



THE UNIVERSITY OF
JORDAN



PRINCIPLES OF PEDIATRIC

Department of anesthesia and ICU

ANESTHESIA

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Children are not
little adults!

Different Anatomy

Different Physiology

Different Pharmacology

Different psychology

Different Approach and preparation

Introduction

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

- o Safe anesthetic management depends on full appreciation of the physiological, anatomic, and pharmacological characteristics of each group.
- o Indeed infants are at much **greater risk of anesthetic morbidity and mortality** than older children; risk is generally inversely proportional to age.
- o 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

*Age-related changes in vital signs:

Age	Heart rate	SBP	Resp. rate
Newborn	110-170	> 60	30-50
1 year	100-160	> 80	< 40
5 years	80-130	> 90	< 30
> 10 years	< 90	> 90	< 20

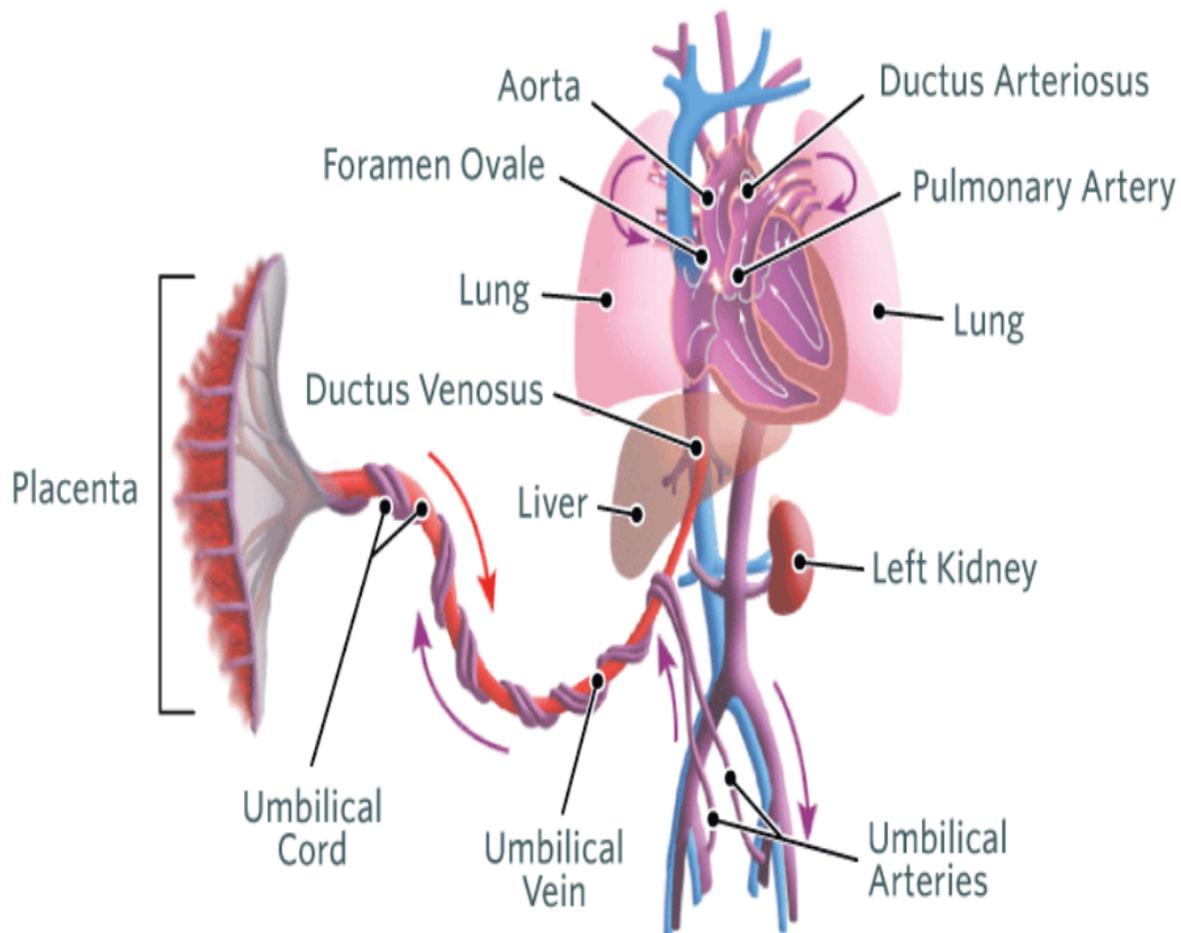
NOTE: Activation of the parasympathetic nervous system by:
anesthetic overdose,
or hypoxia can quickly trigger bradycardia and
profound reductions in cardiac output, that can lead to
hypotension, asystole, and
intraoperative death!!!

