



THE UNIVERSITY OF
JORDAN



PRINCIPLES OF PEDIATRIC ANESTHESIA

Department of anesthesia and ICU

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Children are not
little adults!

Different Anatomy

Different Physiology

Different Pharmacology

Different psychology

Different Approach and preparation

Introduction

- Pediatric anesthesia involves more than simply adjusting drug doses and equipment for smaller patients.
- Neonates (0–1 months), infants (1–12 months), toddlers (12–24 months), and young children (2–12 years of age) have differing anesthetic requirements.

- Safe anesthetic management depends on full appreciation of the physiological, anatomic, and pharmacological characteristics of each group.
- Indeed infants are at much **greater risk of anesthetic morbidity and mortality** than older children; risk is generally inversely proportional to age.
- In addition, pediatric patients are prone to illnesses that require unique surgical and anesthetic strategies.

DEVELOPMENTAL CONSIDERATIONS:

- A. THE CARDIOVASCULAR SYSTEM:

- ❖ Anatomic:

- Noncompliant left ventricle
- Residual fetal circulation
- Difficult venous and arterial cannulation

- ❖ Physiological:

1. Heart-rate-dependent cardiac output (Cardiac stroke volume is relatively fixed)

$$\text{CO} = \text{SV} \times \text{HR}$$

High Heart Rate to maintain CO

- 2. Increased heart rate
- 3. Parasympathetic (ANS) is more dominant
- 4. Reduced blood pressure
- 5. The vascular tree is less able to respond to hypovolemia with compensatory vasoconstriction. Intravascular volume depletion in neonates and infants may be signaled by hypotension without tachycardia.

