% w/v. Water for injection q.s.	-Prevention and correction of hypoglycemia.
Dextrose 50%	Dextrose anhyd. 50% w/v. Water for injection q.s.	Prevention and correction of hypoglycemia.

ISOTONIC (0.9%) SALINE SOLUTION

Solutions	Electrolyte composition (mEq/L) Na	Cl	K	HCO_3^-	Ca	Mg	mOsm
Extracellular fluid	142	103	4	27	5	3	280–310
0.9% NaCl	154	154					308

ISOTONIC (0.9%) SALINE SOLUTION

- This solution is isotonic and contains Na & Cl^- in the concentration almost similar to that in plasma.
- Used for replacing gastrointestinal losses either by vomiting or by nasogastric aspiration or through intestinal fistula.
- It must not be used in first 24 hours after operation due to natural sodium conservation.
- It imposes an appreciable load of excess chloride on the kidneys that cannot be readily excreted. Thus a dilutional acidosis may develop.
- This solution is ideal to use in extracellular fluid deficiency in presence Hyponatremia, Hypochloraemia and metabolic alkalosis.

Hypertonic saline solutions

- 3.5% and 5% solution used for correction of severe sodium deficits.
- Hypertonic saline (7.5%) has been used as a treatment modality in patients with closed head injuries.
- It has been shown to increase cerebral perfusion and decrease intracranial pressure, thus decreasing brain edema.*

* Cottenceau V, Masson F, Mahamid E, et al. Comparison effects of equiosmolar doses of mannitol and hypertonic saline on cerebral blood flow and metabolism in traumatic brain injury. *J Neurotrauma.* 2011;28(10):2003.

Dextrose 4. 3% With Saline 0.18% (1/5th Of Normal Saline)

- It can be used in any case of hypovolaemia, where there is not considerable depletion of sodium and chloride.
- It has an additional effect of having some calorie value.
- It may be infused for prolonged period without any fear of hypematraemia or hyperchloraemia.
- There may be a chance of introducing thrombosis.

DNS

Dextrose & Normal Saline (DNS) .	Dextrose anhyd. 5% w/v Sodium chloride 0.9% w/v Water for injection q.s.	-To raise total fluid volume. -To correct hypoglycemia. -Used as a vehicle for administration of drugs.

Ringer's Lactate Solution

	Na	Cl	K	HCO_3^-	Ca	Mg	mOsm
Extracellular fluid	142	103	4	27	5	3	280–310
Lactated Ringer’s	130	109	4	28	3		273

Ringer's Lactate Solution

- The main **advantage** of this solution is that it has almost similar electrolyte concentration as extracellular fluid and the pH remains normal even if infused in large quantities.
- This solution is the best to be used in hypovolaemic shock while awaiting for blood.
- The chief **disadvantage** is that it has slight hypoosmolarity with respect to sodium.
- It is also quite suitable for gastrointestinal fluid loss.

Isolyte M (Maintenance soln. with 5% dextrose inj.)

Isolyte M (Maintenance soln. with 5% dextrose inj.)	Dextrose anhyd. 5.0gm. Sodium chloride 91.00 mg. Potassium chloride 0.15 gm. Sodium acetate 0.28 gm. Sodium metabisulphite 21.0 mg. Oibasic potassium phospate 0.13 gm. Wajer for injection q.S.	-For i.v. maintenance therapy.

Isolyte G & E

Isolyte G (Gastric replacement solution with 5% dextrose inj.)	Dextrose anhyd. 5.0gm. Sodium chloride 0.37 gm. Potassium chloride 0.13 gm. Ammonium chloride 0.37 gm: Sodium sulphite 15 mg. Water for injection q.S.	-Gastrointestinal losses. (Hyperemesis, Diarrhea resulting in hypovolemic shock).
-		
Isolyte E (Extracellular repl-acement soln. with	Dextrose anhyd. 5.0 gm. Sodium aGetate 0.64 gm. Sodium chloride 0.50 gm.	-Burns. -Fascitis. -Perotinitis.

