THE UNIVERSITY OF JORDAN

PRINCIPLES OF PEDIATRIC ANESTHESIA

Department of anesthesia and ICU

Dr Omar Ababneh

Pediatric Anesthesiologist

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PDA is a heart problem that is frequently noted in the first few weeks or months after birth. It is characterized by the persistence of a normal fetal connection between the aorta and the pulmonary artery which allows oxygen-rich (red) blood that should go to the body to recirculate through the lungs.

All babies are born with this connection between the aorta and the pulmonary artery. While your baby was developing in the uterus, it was not necessary for blood to circulate through the lungs because oxygen was provided through the placenta. During pregnancy, a connection was necessary to allow oxygen-rich (red) blood to bypass your baby's lungs and proceed into the body. This normal connection that all babies have is called a ductus arteriosus.

At birth, the placenta is removed when the umbilical cord is cut. Your baby's lungs must now provide oxygen to his or her body. As your baby takes the first breath, the blood vessels in the lungs open up, and blood begins to flow through them to pick up oxygen. At this point, the ductus arteriosus is not needed to bypass the lungs. Under normal circumstances, within the first few days after birth, the ductus arteriosus closes and blood no longer passes through it.

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.
- A preterm infant is one born before 37 weeks' gestation, a postmature infant is one born after 42 weeks' gestation.
- Any infant born weighing less than 2500 g is considered a low–birth-weight infant

- 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)

CO=SV x 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.

CO=SV *HR

In prenatal circulation, the oxygenated blood comes from umbilical vein. Most of it bypasses the liver by "ductus venosus." Then it goes straight to the right atrium. There is another supply that right atrium gets blood from, which is superior vena cava. Blood from inferior vena cava is much more highly oxygenated, and it goes into the foramen ovale to pass through to the left atrium and left ventricle. Blood coming out of aorta goes mainly to the head. The blood from superior vena cava pass down from right atrium to right ventricle. But since there is high resistance in pulmonary arteries as the lungs are not expanded, the blood is drained into arch of aorta via "ductus arteriosus." Then this mixed blood comes out of fetus by umbilical arteries.

*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

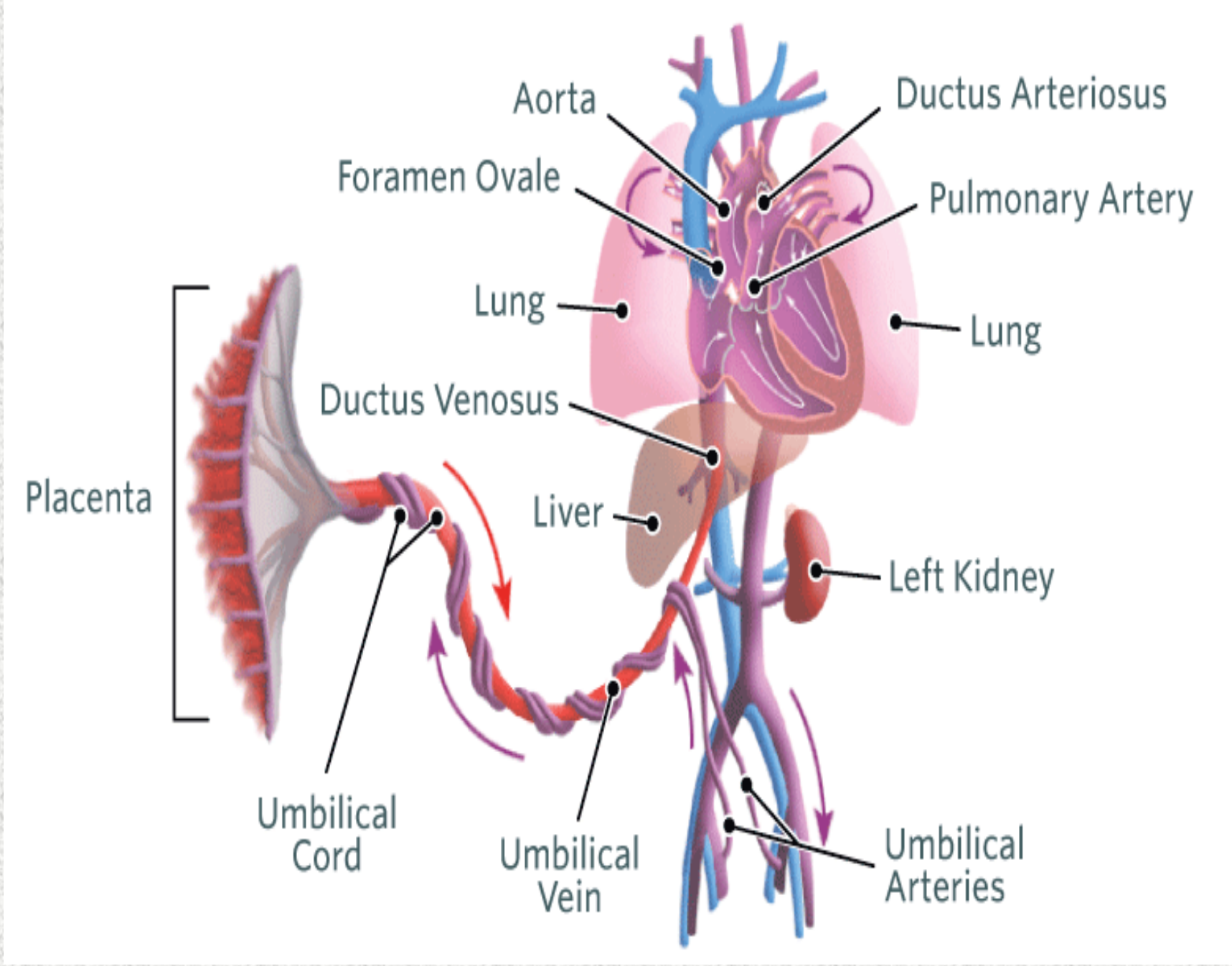
NOTE: Activation of the parasympathetic
nervous system by:
anesthetic overdose,
or hypoxia can quickly trigger bradycardia and
profound reductions in cardiac output, that can lead to
hypotension, asystole, and
intraoperative death!!!