Normal heart rate

Age (days) Rate

1-3 100-140

4-7 80-145

8-15 110-165

Age (months) Rate

0-1 100-180

1-3 110-180

3-12 100-180

Age (years) Rate

1-3 100-180

3-5 60-150

5-9 60-130

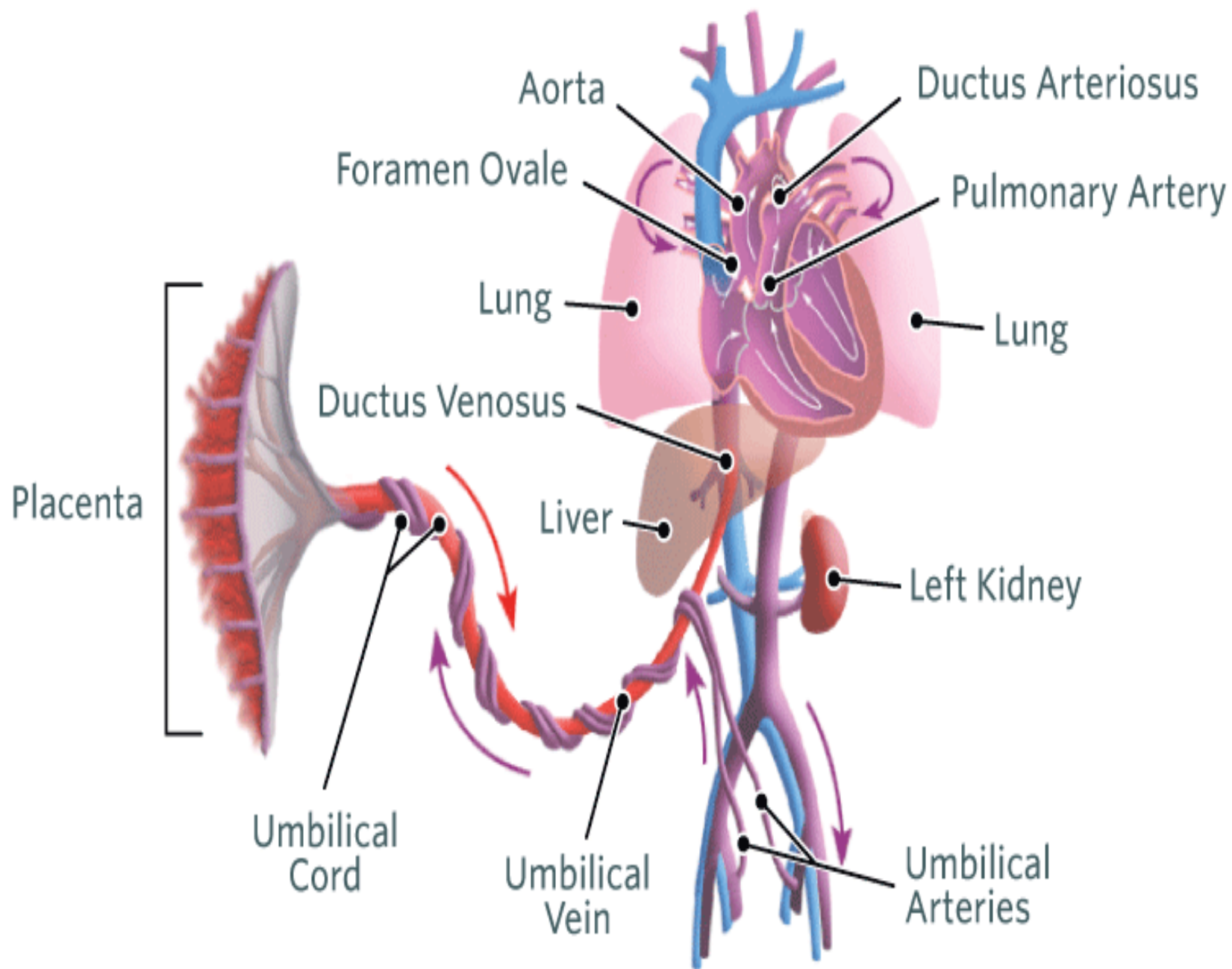
9-12 50-110

12-16 50-100

NOTE: Activation of the parasympathetic nervous system by:
anesthetic overdose,
or hypoxia can quickly trigger bradycardia and
profound reductions in cardiac output, that can lead to
hypotension, asystole, and
intraoperative death!!!

Transitional Circulation? And flip-flop?

It is the period between mechanical and anatomic closure
of the connections(foramen ovale, ductus arteriosus, and
ductus venosus)



Many factors (e.g., hypoxia, hypercapnia, anesthesia-induced changes in peripheral or pulmonary vascular tone and parasympathetic stimulation) can affect this precarious balance and result in a sudden return to the fetal circulation.

When such **a flip-flop** occurs, pulmonary artery pressure increases to systemic levels, blood is shunted past the lungs via the patent foramen ovale, and the ductus arteriosus may reopen and allow blood to shunt at the ductal level. A rapid downhill spiral may occur and lead to severe hypoxemia, which explains why hypoxemic events may be prolonged, despite adequate pulmonary ventilation with 100% oxygen.

B. The Respiratory System:

(Almost all cardiac arrest due to respiratory problem!)