Darrow's solution

- This is the only solution which contains more potassium than available in the plasma or extracellular fluid.
- Its potassium concentration is about 36 mEq/L, sodium 124 mEq/L, Cl 104 mEq/L and lactate 56 mEq/L
- best solution to combat hypokalaemias
- The rate of iv fusion should be slower an other solution to avoid hyperkalaemic state, which is more dangerous and it should not be given more than 60 drops per minute.
- This solution should be given when gastrointestinal losses are being replenished with isotonic saline solution or RL solution for a considerable period.

Mannitol

Mannitol (Soln. of mannitol in water or Normal Saline)	Mannitol (inert form of . sugar mannose)20%	-To raise Intravascular volume. -To reduce interstitial & intracellular edema. - To promote osmotic diuresis.

Colloids

- Colloids also are used in surgical patients, as volume expanders.
- Due to their molecular weight, they are confined to the intravascular space, and their infusion results in more efficient transient plasma volume expansion.
- Colloid solutions with smaller particles and lower molecular weights exert a greater oncotic effect but are retained within the circulation for a shorter period of time than larger and higher molecular weight colloids

Albumin

- Albumin (molecular weight 70,000) is prepared from heat-sterilized pooled human plasma.
- Available as
  1. 5% solution (osmolality of 300 mOsm/L)
  2. 25% solution (osmolality of 1500 mOsm/L)
- Because it is a derivative of blood, it can be associated with allergic reactions.
- Albumin has been shown to induce renal failure and impair pulmonary function when used for resuscitation in hemorrhagic shock.*

* Lucas CE. The water of life: a century of confusion. *J Am Coll Surg.* 2001;192:86.

5%Albumin	**chosen when crystalloids fail to sustain plasma volume when there is an abnormal loss of protein from vascular space; for example, peritonitis, extensive burns.**
25%Albumin	**It is selected when the current plasma volume is diminished, but blood pressure is acceptable, and the total Extra cellular fluid volume is expanded.**

Dextrans

- Dextrans are glucose polymers produced by bacteria grown on sucrose media.
- Available as
  1. 40,000
  2. 70,000 molecular weight solutions.
- Dextrans are used primarily to lower blood viscosity rather than as volume expanders.
- Dextrans have been used, in association with hypertonic saline, to help maintain intravascular volume.

Hydroxyethyl starch solutions

- Hetastarches are produced by the hydrolysis of insoluble amylopectin, followed by a varying number of substitutions of hydroxyl groups for carbon groups on the glucose molecules.
- The molecular weights can range from 1000 to 3,000,000.
- The high molecular weight hydroxyethyl starch hetastarch, which comes as a 6% solution.

- Administration of hetastarch can cause hemostatic derangements related to decreases in von Willebrand's factor and factor VIII, and its use has been associated with postoperative bleeding in cardiac and neurosurgery patients.*
- Hetastarch also can induce renal dysfunction in patients with septic shock and was associated with a significant increased risk of mortality and acute kidney injury in the critically ill. *
- Currently, hetastarch has a limited role in massive resuscitation because of the associated coagulopathy and hyperchloremic acidosis (due to its high chloride content).

1. * de Jonge E, Levi M. Effects of different plasma substitutes on blood coagulation: a comparative review. *Crit Care Med.* 2001;291:1261.
2. Navickis RJ, Haynes GR, Wilkes MM. Effect of hydroxyethyl starch on bleeding after cardiopulmonary bypass: a metaanalysis of randomized trilals. *J Thorac Cardiovasc Surg.* 2012;144(4):223.
3. Schortgen F, Lacherade JC, Bruneel F, et al. Effects of hydroxyethylstarch and gelatin on renal function in severe sepsis: a multicenter randomized study. *Lancet.* 2001;357:911.
4. Zarychanski R, Abou-Setta AM, Turgeon AF, et al. Association of hydroxyethyl starch administration with mortality and acute kidney injury in critically ill patients requiring volume resuscitation: a systematic review and meta-analysis. *JAMA.* 2013;309(7):678.

