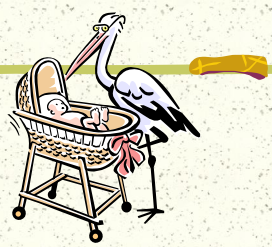
Fundamentals of Neonatal Care



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Self assessment

1. A goal of double walled incubator use is to decrease heat loss via
   - A. convection
   - B. evaporation
   - C. radiation

2. Consequences of neonatal cold stress include
   - A. decreased oxygen consumption and calories for growth
   - B. hypoglycemia and metabolic acidosis
   - C. increased metabolic demand and amount of apnea

Self assessment

3. The initial effect of increased neonatal blood glucose is
   - A. decreased hepatic glycogen breakdown
   - B. improved pancreatic insulin production
   - C. increased glycogen synthesis in the liver

4. Hourly IV rate for an AGA 32 week gestation neonate, birth weight 1.8Kg, on day 1 of life is
   - A. 2ml/hr
   - B. 4ml/hr
   - C. 6ml/hr

Self assessment

5. Insulated hats, often used on neonates at delivery, decrease heat loss since
   - A. a large percentage of heat production is via the brain
   - B. hats provide a conductive heat source for the neonate
   - C. radiant warming beds will augment the insulated fabric
6. A neonate with sepsis presents with hypothermia due to
   - A. decreased ability to mount an immune response
   - B. peripheral vasoconstriction to increase core temperature
   - C. shock, vasodilation, loss of thermoregulatory response

Self assessment

7. Neonatal fluid overload is associated with
   - A. chronic lung disease
   - B. increased insensible water loss
   - C. syndrome of inappropriate antidiuretic hormone
8. Neonatal insensible water loss can be decreased for preterm neonates by use of
   - A. daily fluid maintenance at 180ml/kg
   - B. incubators compared to radiant warming beds
   - C. temperatures greater than the neutral thermal environment

Self assessment

9. A preterm AGA neonate, weighing 900g is receiving 10% dextrose at 80ml/kg/day, providing
   - A. adequate glucose at 2.5 mg/kg/min
   - B. insufficient glucose at 4.5 mg/kg/min
   - C. satisfactory glucose at 5.5 mg/kg/min
10. Infants of insulin dependent diabetic mothers require
    - A. frequent serum glucose monitoring, IV infusion of 5% dextrose
    - B. glucose bolus of 200mg/kg if symptomatic, recurrent glucose screens
    - C. NPO status, obtaining serum glucose level at 6 hours of age

Fundamentals of Neonatal Care

- Thermoregulation
- Glucose homeostasis
  - Hypoglycemia
  - Hyperglycemia
- Fluid balance

THERMOREGULATION

Thermoregulation

- Neonatal thermal stability critical
- Basis of optimal neonatal nursing care
- Proper temperature control will…
  - Improve survival
  - Increase growth rates
  - Decrease amount of apnea
  - Decrease fluid needs
  - Decrease associated complications (acidosis, hypoglycemia, hypoxemia)

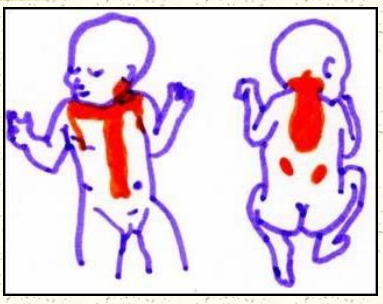
Non-shivering Thermogenesis

- Heat production via increased metabolic processes
- Relative to heat loss, heat production low in neonates compared to adults
- Main source of heat production in neonates
- Complex phenomena

Human Temperature Regulation

- Sympathetic nervous system
- Preoptic area of anterior hypothalamus - temperature "control" center
- Heat gaining center – vasoconstriction, increased metabolism, shivering, decreased sweating, increased thyroid hormone production
- Heat losing center – vasodilatation, sweating, decreased muscle tone