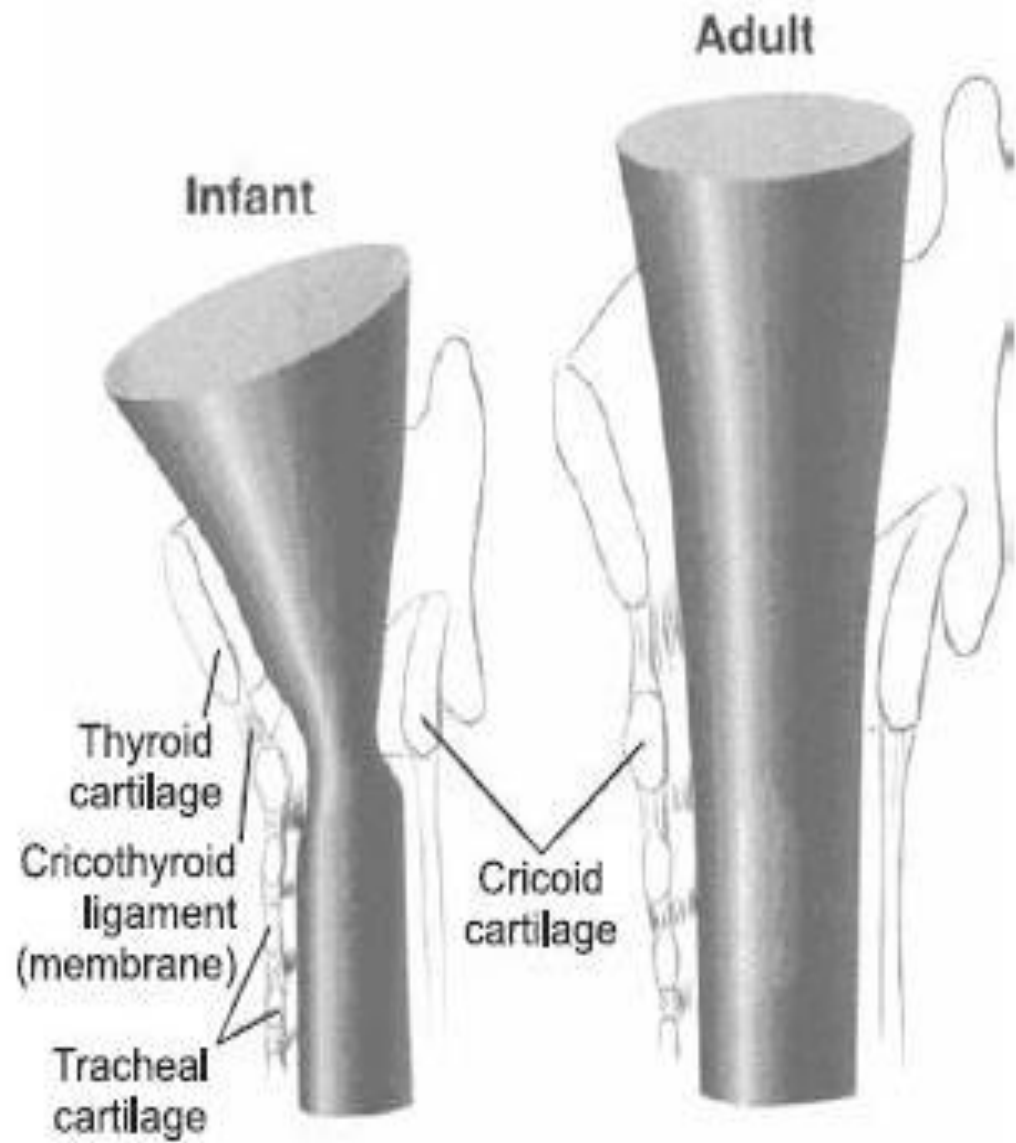
The pulmonary system is not capable of sustaining life until both the pulmonary airways and the vascular system have sufficiently matured to allow the exchange of oxygen from air to the bloodstream across the pulmonary alveolar-vascular bed.

***Independent life is not generally possible until a gestational age of 24 to 26 weeks

At Birth the respiratory system of infants differs from adults in:

- Large head and tongue, short neck
- Narrow nasal passages and small diameter of the airways
- More cephalad and anterior larynx, C4.
- The narrowest point of the A/W is the cricoid cartilage till 5 years
- Long and stiff epiglottis, U to Omega shape, touch the soft palate (easy airway obstruction)
- The vocal cords are angled; consequently, a blindly passed tracheal tube may easily lodge in the anterior commissure rather than slide into the trachea.
- Short trachea, 5 cm in neonates.
- The chest wall is highly compliant, therefore the ribs provide little support for the lungs; that is, negative intrathoracic pressure is poorly maintained.

- Obligate nose breathers until 5 months
- Horizontal ribs so ventilation is mainly diaphragmatic
- Small number of alveoli, low lung compliance,
- Low FRC but still they high minute ventilation and O₂ consumption(oxygen consumption is two to three times higher).
- Hypoxic and hypercapnic ventilatory drive are not well developed in neonates and infants....



That mean:

1. More likely potential for technical airway difficulties in infants than in teenagers or adults.

***Difficult intubation has been estimated to occurs in 0.5- 1% in pediatrics population.

2. Increased work of breathing. Example: In preterm infants, the work of breathing is approximately three times that in adults, and this work can be significantly increased by cold stress (i.e., increased metabolic demand for oxygen) or any degree of airway obstruction.
3. Risk of edema and airway resistance.
4. The resulting decrease in functional residual capacity (FRC) limits oxygen reserves during periods of apnea (eg,intubation attempts) and readily predisposes neonates and infants to atelectasis and hypoxemia.

5.