Fetal circulation moves to transitional circulation(critical period) then to adult circulation

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:

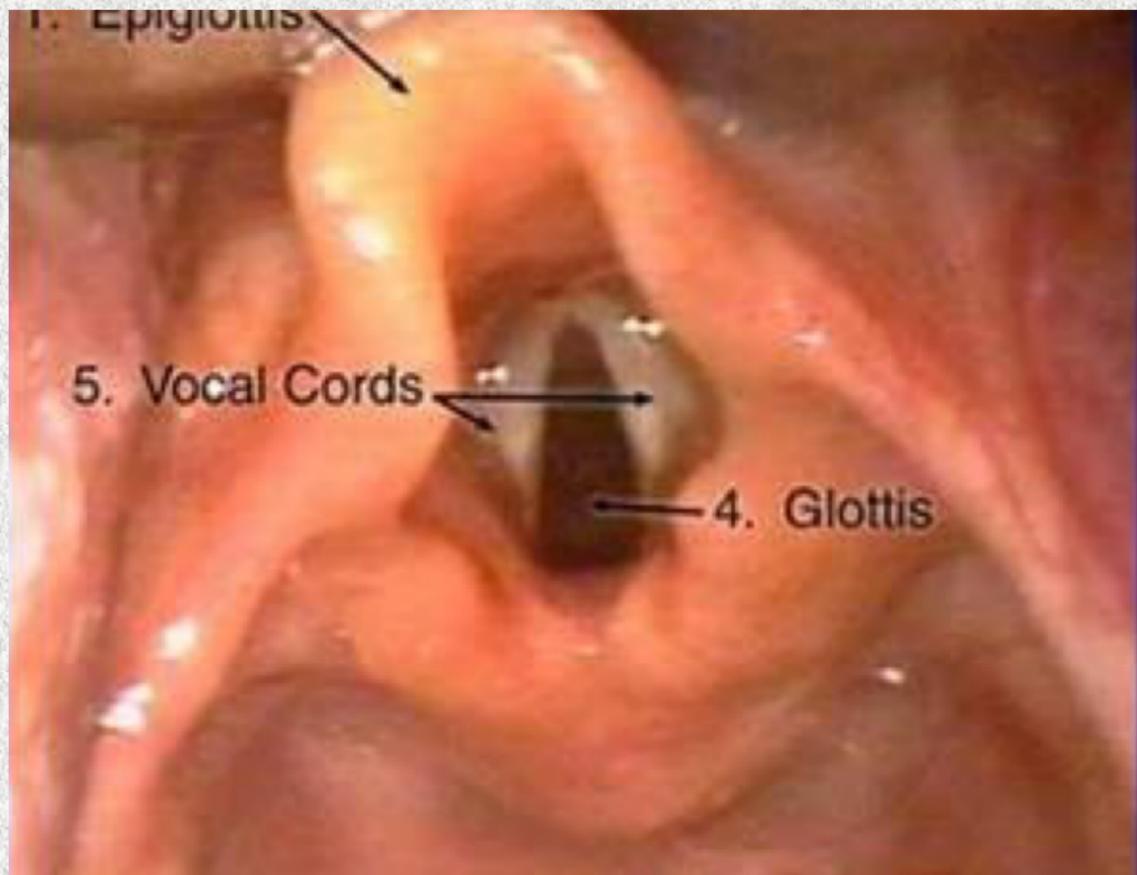
(Almost all cardiac arrest due to respiratory problem!)

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.