Hextend

- Hextend is a modified, balanced, high molecular weight hydroxyethyl starch that is suspended in a lactate-buffered solution, rather than in saline.

- A phase III clinical study comparing Hextend to a similar 6% hydroxyethyl starch in patients undergoing major abdominal surgery demonstrated no adverse effects on coagulation with Hextend other than the known effects of hemodilution. *

* Gan TJ, Bennett-Guerrero E, Phillips-Bute B, et al. Hextend, a physiologically balanced plasmaexpander for large volume use in major surgery: a randomized phase III clinical trial. *Anesth Analg.* 1999;88:992.

Gelatins

- Gelatins are produced from bovine collagen.
- The two major types are
  - urea-linked gelatin
  - succinylated gelatin (modified fluid gelatin, Gelofusine)
- Gelofusine has been shown to impair whole blood coagulation time in human volunteers.*

Coats TJ, Brazil E, Heron M, et al. Impairment of coagulation by commonly used resuscitation fluids in human volunteers. *Emerg Med J.* 2006;23:846.

Haemaccel

Haemaccel (3.5% infusion soln.	Polymer of gelatin derived Polypeptides 3.5 gm. Water for injection.	-To expand plasma volume. (1.5 lit. blood loss can be replaced with haemaccel).

Postoperative fluid regime

- **First 24 hours** There is conservation of sodium and loss of less water than in normal individual.
- **5% dextrose** solution probably the best, and 2 lit. will sufficient in 24 hours.
- If there is **operative loss of blood**. this should be replaced.

Postoperative fluid regime

- **2nd or subsequent 24 hour**
- Insensible loss- 900 ml – 1500 ml
- This loss should be replaced with **5% dextrose.**
- Approx 1 litre of fluid should be given to replace the volume of urine.
- This is given mainly In the form of **5% dextrose**
- If there is nasogastric aspiration going on **1 litre isotonic saline** solution should be given.
- So **3 litres** in total in the 2nd 24 hours will suffice.

- **Third postoperative day** it is better to give isotonic solution of **4.35% dextrose and 0.18% saline** for 2 litres to combat loss of sodium through urine and sweat.
- To combat potassium loss. This is particularly required when nasogastric aspiration is being continued as some loss of potassium is expected through G. I. secretions.
- **Input output chart:**

Input	output
oral	urine
intravenous	vomitus
	Aspiration
	Insensible loss 1000ml

Fluid and electrolyte management in pediatric patients

- Lower glomerular filtration and decreased capability to concentrate urine are the most important physiologic differences in infants up to age 1.
- In addition, patients scheduled for any surgical procedure under sedation or general anesthesia present with a degree of fluid deficit as a result of nothing-by-mouth restrictions.

- Urine output accounts for 60% of the total measurable water losses.
- In neonates and infant patients, water diffusion through the skin accounts for the most significant source of insensible water loss because **of immature stratum corneum** on the epithelium.
- Under normal temperature and humidity conditions, the insensible water loss through the skin is 7 mL/kg/24 h

- The most reliable measurement to assess appropriate hydration in pediatric patients is urine output.
- Under normal renal function, values of 2 mL/kg/h and 1 mL/kg/h for urine output are desirable for neonates and infants, and toddlers and school-age children, respectively.
- One-quarter or one-half percent normal saline and dextrose 5% can be administered IV as replacement solution. The addition of 10 to 20 mEq/L of potassium chloride provides the daily potassium requirements.