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)

True mechanical closure by fibrosis does not occur until 2 to 3 weeks of age.


EPIDURAL



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

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

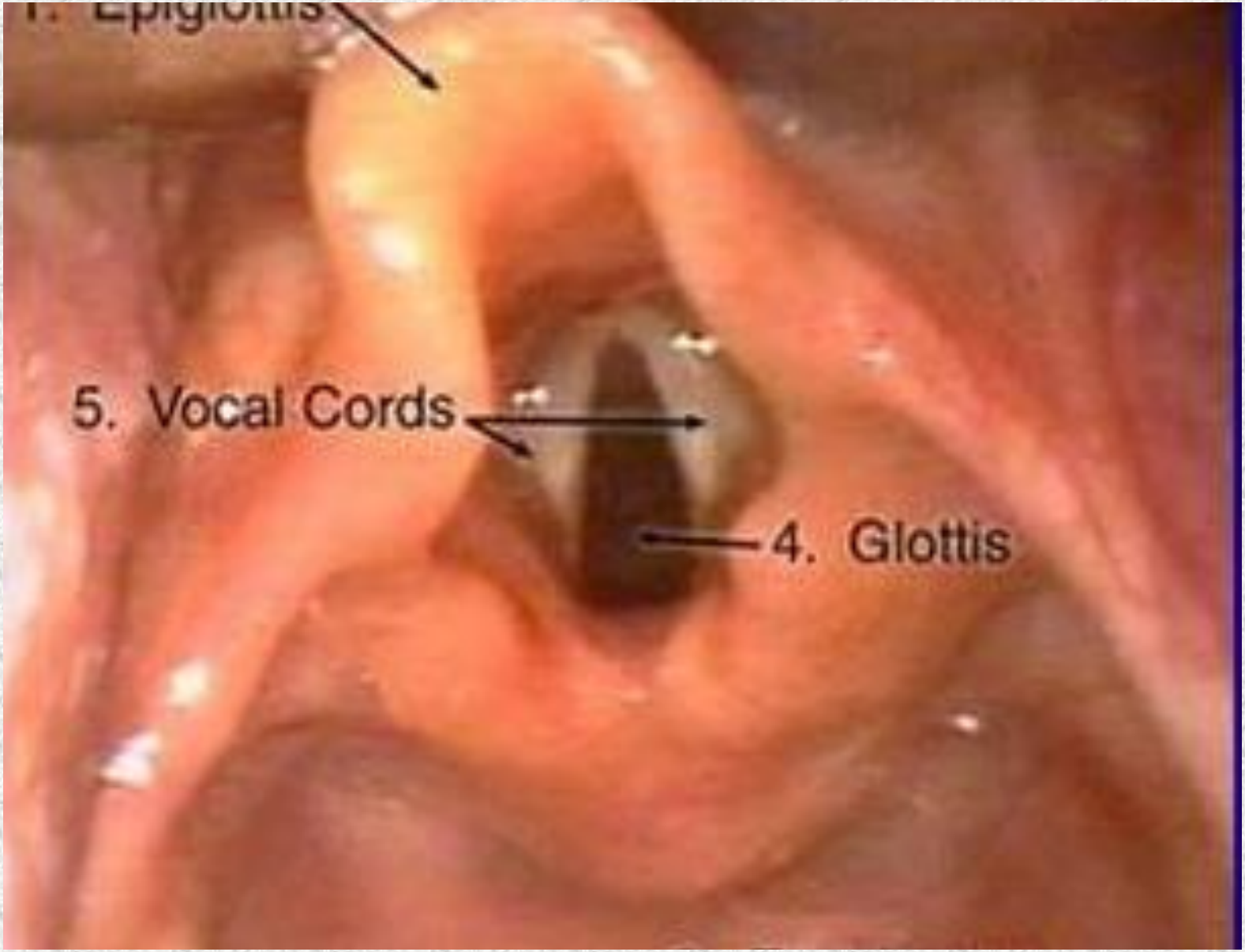
although survival of infants of 22 to 24 weeks' gestational age is possible but with a high percentage of neurocognitive impairment.