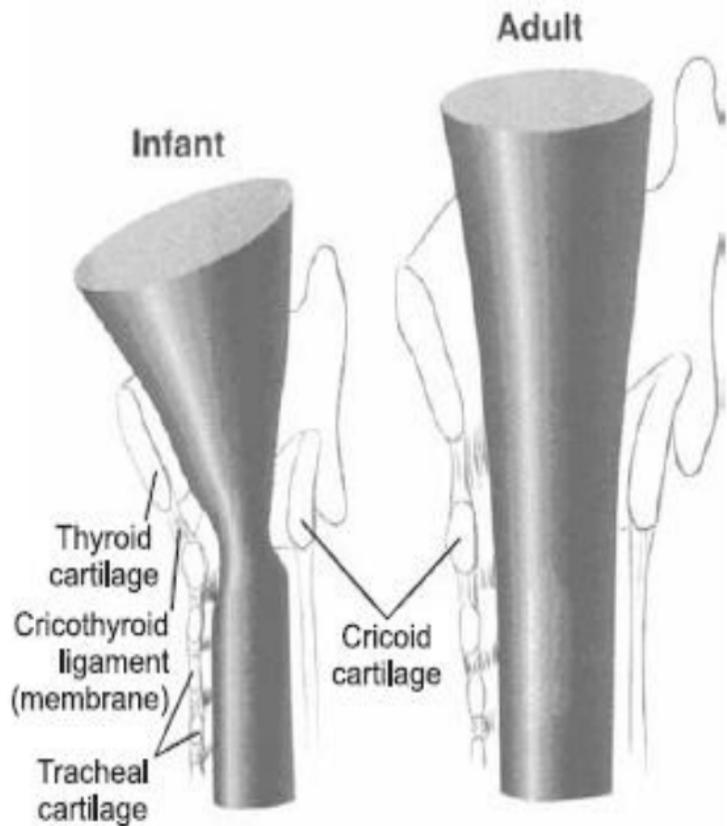
***Independent life is not generally possible until a gestational age of 24 to 26 weeks

At Birth(neonates) the respiratory system 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 nasal breathing until 5 months
- Horizontal ribs so ventilation is mainly diaphragmatic
- Small number of alveoli, low lung compliance,
- **Low FRC and high 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; (small diameter) 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

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

5. Risk of endobronchial Intubation

- ❖ **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**

Age

Size—Internal Diameter (mm)