Brown Fat Locations



Brown Adipose Tissue

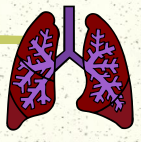
- Production begins 26-28 wks gestation
- Stores increase until 3-5 wks after birth unless depleted by cold stress
- Cannot be replenished once used
- Metabolism initiated by skin thermal receptors (facial trigeminal area prominent)
- Regulation by protein – thermogenin (located in mitochondria)

Factors Interfering with Brown Adipose Tissue Metabolism

- Gestational age
- CNS disturbance
  - Need intact CNS
- Hypothyroidism
- Hypoglycemia
- Hypoxemia

Thermogenesis needs …

- Oxygen



Heat production increases oxygen consumption

Marginal PaO_2 impairs thermogenesis

PaO_2 < 30mmHg abolishes thermogenesis

Neonates at risk: respiratory distress, cyanotic congenital heart disease, etc.

Heat Transfer Mechanisms

- Conduction
- Convection
- Radiation
- Evaporation

Conduction

- Heat transfer via direct contact
- Nursing implications
  - Kangaroo care
  - Warming mattress
  - Warm surfaces for use

Convection

- Heat transfer via air currents
- Nursing implications
  - Incubator heat gain
  - Warm oxygen for use
  - Avoid drafts

Evaporation

- Heat **loss** as liquid converted to vapor
- Nursing implications
  - Depends on air speed, relative humidity
  - Dry off thoroughly at delivery
  - Latent heat of vaporization
  - Humidify oxygen
  - Bathing, tachypnea
  - Humidity in incubator

Radiation

- Heat transfer without direct contact
- Nursing implications
  - Incubator heat loss mechanism
  - Double walled incubator
    ↓ radiant heat loss
  - Heat shield use
  - Radiant warmer beds (pros & cons)
    - Hybrid bed use
  - Heat lamp use

Using Radiant Warmer Beds

- Pros
  - Easy access to baby
  - Powerful heat source
  - Efficient servo-control mechanism (skin probe)
  - Ease of cleaning
- Cons
  - Potential overheating
  - Increased IWL
  - Convective heat loss
  - High resting heat production & oxygen consumption
  - Skin drying
  - Under heating due to blocked heat source
  - Injury potential

Hybrid Beds

- Combine features of radiant warmer bed & incubator

Heat Loss vs. Heat Gain

- Heat loss
  - conduction
  - convection
  - radiation
  - evaporation
- Heat gain
  - conduction
  - convection
  - radiation

Factors Predisposing Tiny Babies to Heat Loss

- Increased surface area compared to body weight
- Increased IWL
- Decreased amount of insulating fat
- CNS immaturity
- Spread eagle posture
- Limited brown fat stores

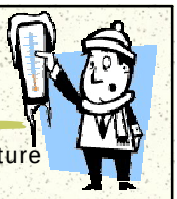
Neutral Thermal Environment

- Relatively narrow range of environmental temperature at which neonates can maintain normal body temperature with least amount of thermogenic activity
- Use minimal glucose & oxygen to produce heat

Normal Neonatal Temperature

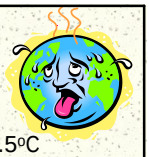
- No single normal
- Normal ranges
- Skin temperature
  36-36.5° C
- Axillary temperature
  36.3-37.5° C
- Rectal temperature risk

Hypothermia



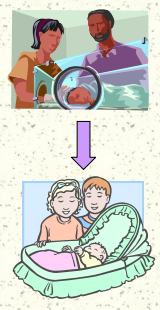
- Abnormally low body temperature
  - 36° C (skin)
  - 35.8° C (axillary)
- Consequences
  - Increased metabolic rate & fatty acid production; utilization of calories, O_2, glucose;
- Treatment
  - Rapid vs. slow
  - Increase environmental temperature
  - Close assessment during re-warming

