FLUID MANAGEMENT IN NEONATES AND INFANTS

CONTENTS

INTRODUCTION

- WHY IS FLUID MANAGEMENT IMPORTANT IN NEONATES --

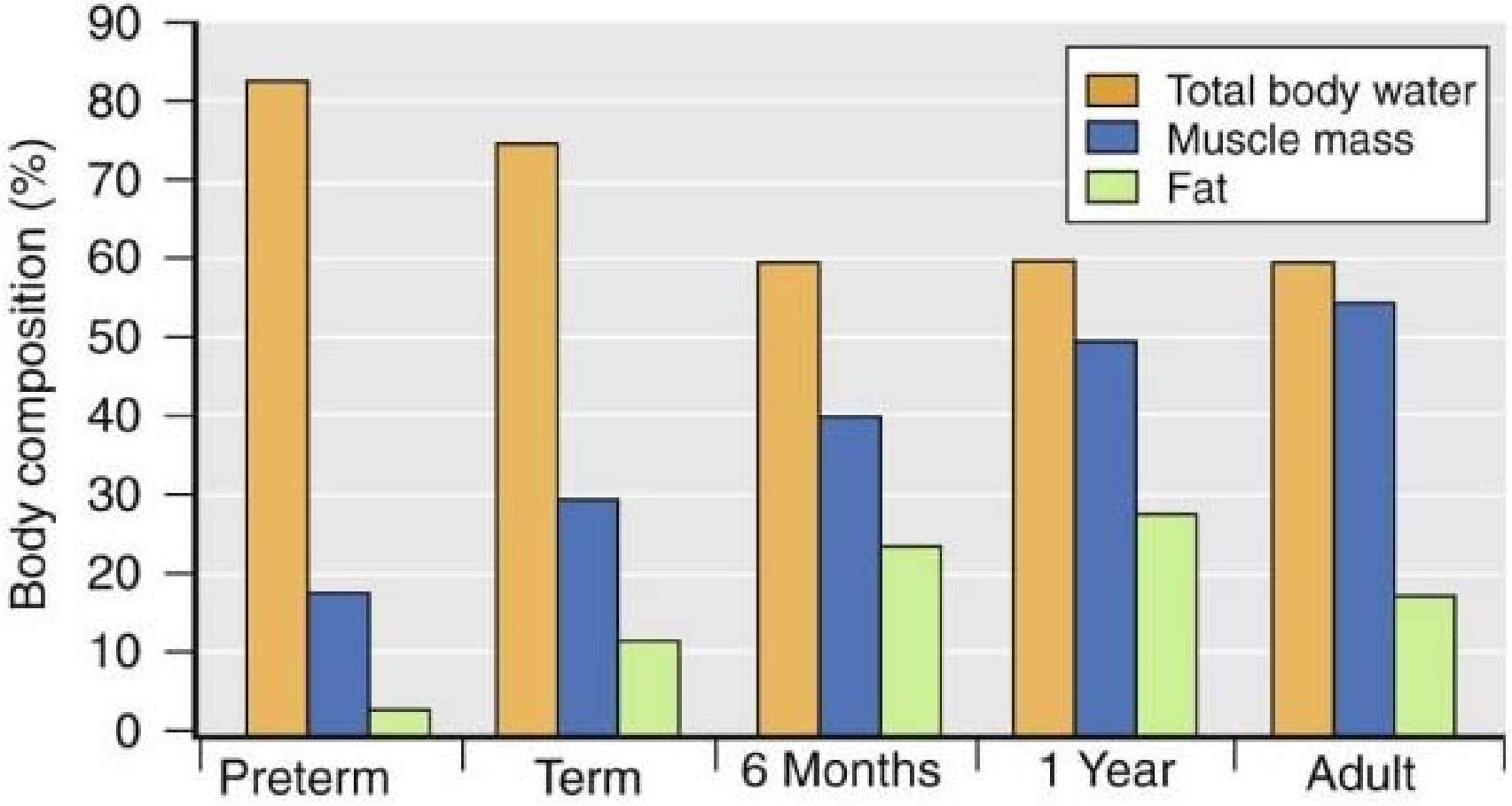
  - Physiology different from adults.
  - All don't need the same IV fluids (either in quantity or composition).
  - If wrong fluids are given, neonatal physiology is not well equipped to handle them.
  - Serious morbidity can result from fluid and electrolyte imbalance.

NEONATAL PHYSIOLOGY HOW IT IS DIFFERENT???