Small FRC

Alveoli numbers is 10 % of adults

Higher O₂ Consumption 6ml-7ml/kg Adults (3-4ml/kg)

Diaphragm in neonates and infants <2y easy fatigue (lacks the Type I muscle fibers)



Rapid desaturation

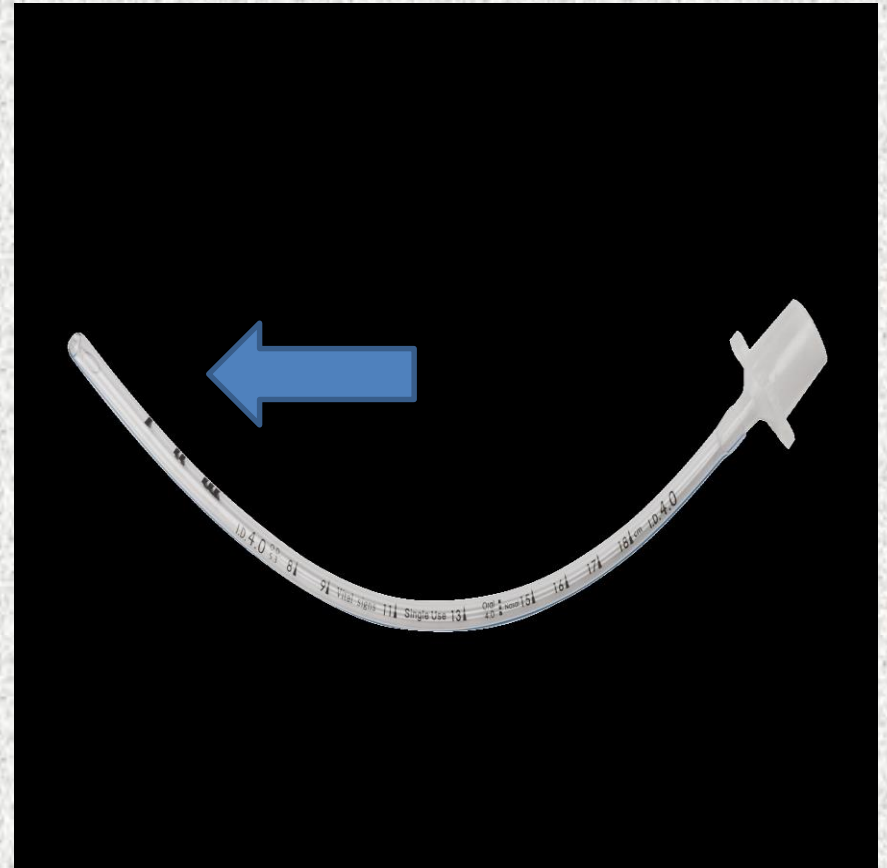
6. Risk of endobronchial Intubation

Age	Size—Internal Diameter (mm)
Newborns	3.0–3.5
Newborn–12 months	3.5–4.0
12–18 months	4.0
2 years	4.5
>2 years	$\text{ETT size} = (16 + \text{age})/4$

Neonates have reduced incidence of subglottic stenosis:

- ☐ Immature cartilage
- ☐ High water content in cartilage
- ☐ Less susceptible for ischemic injuries