Hyperthermia



- Excessive body temperature, >37.5°C
- Assess for environmental cause
  - ?? Signs of infection, dehydration in full term or older
  - Preterm neonate can NOT sweat to dissipate heat
- Consequences
  - Apnea, increased metabolic demands / O_2 consumption, burns, sweating (full term)
- Treatment
  - Cool quickly but safely (undress, un-bundle, decrease incubator temperature), tepid water sponge bath
  - Possible sepsis work up or acetaminophen

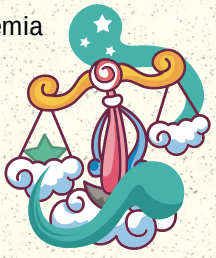
Weaning from Incubator to Open Crib



- "Milestone"
- 1500g, 5 days weight gain, tolerating feeds, medically stable
- Wean over full day
- Dress, bundle in incubator; decrease incubator temperature
- Assess frequently
- Continue to assess when weaned

Glucose Homeostasis

- Hypoglycemia
- Hyperglycemia



HYPOGLYCEMIA

Fetal Glucose Metabolism

- Glucose readily crosses placenta
- Fetal levels 70-80% of maternal
- Glucose major fetal energy source
- Glucose stored as glycogen
- Insulin does NOT cross placenta
- Fetal insulin production begins 11-12 weeks

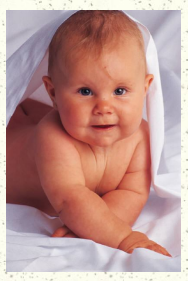
Pathogenesis

- Excess utilization
  - Hyperinsulinism
  - Caloric demand
    - Thermoregulation
    - Muscle activity
  - Shift from aerobic to anaerobic
  - Glucose demand by tissues
  - Inborn errors
  - Acute brain injury
- Inadequate production, substrate
  - Delayed feeding, IV glucose
  - Abnormal hormone regulation
  - Immature metabolic pathways
  - Deficient reserves, precursors, brain glucose transporters

  Suppressed gluconeogenesis

Neonatal Hypoglycemia

- Changing definitions
  - 1959-69 20 mg/dl
  - 1970-88 40 mg/dl
  - 1988-98 50 mg/dl
  - 1999-present 60 mg/dl
- "Operational thresholds"
- Differences for gestation, age, clinical conditions



Guidelines for Intervention

- Asymptomatic: < 30-35 mg/dl, AGA
- Symptomatic: < 45 mg/dl, signs abate with Rx
- Sick neonates: < 45-60 mg/dl
- > 24 hrs old: threshold increases to 40-50 mg/dl
- At any age: < 20 mg/dl, need prompt IV glucose

Neonates at Risk

- Preterm
- Fetal growth disorders (SGA, LBW, LGA)
- Smaller of twins
- Hypothermia
- Maternal glucose disorders / diabetes
- Maternal massive obesity
- Excessive maternal intrapartum glucose
- Some medications
- Perinatal stress
- Sepsis
- Hypoxemia
- Shock, hypoperfusion
- Severe anemia, polycythemia
- Congenital anomalies
- Inborn errors
- Isolated hepatomegaly
- Hyperinsulinism

Medications

- Drug effect → hypoglycemia
- Maternal: beta-sympathomimetic tocolytic agents, oral hypoglycemic agents, inderal, beta-blockers, diuretics
- Neonatal: blood preservatives, inderal, PGE_1

Infants of Diabetic Mothers

Classifications

Class	Age at Onset	Duration	Vascular disease	Insulin
A	Any	Pregnancy	No	No
B	> 20 yrs	< 10 yrs	No	Yes
C	10-19 yrs	10-19 yrs	No	Yes
D	< 10 yrs	> 20 yrs	Benign retinopathy	Yes
F	Any	Any	Nephropathy	Yes
R	Any	Any	Proliferate retinopathy	Yes
H	Any	Any	CV disease	Yes