- All babies are born with an excess of TBW, mainly ECF-

- Adults have 60% water (20% ECF, 40% ICF)
- Term neonates have 75% water (40% ECF, 35% ICF)
- Preterm neonates have more water (23 wks: 90% : 60% ECF, 30% ICF)

DISTRIBUTION OF BODY WATER



NEONATAL PHYSIOLOGY

- High water content provides a large volume of distribution for water-soluble medications.
- Low fat and muscle content provides a small reservoir for drugs that depend on redistribution into these tissues for termination of drug effect.

- **ANAESTHETIC IMPLICATIONS –**
  - Water soluble drugs have larger volume of distribution, require larger initial dose eg., antibiotics, muscle relaxants
  - Drugs depending on redistribution into fat have longer clinical effect eg., thiopental
  - Drugs redistributing into muscle have longer clinical effect eg., fentanyl

NEONATAL PHYSIOLOGY

- After birth, there is efflux of fluid from (ICF) to (ECF) .
- This floods the neonatal kidneys eventually resulting in a salt and water diuresis by 48-72 hours.
- This loss results in physiological weight loss in the first week of life.
- ECW compartment is larger in preterm neonates- the weight loss is greater.
- Term infants are loose up to 10% of their birth weight as compared to 15% weight loss in premature neonates.
- Failure to loose this ECF may be associated with morbidities like
  - Patent ductus arteriosus (PDA)
  - Necrotizing enterocolitis (NEC)
  - Chronic lung disease (CLD)

NEONATAL PHYSIOLOGY

- **RENAL FUNCTION**
  - At birth : Functionality is only 25 %
  - Complete maturation of renal function - by 2 yrs of age
  - t1/2 of drugs excreted by glomerular filtration is prolonged
  - The physiological range for urine osmolality in neonates 50mmol/L to 600 mmol/L in preterms and 800 mmol/L in term infants.

NEONATAL PHYSIOLOGY

- **Cardiovascular physiology**

  - Infants more sensitive to hypovolemia due to-

  relatively low contractile mass/gram of cardiac tissue

  ⇓

  limited ability to ↑ myocardial contractility

  ↓ in ventricular compliance

  ⇓

  extremely limited ability to ↑ stroke volume

  need to ↑HR to ↑cardiac output(Treppe effect)

NEONATAL PHYSIOLOGY

- **Fluid losses-**
  - Apart from sensible water loss,neonates have additional water losses due to evaporation from the skin and respiratory tract - insensible water loss (IWL)
  - Insensible water losses -higher in preterm infants
  - Evaporation through the skin -70% of IWL
  - From the respiratory tract- 30% of IWL

NEONATAL PHYSIOLOGY

- **Increased insensible water loss (IWL)**

- Increased respiratory rate
- Surgical malformations (gastroschisis, omphalocele, neural tube defects)
- Increased body temperature: 30% increase in IWL per C rise in temperature
- High ambient temperature: 30% increase in IWL per C rise in temperature
- Use of radiant warmer and phototherapy: 50% increase in IWL
- Decreased ambient humidity.
- Increased motor activity, crying: 50-70% increase in IWL

- **Decreased insensible water loss (IWL)**

- Use of incubators
- Humidification of inspired gases in head box and ventilators
- Use of plexiglas heat shields
- Increased ambient humidity
- Thin transparent plastic barriers – reduce upto 30% IWL

Anaesthetic concerns

- Covering the neonate during transportation and during surgery
- Maintenance of OT temperature

FASTING GUIDELINES

- EARLIER GUIDELINES-

Fasting Time (hr)

Age	Milk & Solids	Clear Liquids
<6 months	4	
6-36 months	6	
>36 months	8	3
	2	
	3	

NEW FASTING GUIDELINES

- EUROPEAN SOCIETY OF ANAESTHESIA (2011) FASTING GUIDELINES –
  - 2 hours for clear liquids
  - 4 hours for breast milk
  - 6 hours for non human milk, Infant formula
  - 8 hours for solid food