Cuffed and uncuffed tracheal tubes



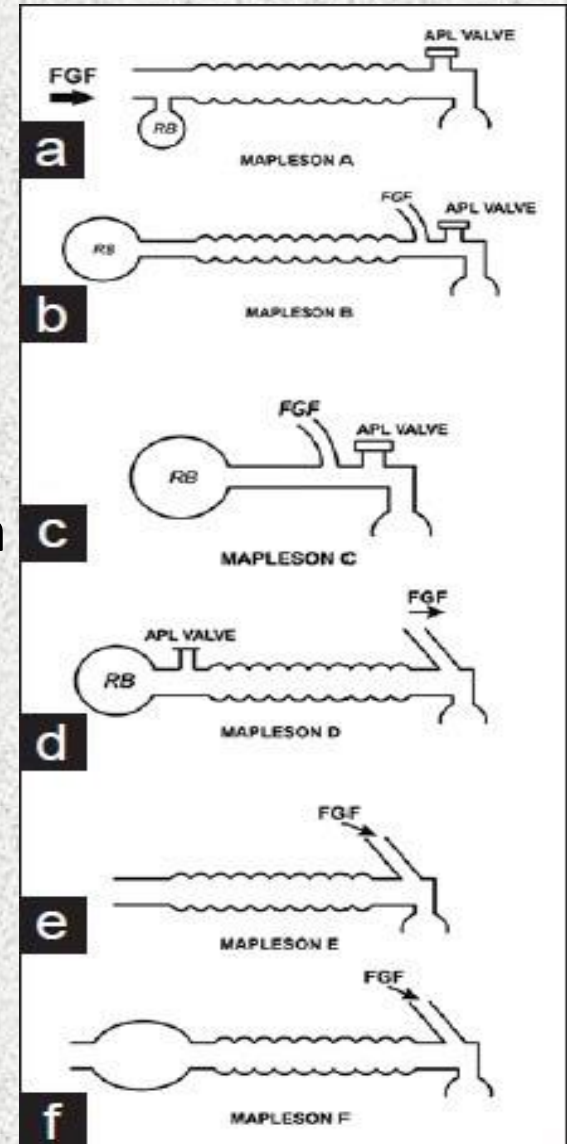
Breathing system



Jackson-Rees' modification of the Mapleson F system

Advantages of T-piece systems

- ☐ Compact
- ☐ Inexpensive
- ☐ No valves
- ☐ Minimal dead space
- ☐ Minimal resistance to breathing
- ☐ Economical for controlled ventilation



Aspiration Risk



Children < 3 years at greater risk of aspiration

- Higher incidence of GERD
- Short esophagus
- Limited stomach compliance
- Baby trust
- Excessive air swallowing during crying
- No muscle relaxants Inadequate anesthesia

PREOPERATIVE FASTING RECOMMENDATIONS IN INFANTS AND CHILDREN

Type Fasting Time (hrs)