Body weight method for calculating maintenance fluid volume

Body weight	Fluid per day
0 – 10 kg	100 mL/kg
11 – 20 kg	1000 mL + 50 mL/kg for each kg >10 kg
>20 kg	1500 mL + 20 mL/kg for each kg >10 kga

From Greenbaum LA. Pathophysiology of body fluids and fluid Therapy: maintenance and replacement Therapy. In: Berhman R, Kliegman R, Jenson H, editors. Nelson textbook of pediatrics. 17th edition. Philadelphia: Elsevier Science; 2004. p. 242–5.

Geriatric Patients

- With aging, there are increases in total body fat and decreases in total body water. Both can contribute to an imbalance in fluids and electrolytes.
  - Decreased urinary concentrating ability
  - Limitations in excretion of water, sodium, and potassium
  - ‘‘Iatrogenic injury’’ with intravenous fluid overload can exacerbate trauma to tissues further and alter the hemodynamic state of patients.

Strategies to preventive imbalances in Geriatric Patients

- perioperative measurements of serum electrolytes, urea nitrogen, serum creatinine, and creatinine clearance and a baseline urinalysis.
- Normal fluid management should be maintained in a range of 1.5 to 2.0 L/d with an average urine output of 20 to 30 mL/h.
- Elderly patients who have undergone uncomplicated dentoalveolar surgery are encouraged to resume oral intake as soon as possible in order to maintain fluid and electrolyte balance.
- Patients who are in the postoperative phase after general anesthesia must be monitored for ongoing fluid losses from all sites, including insensible losses.

Burn patients

- The principle of fluid resuscitation is that the intravascular volume must be maintained following a burn in order to provide sufficient circulation to perfuse not only the essential visceral organs such as the brain, kidneys and gut, but also the peripheral tissues, especially the damaged skin
- Intravenous resuscitation is appropriate for any child with a burn greater than 10 per cent TBSA. The figure is 15 per cent TBSA for adults.

Burn patients

- If oral resuscitation is to be commenced, it is important that the water given is not salt free. It is rarely possible to undergo significant diuresis in the first 24 hours in view of the stress hormones that are present.
- Hyponatraemia and water intoxication can be fatal. It is therefore appropriate to give oral rehydration with a solution such as Dioralyte®.
- The resuscitation volume is relatively constant in proportion to the area of the body burned and, therefore, there are formulae that calculate the approximate volume of fluid needed for the resuscitation of a patient of a given body weight with a given percentage of the body burned.

- There are three types of fluid used.
  - The most common is Ringer’s lactate or Hartmann’s solution
  - human albumin solution or fresh-frozen plasma
  - hypertonic saline.
- **The Parkland Formula-** This calculates the fluid to be replaced in the first 24 hours by the following formula:
- total percentage body surface area × weight (kg) × 4 = volume (mL).
- Half this volume is given in the first 8 hours and the second half is given in the subsequent 16 hours.

- **Crystalloid resuscitation** Ringer's lactate is the most commonly used crystalloid. Crystalloids are said to be as effective as colloids for maintaining intravascular volume. They are also significantly less expensive. Another reason for the use of crystalloids is that even large protein molecules leak out of capillaries following burn injury; however, non-burnt capillaries continue to sieve proteins virtually normally.
- In children, maintenance fluid must also be given. This is normally dextrose–saline given as follows:
  - • 100 mL/kg for 24 hours for the first 10 kg;
  - • 50 mL/kg for the next 10 kg;
  - •20 mL/kg for 24 hours for each kilogram over 20 kg body weight.

Hypertonic saline

- Hypertonic saline has been effective in treating burns shock for many years. It produces hyperosmolarity and hypernatraemia. This reduces the shift of intracellular water to the extracellular space. Advantages include less tissue oedema and a resultant decrease in escharotomies and intubations.

Colloid resuscitation

- Human albumin solution (HAS) is a commonly used colloid. Plasma proteins are responsible for the inward oncotic pressure that counteracts the outward capillary hydrostatic pressure. Without proteins, plasma volumes would not be maintained as there would be oedema.
- Proteins should be given after the first 12 hours of burn because, before this time, the massive fluid shifts cause proteins to leak out of the cells.