ADVANTAGES OF THESE LIBERAL GUIDELINES-

- Prevent dehydration and hypoglycemia
- Reduce the risk of aspiration

INTRAOPERATIVE FLUID THERAPY

- **DEFICIT THERAPY-** TO COMPENSATE FOR DEHYDRATION OR FASTING

- **MAINTAINENCE THERAPY** – TO COMPENSATE FOR LOSS DUE IWL AND URINE

- **REPLACEMENT THERAPY-** FOR BLOOD LOSS AND THIRD SPACE LOSSES

ASSESSMENT OF FLUID AND ELECTROLYTE STATUS

- **History:**
- **Physical Examination**:
  - Weight: Most important criteria
  - Skin/Mucosa: Altered skin turgor, sunken AF, dry mucosa, edema etc
- Cardiovascular:
  - Tachycardia can result from too much (ECF excess in CHF) or too little ECF (hypovolemia)
  - Delayed capillary refill can result from low cardiac output
  - Hepatomegaly can occur with ECF excess
  - Blood pressure changes very late

- Lab evaluation:

  - Serum electrolytes and plasma osmolarity
  - Urine output
  - Urine electrolytes, specific gravity
  - Blood urea, serum creatinine
  - ABG

Clinical Sign	Mild dehydration (<3% wt loss)	Moderate (3-10%)	Severe >10%
General condition	Alert, restless	Thirsty ,lethargic	Cold , sweaty, limp
Pulse	Normal rate, volume	Rapid, weak	Rapid, feeble
respiration	Normal	Deep rapid	Deep
Systolic pressure	Normal	Normal or low	Low, Unrecordable
Reduced urine output	NO	YES	YES
Dry mouth	NO	YES	YES
Sunken eyes	NO	YES	YES
Ant. fontanellae	Normal	Sunken	Very sunken
Reduced skin turgor	NO (recoils instantly)	YES (1-2 secs)	YES (>2secs)
Prolonged capillary refill time	NO	May be slightly prolonged	YES (cool/mottled /pale peripheries)
drowsiness	NO	YES	Severe
Estimated deficit	30-50ml/kg	60-100ml/kg	>100ml/kg

MANAGEMENT

Goal:

- Allow initial loss of ECF over first week (as reflected by wt loss), while maintaining normal intravascular volume and tonicity (as reflected by HR, U O, lytes, pH). Subsequently, maintain water and electrolyte balance, including requirements for body growth.
- Individualize approach according to response of the child and age.

DEFICIT DUE TO FASTING

- HOURLY REQUIREMENT BASED ON HOLLIDAY AND SEGAR – 100ml water for 100 calories expended

4-2-1 rule-based on b. wt.

Weight	Hourly fluid requirements
<10 kg	4 ml/kg
10-20 kg	40 ml + 2 ml/kg Above 10 kg
>20 kg	60 ml + 1 ml/kg Above 20 kg

CHILDS RESPONSE TO FLUIDTHERAPY SHOULD ALWAYS BE MONITORED

Millers anaesthesia 7th edition

Fluid deficit due to fasting

MANAGEMENT -

- Hourly maintenance requirements x hours of fluid restriction

- 50% 1st hour

- 25% each in next 2 hours

MAINTAINENCE FLUID IN NEONATES

- MEETS THE LOSSES DUE TO IWL AND URINE

Birth weight	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
<1000g	80	100	120	130	140	150	160
1000 to 1500g	80	95	110	120	130	140	150
>1500g	60	75	90	105	120	135	150

*** Fluid and Electrolyte Management in Term and Preterm Neonates, Indian journal of pediatrics, volume 75 - march 2008**

MAINTAINENCE FLUID

- CHOICE OF FLUID ?????

- Term Babies and Babies With Birth Weight > 1500 Grams

DAY 1 - 10% Dextrose to maintain a glucose infusion of 4-6mg/kg/min

DAY 2 TO 7 - 10% Dextrose and sodium and potassium to be added after 48 hours

- Preterm Baby With Birth Weight 1000-1500 Grams

DAY 1 - 10% Dextrose

DAY 2 TO 7 - 10% Dextrose and sodium and potassium to be added after 48 hours

AFTER DAY 7 - Fluids should be given at 150-160 ml/kg/day and sodium supplementation at 3-5 mEq/kg should continue till 32-34 weeks corrected gestational age.

MAINTAINENCE FLUID DURING SURGERY

- The maintenance fluid used during surgery should be isotonic such as 0.9% sodium chloride or Ringer lactate /Hartmann's solution in infants.
- Neonates in the first 48 hours of life should be given dextrose during surgery.
- Maintenance fluid to be calculated by Holliday and segar for patients more than 4 wks of age.