Clear liquids 2

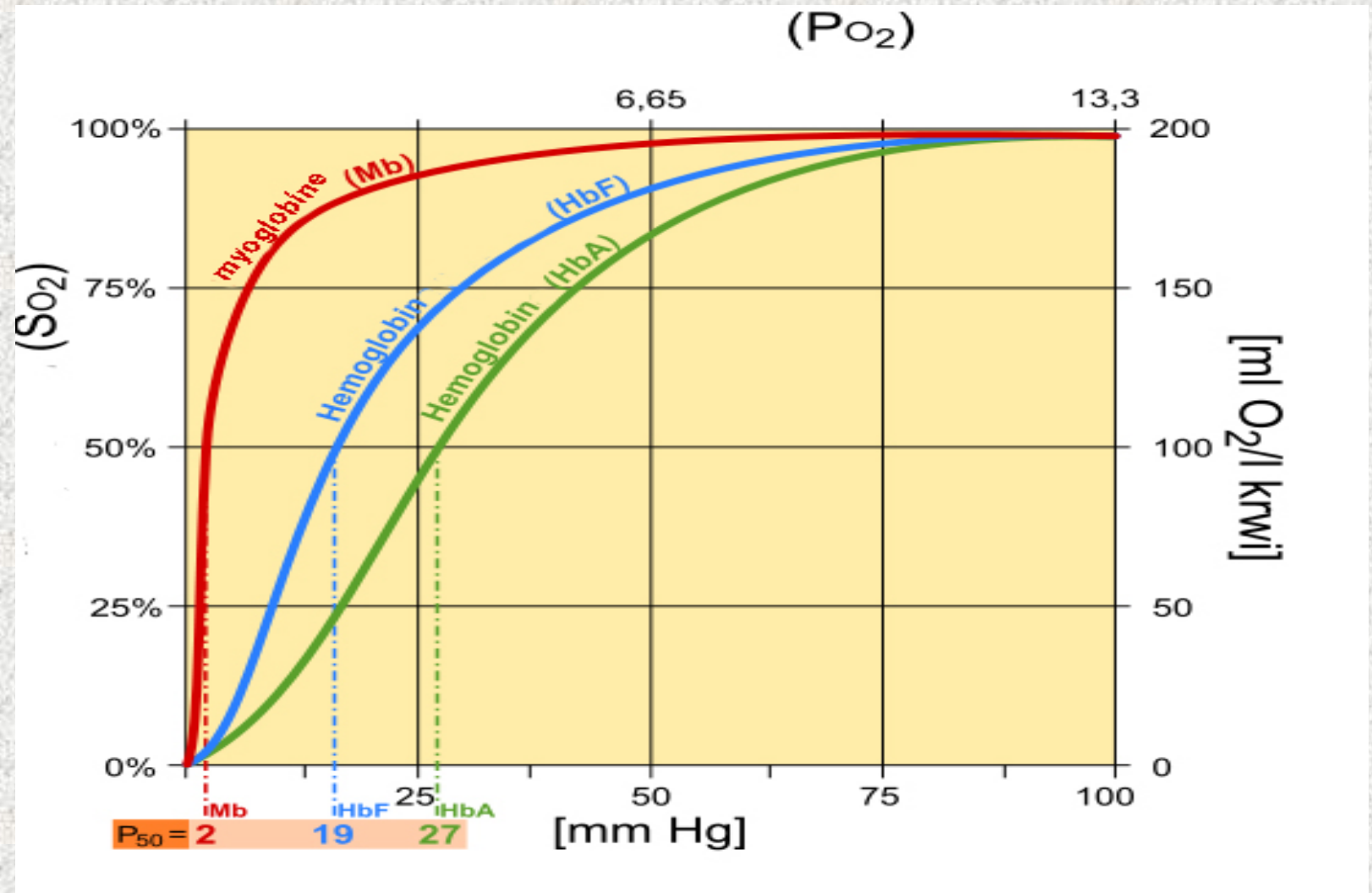
Breast milk 4

Infant formula 6

Solid (fatty or fried) foods 8

1. Less dehydration
(better induction hemodynamic profile)
2. Less agitation and crying
Promotes motility
3. Decrease gastric volume and PH

Neonatal period the HB is HbF .HbF has high affinity to O₂P50 is HbF decline with age
HbA peaks at 9 month



Thermoregulation

- Greater heat loss
 - Thin skin
 - Low fat content
 - High surface area/weight ratio
- No shivering until 1 yo
- Thermogenesis by brown fat
- More prone to iatrogenic hypo/hyperthermia





Large surface area relative to body weight(2-2.5x BW)

Thin skin and subcutaneous fat(less insulation)

Neonates no shivering

Immature thermoregulation center

Maintenance Fluid Therapy:

Replace Deficits, losses, and bleeding by isotonic fluid like Lactated Ringer (not glucose containing fluid) Risks of Hyperglycemia

Term Newborn (ml/kg/day)