At Birth(neonates) the respiratory system differs from adults in:

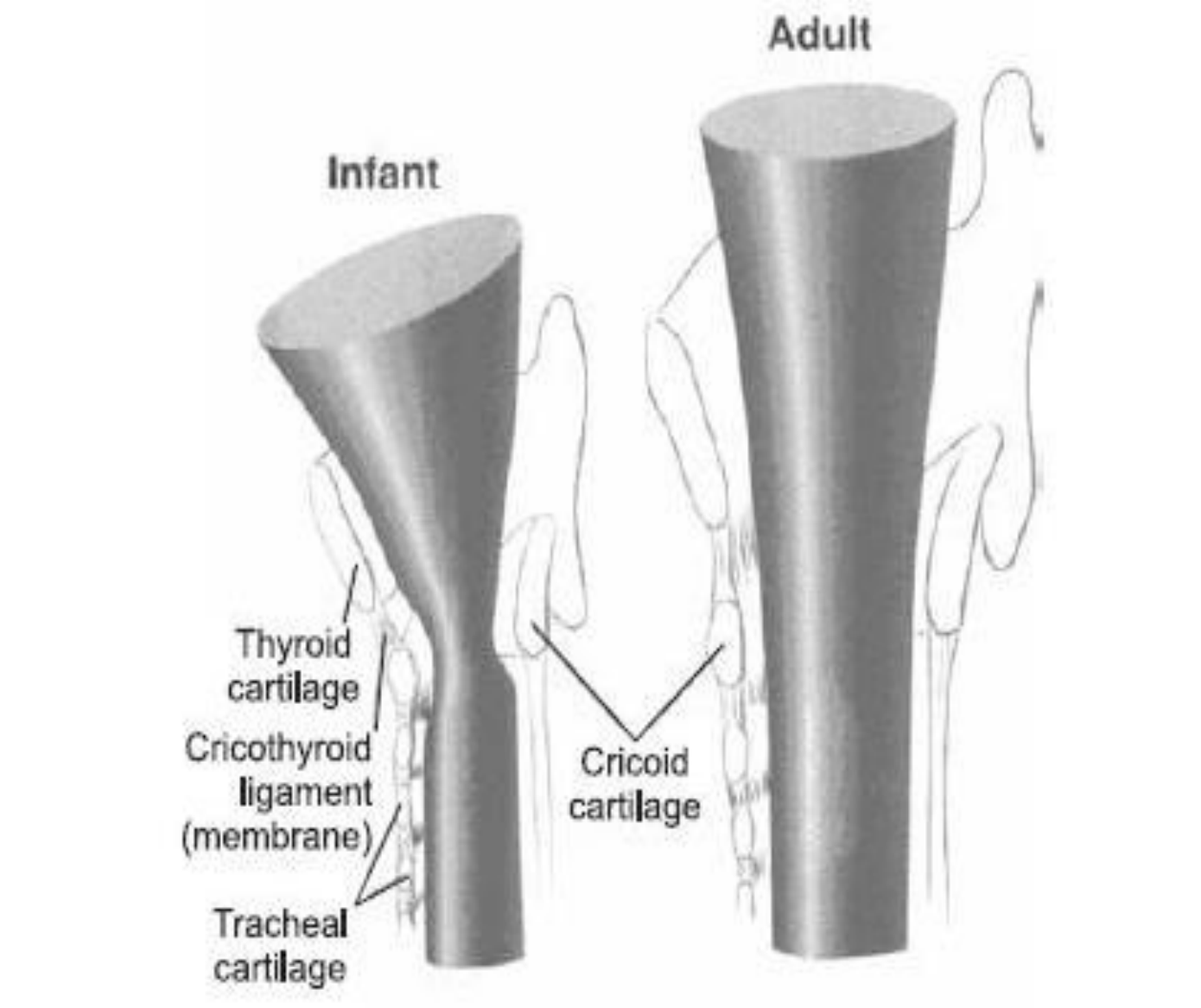
- Large head and tongue, short neck
- Narrow nasal passages and small diameter of the airways
- More cephalad and anterior larynx,C4.
- The narrowest point of the A/W is the cricoid cartilage till 5 years
- Long and stiff epiglottis, U to Omega shape ,touch the soft palate(easy airway obstruction)
- 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.