Newborns

3.0–3.5

Newborn–12 months

3.5–4.0

12–18 months

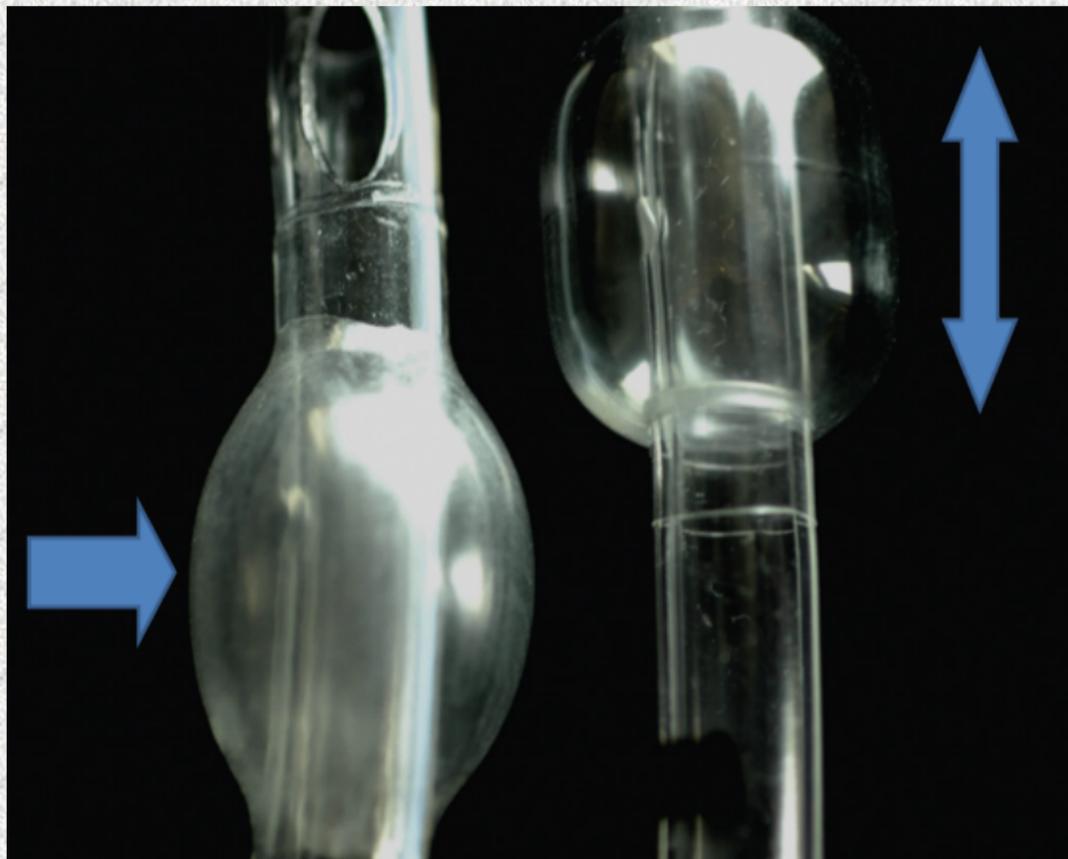
4.0

2 years

4.5

>2 years

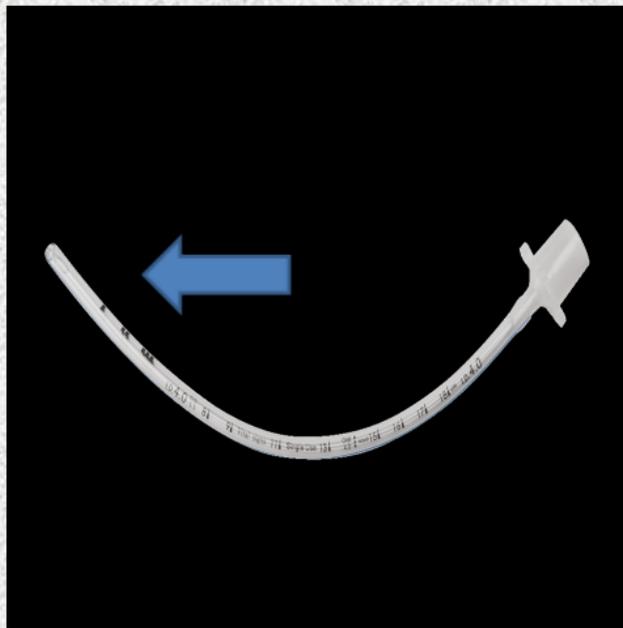
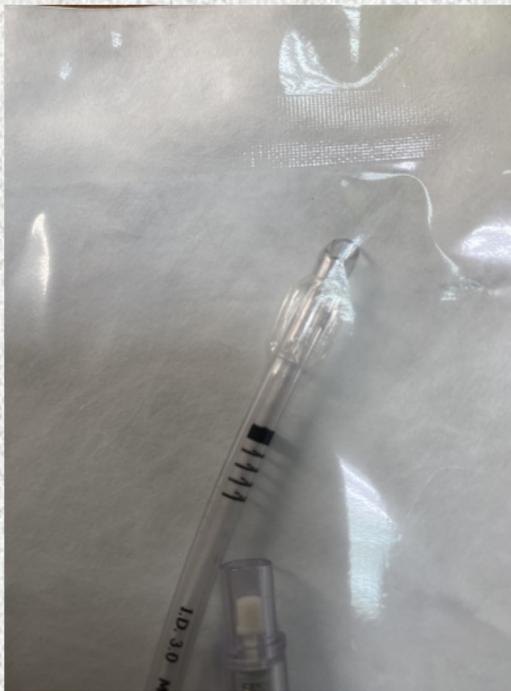
ETT size = $(16 + \text{age})/4$



Neonates have reduced incidence of subglottic stenosis:

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

Cuffed and uncuffed tracheal tubes





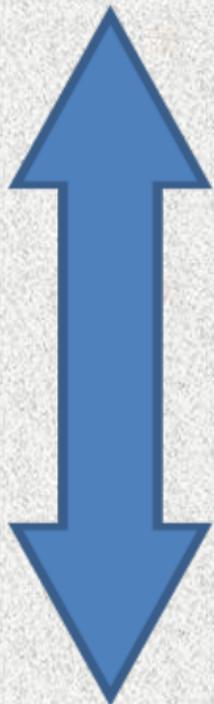
Breathing system



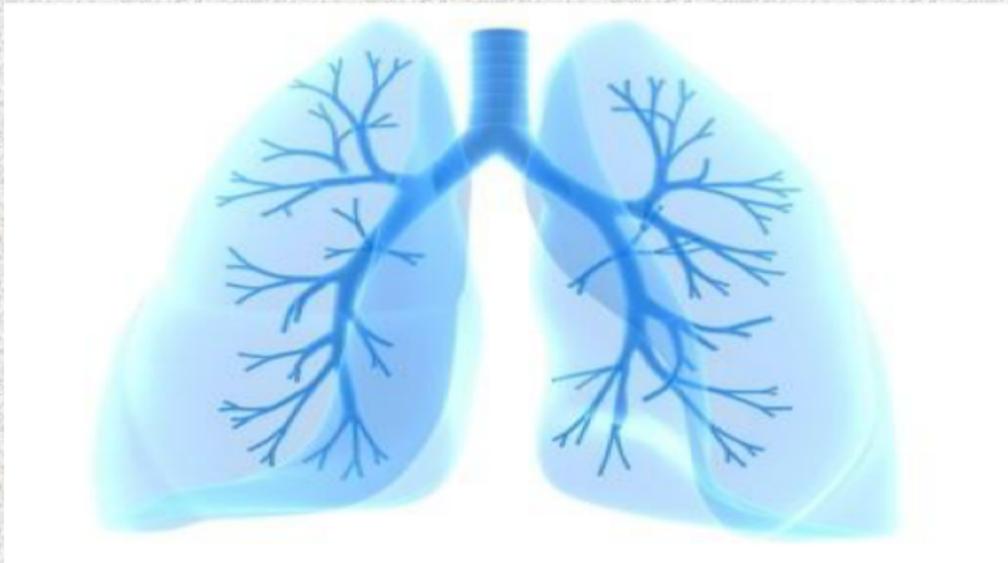
Jackson-Rees' modification of the
Mapleson F system