Guide for Maintenance Fluid Therapy

Newborn Term

Day 1	50-60 ml/kg/day	D10 W
Day 2	80 ml/kg/day	D10 W
>Day 7	100-150 ml/kg/day	D5-D10 1/4 NS

Older Child

4-2-1 rule (Holliday & Segar method)

ROLE OF GLUCOSE IN PERIOPERATIVE PERIOD

- Lack glycogen stores
- Hyperglycemia is more commonly encountered
  - Response to anaesthesia and surgery
  - Anxiety
  - Pain
- Hypoglycaemia →brain damage
- Hyperglycemia → Osmotic diuresis → dehydration and electrolyte imbalance

The present recommendations is that the replacement fluid used should either be free of dextrose or should not have more than 1% dextrose.*

***Perioperative fluid therapy in pediatrics, Pediatric Anesthesia 2008 18: 363–370**

EXCEPTIONS TO THIS ????

- Neonates in the first 48 hours of life
- Preterm and term infants already receiving dextrose containing solutions
- Children on parenteral nutrition preoperatively
- Children of low body weight (less than 3rd %tile) or having prolonged surgery.
- Children with diminished sympathetic response to regional anaesthesia.

RELACEMENT THERAPY

- FLUID MANGEMENT FOR -
  - Third space losses
  - Blood loss

THIRD SPACE LOSS

SURGICAL TRAUMA	3rd SPACE LOSS
MINIMAL	
MODERATE	4-7 ml/Kg/hr
SEVERE	6-10 ml/Kg/hr
15-20ml/kg/hr	– major abdominal
50ml/kg/hr	– surgery of NEC in premature infants
Balanced salt solution	– preferred
1-2 ml/Kg/hr	

BLOOD LOSS

Determinants of Blood Transfusion

1) Estimated Blood Volume

2) Preoperative Hematocrit

3) Co-existing Illness

ESTIMATED BLOOD VOLUME

Premature Neonates		/kg
Full Term Neonates	95 -100 ml	85-90 ml / kg
Infants		

80 ml / kg

BLOOD LOSS

- "Davenport's law"

- MABL= $\frac{\text{EBV X(Starting Hct-Target Hct)}}{\text{Starting Hct}}$

  1:1 blood/colloid

  3:1 crystalloid

- Replaced by PRBC
- Vol of PRBC = $\frac{\text{(Desired Hct – Present Hct) x EBV}}{\text{Hct of PRBC}}$

POSTOPERATIVE FLUID MANAGEMENT

- **RECOMMENDATIONS –**

  - Avoid dehydration and correct hypovolemia
  - Composition of fluid to be administered should be a compromise between sodium, energy requirements and osmolarity.
  - Beware of hidden fluid administration (drugs).
  - Monitoring of serum sodium and glucose in sick patients at least once daily.

- Early oral intake
- If oral intake is delayed, fluid therapy should be administered :

  Provide basic metabolic requirements (4-2-1)

  Replace ongoing losses (isotonic fluids)

ELECTROLYTE IMBALANCE IN PERIOPERATIVE PERIOD

ELECTROLYTE PHYSIOLOGY

SODIUM

- Daily sodium requirement-2-4 meq/kg/day

- OBLIGATE SODIUM LOSERS

- Positive pressure ventilation and PEEP → natriuresis, water retention

POTASSIUM

- Daily requirement- 2-4 meq/kg/day

SODIUM IMBALANCE

HYPONATREMIA

- The most frequent electrolyte disorder

  S . Na^+ < 135 meq/L
- Most common cause - administration of hypotonic fluids
- Others - Pituitary or adrenal insufficiency, brain injuries, brain tumours, stress ,pain, nausea and vomiting are all potent causes of ADH release.
- It has been recommended that hypotonic fluids should not be used for postoperative maintenance.

SMITHS Anaesthesia for Infants and Children 7th edition

- The early signs - non-specific
- The first presenting feature is a seizure or respiratory arrest.(s.sodium <125 meq/L)

Management

- Medical emergency and transfer to PICU.
- Hyponatraemic seizures - respond poorly to anticonvulsants
- Initial management is to give an infusion of 3% NaCl Sol.
- One ml/kg of 3% sodium chloride will normally raise the serum sodium by 1mmol/l.

SMITHS Anaesthesia for Infants and Children 7th edition

- The amount of Na required can be calculated according to the following formula:

  mmol of Na = (130-present serum Na)x0.6 x Wt

  (kg)

- **Targeted rate of correction 0.5meq/l/hr**
- **Rapid treatment- pontine myelinolysis**
- **Correction should be stopped if child is asymptomatic,or serum sodium > 125meq/l.**
- **The child with asymptomatic hyponatraemia does not require active correction with 3% sodium chloride solution.**

HYPERNATREMIA

Common cause- excessive water loss, restricted water intake.