Etiology – Hypoglycemia in IDM

- Maternal hyperglycemia
- Fetal hyperglycemia (fetal pancreatic islet cell hypertrophy)
- Fetal hyperinsulinism (increase in hepatic glucose uptake, lipogenesis, glycogen & protein synthesis)
- Delivery occurs
- Neonatal hypoglycemia (glucose source ends)
- Inadequate neonatal compensation
- Continued hypoglycemia

Common Problems of IDM

- Hypoglycemia
- Altered growth
  - LGA, SGA
- Hypocalcemia
- Hyperbilirubinemia
- Surfactant deficiency
- Polycythemia
- Renal vein thrombosis
- Congenital malformations

Congenital Anomalies - IDM

- 9-36% incidence
- 3x general population
- More common in mothers with long standing, poorly controlled diabetes
- Caudal regression syndrome
- CV – myopathy, structural anomalies
- Renal, GI

Neonatal Hypoglycemia - Signs

- Tremors
- Jitteriness
- Irritability
- Seizures
- Hypotonia
- Apnea
- Cyanosis
- Hypothermia
- Bradycardia
- High pitched cry
- Poor feeding
- Eye rolling
- Mottled skin
- Cardiac failure
- Sweating
- Tachypnea

Monitor Neonates at Risk

- Routine screening of ALL neonates not recommended
- Screen “at risk” neonates
- When to screen?
- Laboratory confirmation
- Demonstrate symptoms due to hypoglycemia
- Documentation important

Monitoring Neonatal Hypoglycemia

- Screening tool ??
- Diagnostic tool ??
- Designed for neonatal use ??
- Laboratory confirmation??
- Minimize “travel time” to lab (glycolysis risk)

Asymptomatic Hypoglycemia

- Frequency < symptomatic hypoglycemia
- Risk groups: IDM, glycogen storage disease
- Lack of symptoms due to use of substrates supports brain metabolism & prevents clinical manifestations
- Management: verify screen, begin feedings, recheck glucose, IV glucose if still hypoglycemic

Symptomatic Hypoglycemia - Management

- Verify laboratory analysis
- Administer glucose bolus
- Begin IV glucose (10 % dextrose, 6-8 mg/kg/min)
- Recheck laboratory glucose (? etiology)
- Symptoms clear → transient neonatal hypoglycemia
- Symptoms clear but recur → increase IV glucose rate
  - ? etiology – pituitary abnormality, hyperinsulinism, inborn error
- Symptoms persist with normoglycemia
  - ? etiology - CNS, CV disease, sepsis, drug effect

IV Glucose Bolus

- Dose = 200 mg/kg of glucose
- Equals 2 ml/kg of 10% dextrose
- Glucose content IV solutions
  - 10% dextrose = 100 mg glucose per ml

Glucose calculations

- 3 kg neonate, receiving 9ml/hr of 10% dextrose
- (10% dextrose = 100 mg/ml glucose)
- $\frac{9 \text{ ml/hr} \times 100 \text{ mg/ml}}{3 \text{ kg}} = 300 \text{ mg/kg/hr}$
- $\frac{300 \text{ mg/kg/hr}}{60 \text{ min/hr}} = 5 \text{ mg/kg/min}$

Drug Therapy

- Uncommon
- Steroids
- Glucagon
- Epinephrine

HYPERGLYCEMIA

Neonatal Hyperglycemia

- As survival of ELBW increase, hyperglycemia incidence increases…
- Etiology: excessive IV glucose, physiologic & biochemical mechanisms → excessive glucose production, insulin resistance, glucose intolerance
- Definition: whole blood glucose > 120-125 mg/dl, plasma glucose > 145-150 mg/dl
- Signs: asymptomatic, osmotic diuresis, weight loss, failure to thrive, fever, glycosuria, ketosis, metabolic acidosis

Pathogenesis

- Disordered glucose homeostasis with decreased maturity
- Inadequate insulin release in response to hyperglycemia
- Post-insulin receptor problems
- Delays in insulin sensitivity due to hormone function
- Excessive glucose production
  - Stress, common in ELBW