The Muir And Barclay Formula:

- • 0.5 × percentage body surface area burnt × weight = one portion;
- • periods of 4/4/4, 6/6 and 12 hours, respectively;
- • one portion to be given in each period.

- **Monitoring of resuscitation** The key to monitoring of resuscitation is urine output. Urine output should be between 0.5 and 1.0 mL/kg body weight per hour. If the urine output is below this, the infusion rate should be increased by 50 per cent. If the urine output is inadequate and the patient is showing signs of hypoperfusion (restlessness with tachycardia, cool peripheries and a high haematocrit), then a bolus of 10 mL/kg body weight should be given.
- It is important that patients are not overresuscitated, and urine output in excess of 2 mL/kg body weight per hour should signal a decrease in the rate of infusion.
- Other measures of tissue perfusion such as acid–base balance are appropriate in larger, more complex burns, and a haematocrit measurement is a useful tool in confirming suspected under- or overhydration. Those with cardiac dysfunction, acute or chronic, may well need more exact measurement of filling pressure, preferably by transoesophageal ultrasound or with the more invasive central line.

Acute head injury and fluid management

- One in three patients with multiple trauma has nassociated cerebral injury, which is a leading cause of mortality in trauma patients.
- Patients with midface and orbital blowout fractures have a 21.9% and 23.8% chance of concomitant neurologic injury, respectively .(Al-Qurainy IA etal, Br J Oral Maxillofac Surg 1991;29(6):368 –9.)
- Secondary ischemic injury caused by reduced cerebral perfusion pressure and inadequate ventilation is more common than primary traumatic cerebral injury.
- Adequate oxygenation and hemodynamic stability are vital for controlling this preventable injury.
- The degree of cerebral injury sustained can be assessed with the simple AVPU system or the Glasgow Coma Score. Frequent re-evaluation is key to detecting deterioration in neurologic function.

- Early fluid resuscitation of the multitrauma patient with head injury must achieve restoration of circulating volume and the efficient correction of shock, which avoids secondary ischemic insult to the brain.
- Efforts also are geared toward controlling increased ICP that may occur later [54]. The infusion of normal saline (0.9%) or Ringer’s lactate is often used to resuscitate trauma patients. The volume required to restore circulating volume (4–6 L) may worsen ICP by enhancing brain edema, however. Colloids (typespecificblood or O-negative blood when type specific is not available) should be infused once more than half a patient’s estimated blood volume must be given.

- Standard fluid Therapy includes the use of mannitol, which acts as a diuretic. It acts as an osmotic agent that dehydrates normal and abnormal brain. Its hemodynamic profile includes improving preload and cerebral perfusion pressure and reducing ICP through cerebral autoregulation. Other actions include reduction of blood viscosity. Its shortcomings include hypovolemia and induction of hyperosmotic state. Monitoring should keep osmolality less than 320 mOsm/kg [55]

- The literature also supports the use of hypertonic saline [54,55]. The hemodynamic profile of hypertonic saline includes improved cerebral perfusion pressure, cardiac index, and pulmonary artery occlusion pressure. It also includes significant reduction in ICP [56

Fluid and electrolyte management renal

- Euvolemia should be maintained perioperatively in patients who have ESRD.
- For patients not undergoing dialysis, euvolemia can be achieved with appropriate hydration or diuresis.
- Patients undergoing dialysis should be dialyzed before surgery to prevent fluid overload.
- Patients who have stable dry weight with minimal fluid gain between dialysis may undergo emergency surgery without dialysis if no other indications exist for dialysis.
- Postoperative dialysis may be required to remove extra volume if large amounts of fluids were given during surgery

Lee R. Carrasco, DDS, MD, Perioperative Management of Patients with Renal Disease
Oral Maxillofacial Surg Clin N Am 18 (2006) 203 – 212