- Signs of hypernatraemia are more severe when it develops rapidly or when the serum Na > 150mmol/l.

Management

- **Replacement with 0.9% sodium chloride** given in boluses of 20ml/kg to restore normovolaemia.(hypovolemic hypernatremia)
- Complete correction : very **slowly over at least 48 hours**
- The serum Na should be corrected at a rate of no more that 12mmol/kg/day.
- In hypervolemic hypernatremia - diuresis followed by replacement with hypotonic fluids.

POTASSIUM IMBALANCE

HYPOKALEMIA

- Serum K< 3.5mmol/l
- Symptoms - cramps
  - arrythmias
  - paralytic ileus

Management

- oral supplements
- severe cases: IV correction not faster than 0.25meq/kg/hr to a maximum of 0.5meq/kg/hr

POTASSIUM IMBALANCE

HYPERKALEMIA

serum K > 5.5meq/l in infants and > 6meq/l in neonates

Immediate treatment

- 10% Calcium gluconate- 100mg/kg per dose

Increase intracellular shift of potassium:

- sodium bicarbonate-1-2mmol/Kg
- glucose-0.3-0.5g/kg/hr with 1 unit of insulin for every 5g of glucose
- nebulised salbutamol -2.5 to 5mg

Removal of potassium : calcium resonium 1g/kg per dose
furosemide -1 mg/kg
dialysis or haemofiltration

COMMONLY USED IV FLUIDS

	NS	RL	Iso lyte P	Plasmalyte A	5D	Album in5%	Hetastarch 6%
Na	154	130	26	140		150	154
K		4	21	5		<2.5	
Cl	154	109	21	98		100	154
Ca		3					
Mg			3	3			
Acetate Lactate		28	24	27			
Glucose			5		5		
Phosphate			3				
Osmolality	308	274		295	252	330	310

Isolyte-P

- Earlier, most widely used maintenance fluid for younger children
- Ideal electrolyte concentration (Na 25 & K + 20 mEq/l)
- Contains acetate, which provides bicarbonate
- Provides magnesium and phosphate
- Provides 50 g /l of glucose to provide calories
- Uniform administration of fluid and electrolytes

- Not an ideal maintenance fluid for older children
- In children as weight increases, water requirement reduces rapidly,
- Sodium requirement remains static (2.5 mEq/kg)
- Children with greater weight will need I.V. fluids with greater sodium concentration
- For children with weight greater than 15 kg, additional sodium supplementation is needed
- Isolyte-M contains greater (Na = 40 mEq/l) sodium

GOALS OF PERIOPERATIVE FLUID THERAPY

- Urine output 1 – 3 ml/kg/hr.
- Allow a weight loss 1 – 2% / day in 1st wk.
- Absence of Edema / Dehydration/ Hepatomegaly
- Urine Sp. gravity 1005 – 1015
- Euglycaemia 75 – 100 mg / dl
- Normonatremia 135 - 145 mEq / lit
- Normokalemia 4 – 5 mEq / lit

CONCLUSION

- Understanding of neonatal physiology is important.
- Preoperative fasting should be confined to a minimum.
- Glucose containing fluids are best avoided.
- Restoration of the circulating volume and vital organ perfusion is the first priority in perioperative fluid management and is best accomplished with isotonic crystalloid.

- Replacement of fluid should be based on individual response to therapy.
- Symptomatic hyponatraemia and hyperkalaemia are the electrolyte disturbances that warrant emergency management.

THANK YOU

Calculate the fluid requirement of a 10kg breast feed infant scheduled for herniotomy??

- Fasting – 4 hours for breast milk , 2 hours for liquids

  Deficit due to fasting – 40ml x 4hr = 160ml

Fluid requirement in 1st hour

80ml to be given in first hour + maintenance fluid requirement i.e 4ml/kg/hr + 3rd space loss i.e 1ml/kg/hr + blood loss

Fluid requirement in 2nd hour

40ml + 40ml + 10ml + blood loss

Fluid requirement in 3rd hour

40ml + 40ml + 10ml + blood loss

After 3rd hour in each hour

40ml + 10ml + blood loss

Choice of fluid - ringer lactate or balanced salt solution