Clinical settings…

- Low birth weight
- Preterm
- Critically ill
- Glucose administration
- Excessive lipid administration
- Stress
- Insulin resistance
- Transient neonatal diabetes
- Medications
  - Caffeine, steroids, catecholamines, dilantin

Complications

- Hyperosmolarity
- Osmotic diuresis
- Polyuria, glucosuria
- Dehydration
- Cerebral hemorrhage (IVH)
- Increased CO_2
- Electrolyte imbalance

Treatment

- Confirm bedside screen
- Note IV dextrose concentration, meds
- Assess: urine output, SG, urine dipstick, serum electrolytes, weight, total fluid administration
- Decrease exogenous glucose administration
- Feed as appropriate
- Exogenous insulin administration

Neonatal Insulin Use

- Initiation guidelines controversial
- Most begin use: glucose > 300-400 mg/dl
- Continuous infusion (0.02-0.05 units/kg/hr)
- SQ administration possible
- Risk of hypoglycemia, hypokalemia
- Variable IV delivery due to insulin adsorption to plastic tubing

Insulin Infusion

- Use regular insulin U 100 (100 units/ml)
- Make dilution
  - 0.1 ml of U 100 (10 units) + 9.9 ml NSS = 10ml fluid
  - Or 10 units in 10 ml (1 unit / ml)
- Units/kg/hr x wt x volume to prepare = units to place in volume to IV infusion rate prepare
- Example
  - 0.05 units/k/g/hr weight 900g IV rate 0.5 ml/hr
  - 0.05 x .9 x 50 ml = 4.5 units
    0.5cc.hr

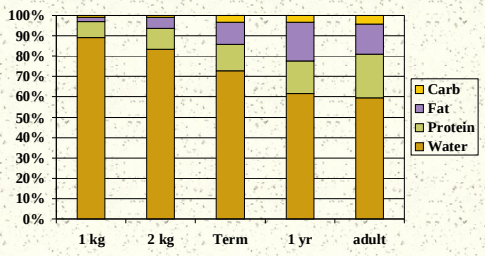
FLUID BALANCE

Neonates are NOT small adults !!

Fluid imbalance due to…

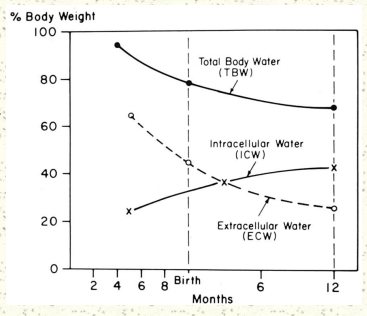
- Excess
  - Renal failure
  - Decreased CO, CHF
  - Cellular hypoxia
  - Inflammation
  - IV overload
  - Increased Na intake
  - Venous pooling
  - Poor lymphatic drainage
- Deficit
  - Hypovolemic shock
  - 3rd spacing of fluids
  - Infection
  - Ostomy, wound drainage
  - Electrolyte imbalance
  - Acid-base imbalance
  - Vomiting
  - Diuretics
  - Renal immaturity
  - Increased IWL

Body composition

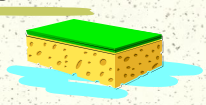


Body water distribution

- Intracellular
- Extracellular
  - intravascular
  - interstitial



Keeping body water where it belongs…



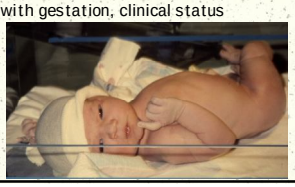
- BP
- Oncotic pressure
  - Plasma proteins / colloids act as "sponges"
  - Preterm neonates have low albumin levels
- Fluid shifts into 3rd space
  - Fluid in interstitial space
  - Physiologically useless
  - Seen with NEC, surgery, asphyxia, sepsis