- Hyperkalemia may be present before or after surgery., one study suggests general anesthesia should be avoided in patients who have a potassium level more than 5.5 mEq/L . If the ECG shows signs of arrhythmia, 10 mL of calcium gluconate should be infused with ECG monitoring to provide membrane stabilization and cardioprotection.
- Medical management of hyperkalemia includes use of
  - polystyrene-binding resins,
  - insulin in combination with intravenously administered dextrose,
  - b2-adrenergic agonist,
  - intravenously administered bicarbonate.
- A standard oral dosage is 40 g of polystyrene resin dissolved in 80 mL of sorbitol.
- If oral intake is not possible perioperatively then 50 to 100 g of polystyrene resin in 200 mL of water can be given as a retention enema.
- The resin should be given every 2 to 4 hours, although the surgeon must remember that the resin may cause intestinal necrosis especially when given with sorbitol within the first week after surgery

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- Insulin administration decreases intravascular potassium by driving potassium intracellularly. This process occurs through the stimulation of Na-K-ATPase. Insulin should be given with glucose, and patients should be closely monitored for hypoglycemia. The administration of a b2 agonist also stimulates the Na-K-ATPase to shift potassium into the cells.
- However, this technique is not typically used in patients who have ESRD because of the risk for tachycardia and arrhythmias. Sodium bicarbonate only reduces the serum potassium level by a small amount unless moderate or severe metabolic acidosis is present. Sodium bicarbonate, insulin, and b2 agonist only decrease the serum potassium temporarily by shifting potassium from one compartment to another and levels may rebound with time. Only polystyrenebinding resins and dialysis remove excess potassium from the body. If the potassium level in a patient who has ESRD exceeds 6 mEq/L, either before or after surgery, dialysis is the treatment of choice [25].

Management of Diabetic patient undergoing surgery

- The goal of intraoperative management of the patient who has diabetes should be to maintain blood glucose within a narrow range throughout the surgery because of the devastating effects of hyper- or hypoglycemia.
- Insulin administration may be considered for all patients who have diabetes, whether a type 1 or type 2, because they are generally insulin-deficient.
- One exception is the patient who has well-controlled type 2 diabetes mellitus who is undergoing a short surgical procedure.

- The goals during preoperative management of patients who have diabetes is to prevent protein catabolism, glucose infusion with insulin coverage is administered.
- An intravenous infusion of a solution containing 5% dextrose at 125 mL/h reduces catabolism in patients who have maintained an NPO status.
- Fluid management is determined partially by the duration of the procedure and modified according to patient restrictions.
- For patients who undergo minor procedures who are anticipated to return to normal oral fluid intake within hours after surgery, D5 1⁄2 NS is acceptable at 100 ml/h.
- When fluid restriction is necessary, the physician may consider using 10% dextrose at 50 ml/h. Losses must be replaced by non–lactate- and non–dextrose-containing solutions to avoid contributing to hyperglycemia.

Establish adequate Diabetic control at least 2-3 days pre-operatively

Stop metformin 24- 48 hrs before surgery

Contact Anaesthetist well in advance

perform operation as early as possible in morning

On the morning of surgery omit usual insulin or oral anti-diabetic drugs and check blood glucose, electrolytes, urea and creatinine

Type 1 diabetes

Type 2 diabetes

Major surgery

Minor surgery

At 0800-0900 hrs establish intravenous infusion of 500ml 10% dextrose + 10-20 unit short acting (soluble) insulin + 20 mmol K^+ given at a rate of 100 ml/hr

Check blood glucose using blood glucose meter or strip 2-4 hrly and adjust insulin content of infusion to maintain value within the range 5-11 mmol/L (90-199mg/L)

Simply observe; measure blood glucose frequently

Glucose/ insulin/ potassium iv if necessary post-operatively

Davidson's principle and practice of Medicine 20th edition


THANKYOU