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

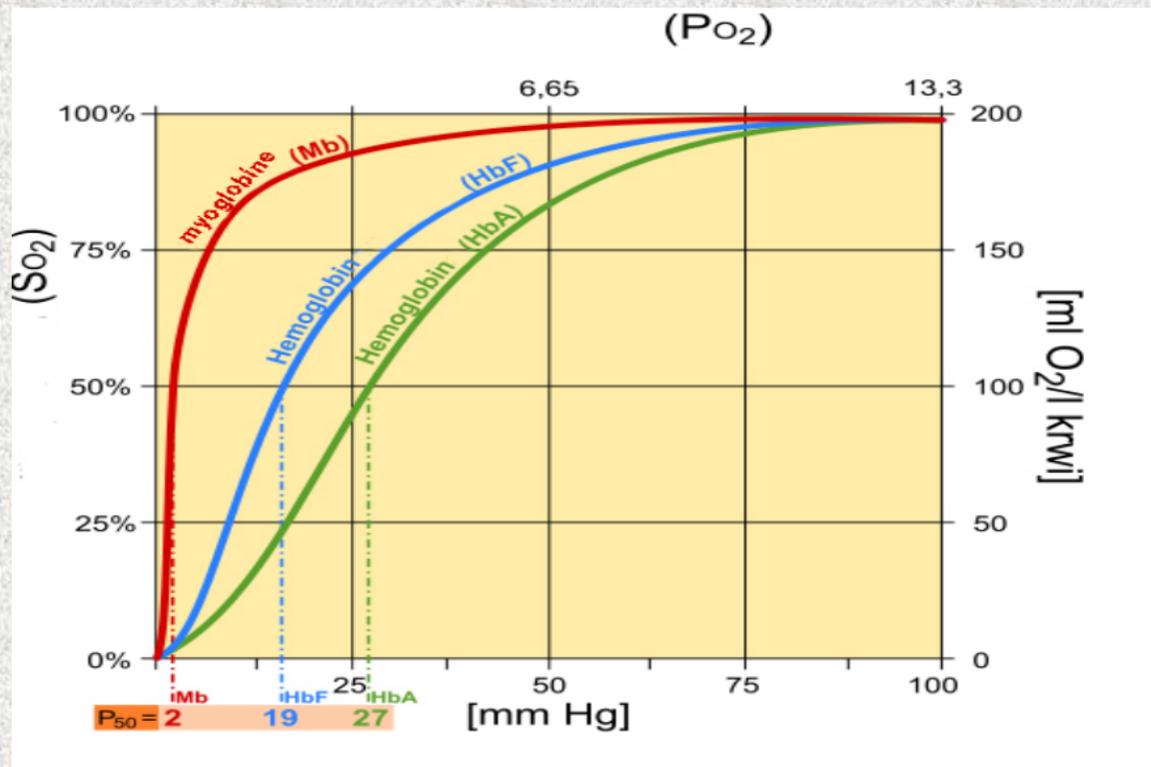
Solid (fatty or fried) foods 8



Encourage water intake within two
hours

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



Forced air warming systems always available
Fluid warmer
Room temperature





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

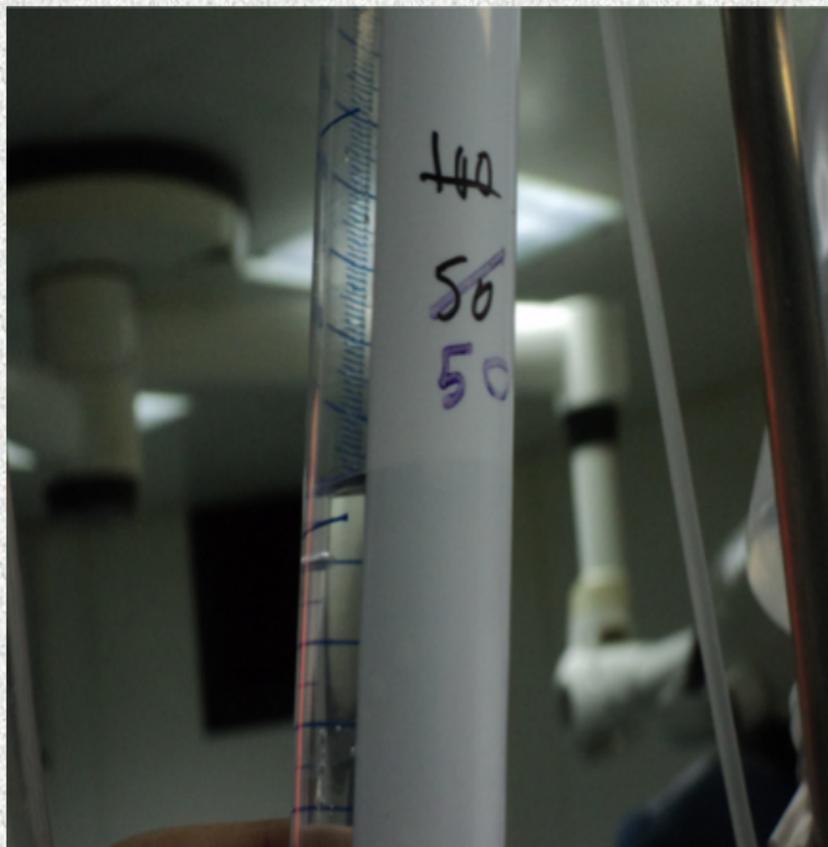
>Day 7 100-150 D5-D10 1/4 NS

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

Preoperative Psychological Care:

Assessment of current clinical status and alleviate fear and anxiety of the child and family

- 1.The process of anesthetizing an infant or child and the associated risks must be demystified during the preoperative visit since parents often have more anxiety about their child undergoing anesthesia than they do for themselves.
- 2.An opportunity for the anesthesiologist to evaluate the child psychological status and family interactions.
- 3.As infants begin to differentiate their primary caregivers from others, they develop a previously absent wariness of strangers.

This change begins to occur at approximately **eight months** of age, whereas infants younger than this will usually separate easily from their primary caregiver.

A discussion of the infant's behavior and the presence of **stranger anxiety** should be included in the preoperative interview so that the anesthesiologist may obtain a sense of how easily the infant will separate (**Separation Anxiety**) from the parent and how anxious the parent is.

< Prior to the onset of stranger anxiety in an infant, **parental presence is not required** or advisable during the induction of anesthesia; therefore parents of young infants should not be invited into the operating room.

An explanation of what will occur after the infant is taken from the parents is usually sufficient.

If stranger anxiety is already present in an older infant, then **a parent may be invited into the operating room** until the child is unaware of his or her presence if the anesthesiologist feels it would be safe.

Premedication :

****Parental presence, distraction, and premedication** have all been used successfully, but no single strategy is effective for all children.

When the need for premedication arises, **the standard agent of choice has been midazolam(Syrup)**, which has been shown to be effective in infants not only for premedication but to decrease anxiety during interventional procedures performed without general anesthesia.

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

Pediatric psychology

Pediatric Perioperative anxiety

Highest incidence 1-5 years

Anesthesia induction is the most stressful procedure in the perioperative period



1. Parental presence induction anesthesia (PPIA)
2. Comfortable separation in the holding area usual (from 1 to 5 years old)
3. >6 years: Child becomes primary focus. Explain exactly what will happen; what you will do then do it that way. (Be trustworthy!)
4. Pharmacologic interventions:
Midazolam is most commonly used as syrup orally (0.5mg/kg) or IV injection
Propofol is a proper option also.