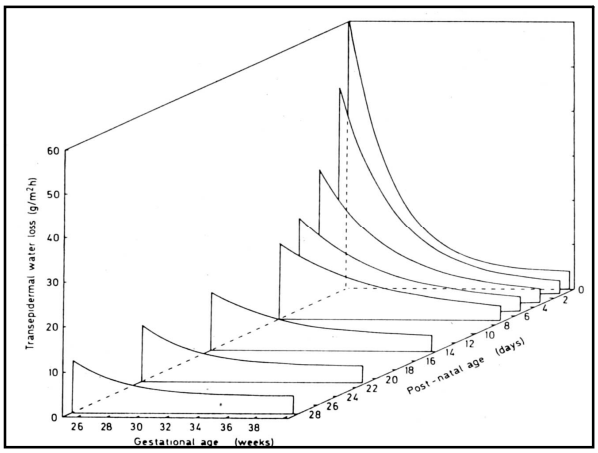
Fluid requirements

- Change daily
- ↑metabolism ↑need
- Depend on
  - TBW composition
  - GI losses
  - Urine output
  - Abnormal losses
    - Abdominal wall defects, ostomy, vomiting, diarrhea
  - IWL

Insensible water loss (IWL)

- Continuous, "invisible" water lost across skin & respiratory tract; excludes sweating
- Exact amounts difficult to predict
  - Respiratory 10-20 ml/kg/day
  - Across the skin 25-35 ml/kg/day
  - Varies with gestation, clinical status





IWL in preterm neonates

- Large surface area to body weight
- Little SQ fat
- Thin epidermis
- Increased total body water
- Fluid in ECF compartment
- Spread eagle posture

Influences on IWL

- Increase
  - Prematurity
  - Respiratory distress
  - Radiant warmers
  - Heat lamps
  - Photo therapy
  - Activity
  - Cold stress
  - Ambient temperature beyond NTE
- Decrease
  - Heat shields
  - Thermal blankets
  - Double wall incubator
  - Clothing
  - Humidity
  - Fewer air currents

Assess fluid balance

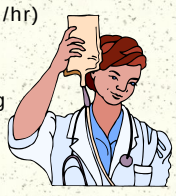
- Assess
  - Weight
  - Vascular volume
    - Hct, BP
  - Perfusion
  - Time to first void
  - Serum electrolytes & osmolaltiy
  - Urine
    - SG, osmolality, electrolytes, pH

Complications of fluid overload

- Edema
- PDA
- Worsening of respiratory distress
- Chronic lung disease
- NEC

Daily fluid requirements

- Fluid needs =
  IWL + urine loss + GI loss + abnormal loss – oxidation of water
  - IWL = 45 ml/kg
  - Urine loss = 48 ml/kg (2ml/kg/hr)
  - GI loss = 10 ml/kg
  - Abnormal loss = ??
  - Oxidation of water = 10 ml/kg



Neonatal fluid requirements

- Begin with 60-80 ml/kg/day (preterm), 100 ml/kg/day (term)
- Increase by 10-20 ml/kg/day
- Adjust fluids based on need
- Total fluids ~ 150 ml/kg/day
- Variation with gestation, clinical status, disease process

Case 1

- Day 1 of life, 32 wk AGA, BW 2 kg, mild respiratory distress, NCPAP, no stool as yet, voiding
- Rate (ml/hr) to infuse PIV of 10% dextrose?

Case 2

- Day 2 of life, 26 wk AGA, BW 758g, respiratory distress requiring mechanical ventilation, on radiant warmer, asphyxia history, poor urine output
- Current fluids
  - UAC ½NS with heparin at 1 ml/hr
  - double lumen UVC
    - Dopamine (3 mcg/kg/min) 10% dextrose at 1 ml/hr
    - Maintenance IV fluids

Case 2 (continued)

- What is the needed maintenance fluid infusion rate?

Case 2 (continued)

- Is the neonate receiving adequate glucose?

Case 3

- Day 4 life, FTN (born via C-section), 3.5 Kg, full PO feedings (formula), feeding every 4 hours
- What volume of formula is appropriate every 4 hours?