Day 1 50-60 D10W

Day 2 100 D10 1/2 NS

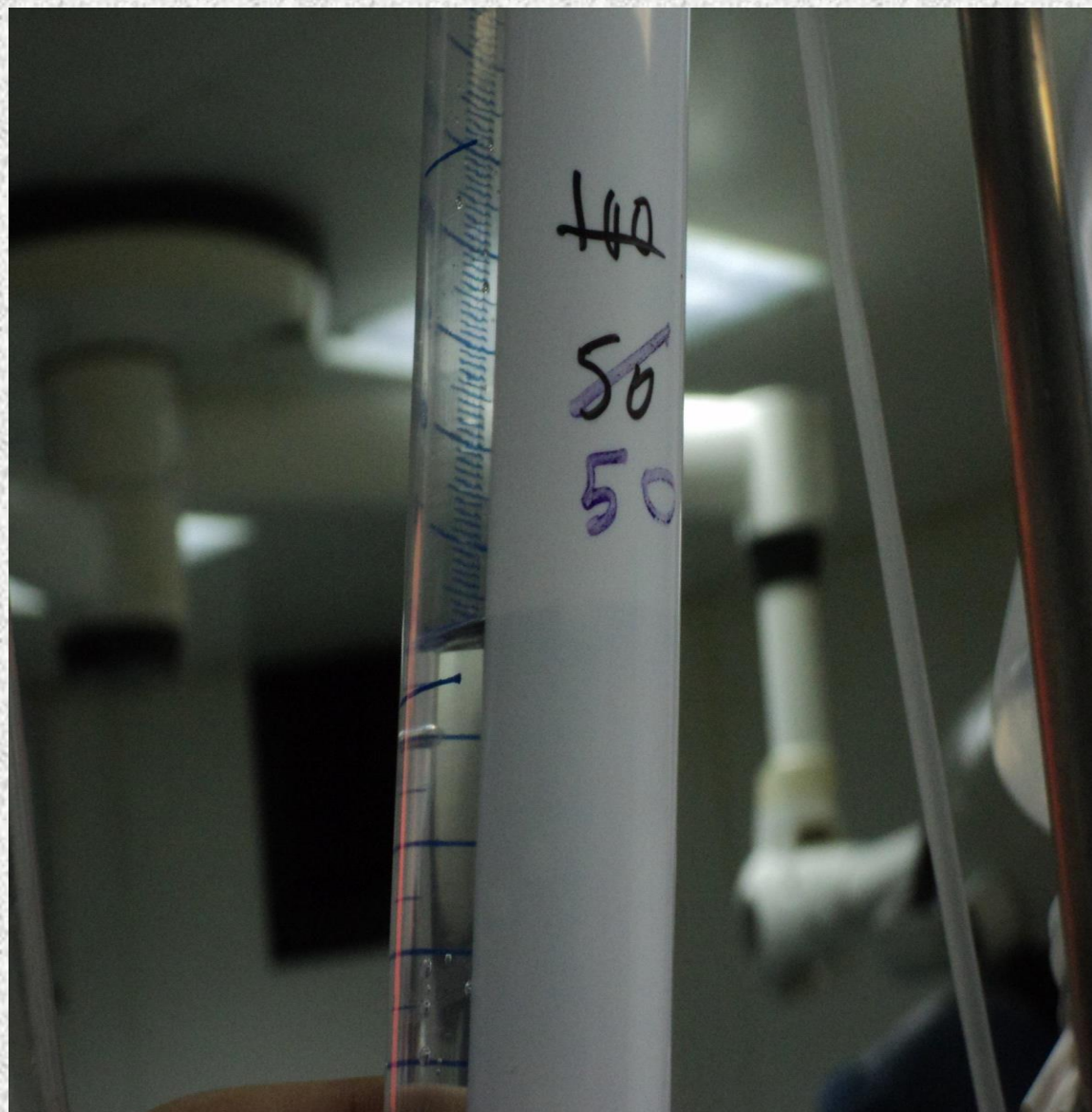
>Day 7 100-150 D5-D10 1/4 NS

Older Child: 4-2-1 rule:

4 ml/kg/hr 1st 10 kg +

2 ml/kg/hr 2nd 10 kg +

1 ml/kg/hr for each kg > 20



Include dextrose in the maintenance hydration fluid (Dextrose 1% or Dextrose 2.5%)

*Risk of Hypoglycemia is higher in Premature

**Sick babies(malnutrition , cardiac)

****Regional anesthesia! Why?

*****Glucose infusion

- ❖ **Immature Kidney and liver functions** more free fraction of medication leads to greater effect of the high protein bounded drugs:
 - Barbiturates
 - Bupivacaine
 - Alfentanil
 - Lidocaine
- ❖ Water soluble Drugs will distribute more,so a higher loading dose to achieve desired serum levels is required:
 - Muscle relaxants
 - Antibiotics
- ❖ Drugs that redistribute to fat have larger initial peak levels (Opioids are more potent)
- ❖ Less muscle mass (more sensitive to muscle relaxants)
- ❖ **Delayed metabolism and excretion**

Induction of GA

IV[better] or inhalational?





MAC

HIGHER MAC

Highest MAC in infants 6 months
and 1 year

Fast induction !How?

- Greater Alveolar ventilation to FRC ratio
- High cardiac out put to vessel rich organs(brain)
- Reduced tissue blood solubility



SVOFLURANE
HALOTHANE



ISOFLURANE
DESFLURANE

URTI

- **Symptoms new or chronic?**

- Infectious vs allergic or vasomotor

- **Viral infection within 2 - 4 weeks of GA with intubation increases perioperative risk**

- Wheezing risk increased 10x

- Laryngospasm risk increased 5x

- Hypoxemia, atelectasis, recovery room stay, admissions and ICU admissions all increased

- **If possible, delay nonemergent surgeries**

Intravenous access may be DIFFICULT!! or even impossible!!!