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

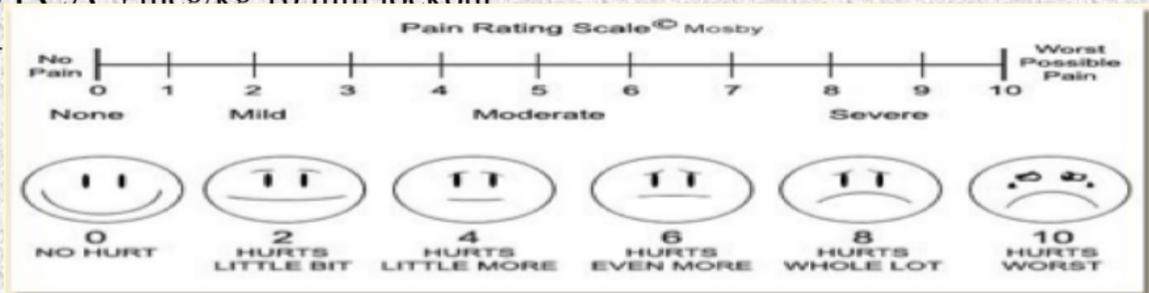
- Involuntary spasm of laryngeal musculature
 - Superior laryngeal nerve stimulation
- Risk increased
 - Extubated while lightly anesthetized
 - Recent URI
 - Tobacco exposure

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 (Caudal)
- Acetaminophen
 - PO 10-15 mg/kg, PR 40 mg/kg, IV 20mg/kg
- NSAIDS (diclofenac sodium suppository)
- 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

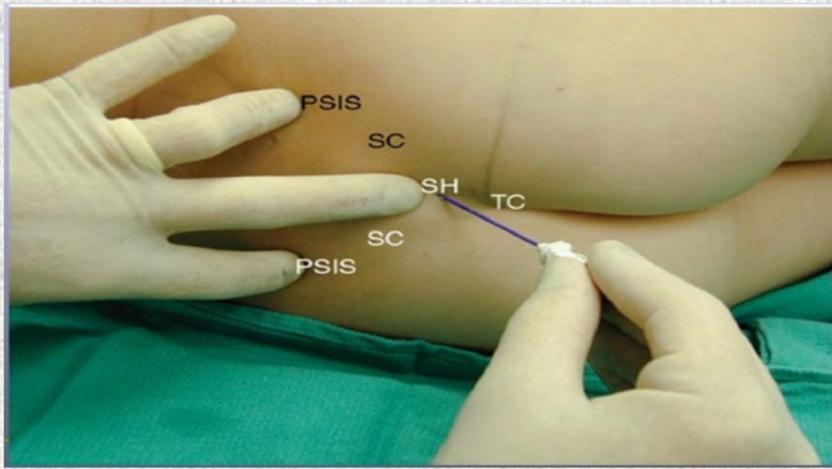


Regional Anesthesia:

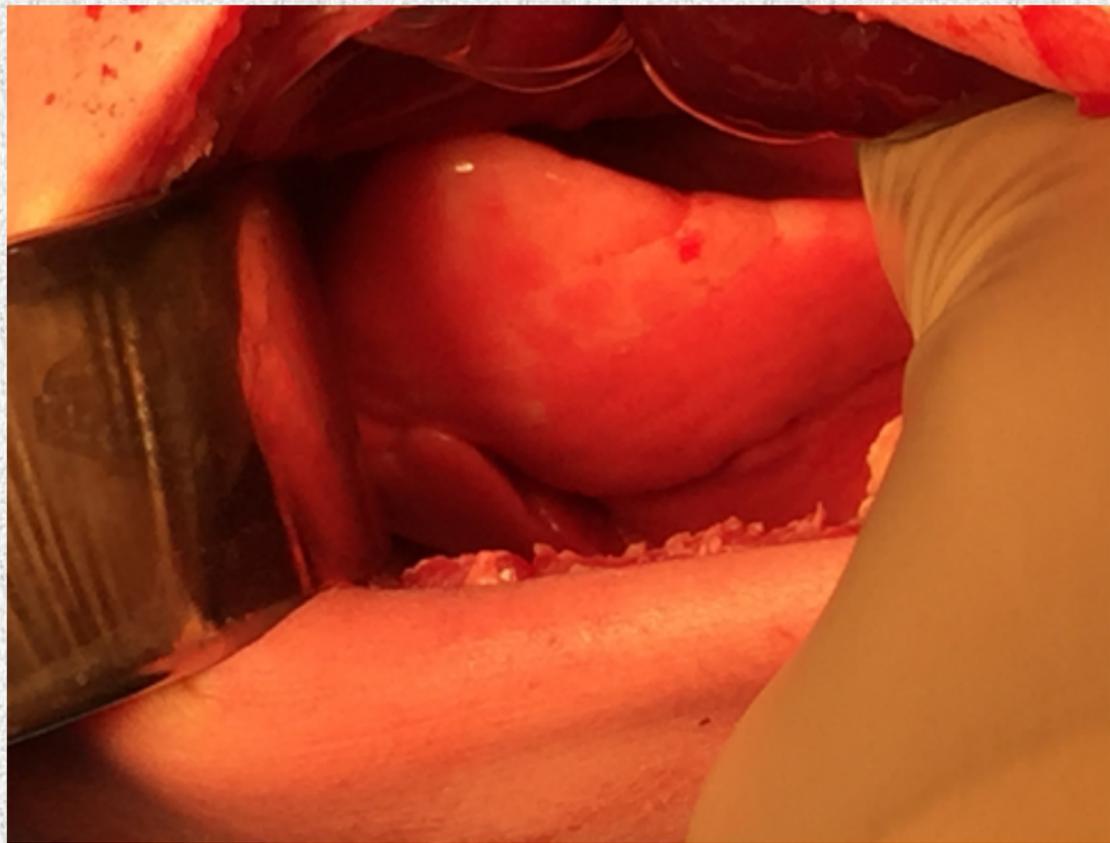
- it decrease anesthetic requirements
- Operative and postoperative utility
- **Caudal block is the most common**
- Options in adults available for children:
 - Peripheral blocks and catheters
- Epidural
- Spinal