Keep **Intraosseous** option in your mind can be used for

- drug administration
- And fluid replacement
- blood sampling

Laryngospasm

Etiology

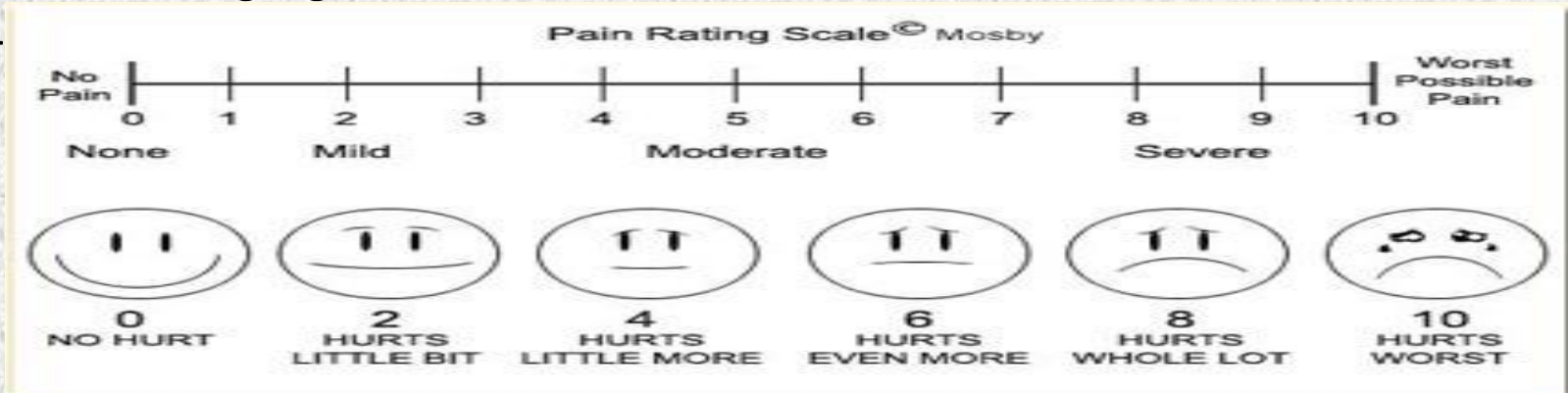
- Involuntary spasm of laryngeal musculature
 - Superior laryngeal nerve stimulation
- Risk increased
 - Extubated while lightly anesthetized
 - Recent URI
 - Tobacco exposure

Treatment

- Positive pressure ventilation (PEEP>10cmH₂O)
 - Laryngospasm notch
 - Propofol
 - 0.5–1 mg/kg IV
 - Succinylcholine
 - 0.2-0.5 mg/kg IV
 - 2-4 mg/kg IM
- And intubation

Perioperative pain control

- Regional
- Acetaminophen
 - PO 10-15 mg/kg, PR 40 mg/kg
- NSAIDs
- Ketorolac 0.5-0.75 mg/kg IM/IV
- Opioids
 - Morphine 50-100 mcg/kg
 - PCA 20 mcg/kg 10 min lockout(>8 years old)
 - Hydromorphone 10-20 mcg/kg
 - PCA 5 mcg/kg 10 min lockout



Regional Anesthesia:

- it decrease anesthetic requirements
- Operative and postoperative utility
- **Caudal block is the most common**
- Options in adults available for children:
 - Peripheral blocks and catheters
- Epidural
- Spinal

Monitoring:

- BP
- blood sugar for neonates (Neonates have low glycogen stores ..risk of hypoglycemia)
- a precordial stethoscope
- ECG
- pulse oximeter and capnography
- Temperature: rectal, esophageal, nasopharynx.
- A/W pressure monitoring.

Malignant hyperthermia

- Acute hypermetabolic state in muscle tissue
- Triggering agents
 - Volatile agents
 - Succinyl Choline
- Incidence
 - 1:15,000 peds
 - 1:40,000 adults
- MH may occur at any point during anesthesia or emergence
- Recrudescence despite treatment

MH anesthesia

- Family history
 - Muscle bx → caffeine contracture test
 - +/- Ryanodine receptor abnormality
- High flow O2 flush circuit x 20 min
- Nontriggering
 - TIVA, Nitrous

Increased risk of MH:

- Duchenne's muscular dystrophy
- Central core disease
- Osteogenesis imperfecta
- King Denborough syndrome

Classic signs of MH

Specific

- Rapid rise in EtCO₂ early sign
- Rapid increase in temp late sign
- Muscle rigidity +/-
- Rhabdomyolysis
 - Increase CK
- Myoglobinuria

Nonspecific

- Tachycardia
- Tachypnea
- Acidemia
 - Metabolic
 - Respiratory
- Hyperkalemia
- Dysrhythmias

MH treatment

- Discontinue triggering agents
- Hyperventilate with 100% FiO₂
- NaHCO₃ 1-2 mEq/kg IV
- Dantrolene 2.5 mg/kg IV
- Cool patient
- Support as indicated → intropes, dysrhythmias
- Monitor labs
- Consider invasive monitoring
- 1 800-MH-HYPER

Questions?

THANK YOU ALL