Caudal

- Perioperative analgesia
 - **Ropivacaine 0.2% 1 cc/kg (up to 2 mg/kg)**
 - **Bupivacaine 0.25% 1 cc/kg (up to 2.5 mg/kg)**
 - Opioids
 - Duramorph 25-50 mcg/kg
 - Hydromorphone 5-10 mcg/kg
 - Clonidine 2 mcg/kg
- Minimal epidural fat
 - May advance catheter region







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
 - SuccinylCholine
- 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 +/-
- Rhabdomyolosis
- Increase CK
- Myoglobinuria

Nonspecific

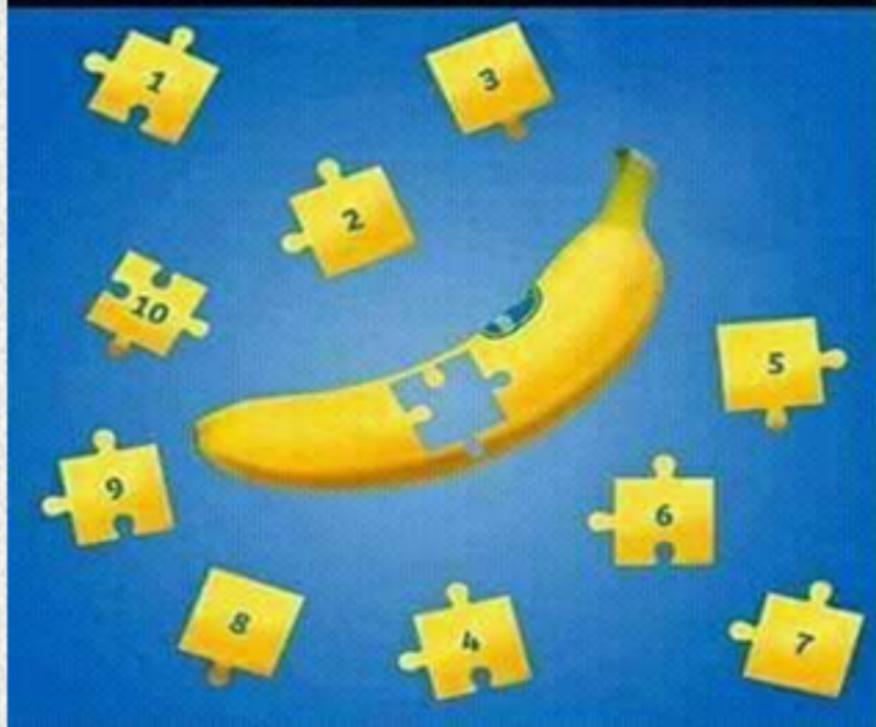
- Tachycardia
- Tachypnea
- Acidemia
- Metabolic
- Respiratory
- Hyperkalemia
- Dysrhythmias

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?

رقم القطعة الناقصة هو : ؟



THANK YOU
ALL