Respiration is less efficient in infants. The small diameter of the airways increases resistance to airflow; resistance is inversely proportional to the radius raised to the fourth power for laminar flow and to the fifth power for turbulent flow. The airway of infants is highly compliant and poorly supported by the surrounding structures

***(1) The relatively large size of the infant's tongue, in relation to the oropharynx, increases the likelihood of airway obstruction and technical difficulties during laryngoscopy.


5. Vocal Cords
4. Glottis

- 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….



Funnel shaped larynx

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 atelectasis and hypoxemia.

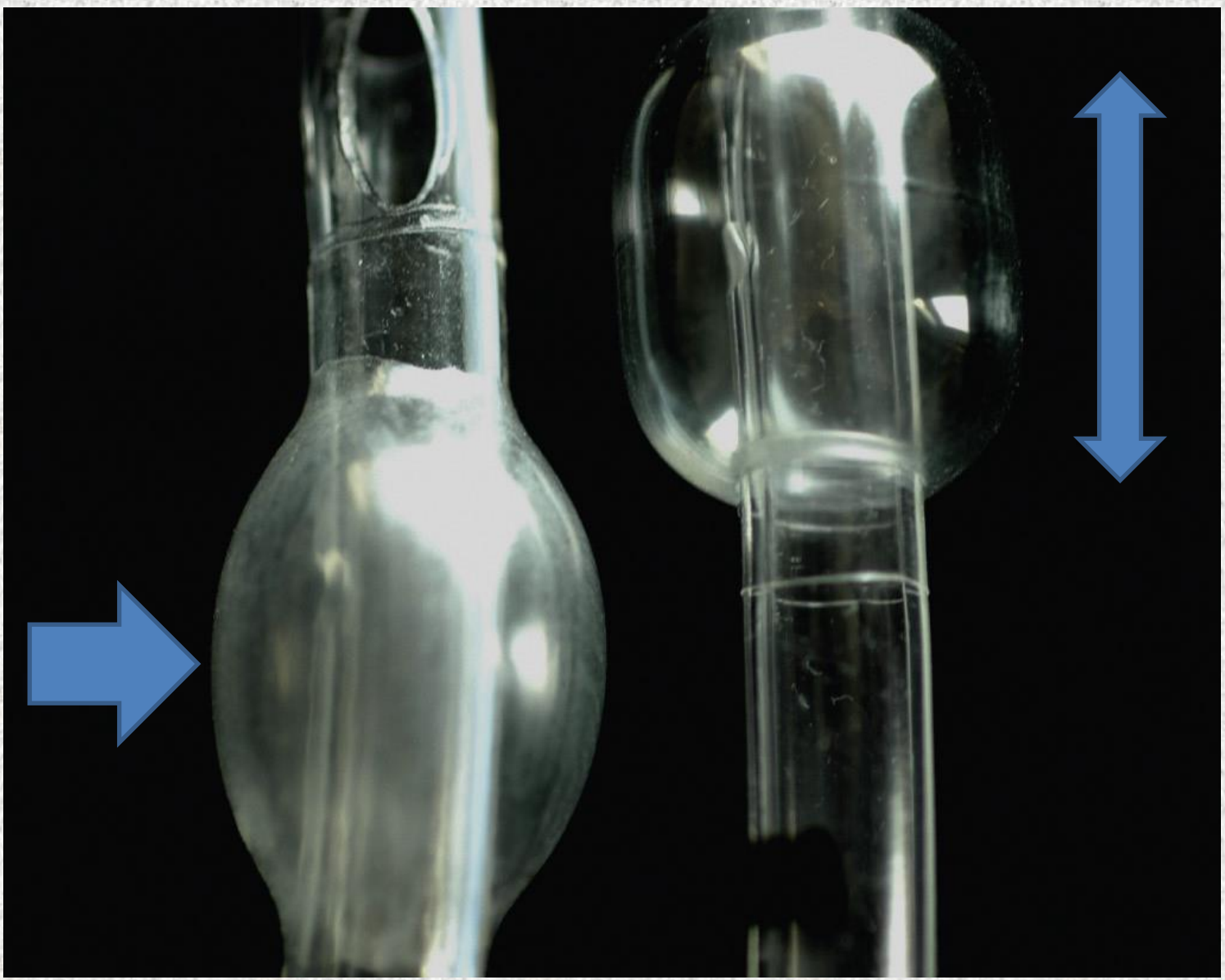
Small FRC
Alveoli numbers is 10 % of adults
Higher O2 Consumption 6ml-7ml/kg Adults (3-4ml/kg)
Diaphragm in neonates and infants<2y easy fatigue (lacks the Type I muscle fibers)

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 + age)/4

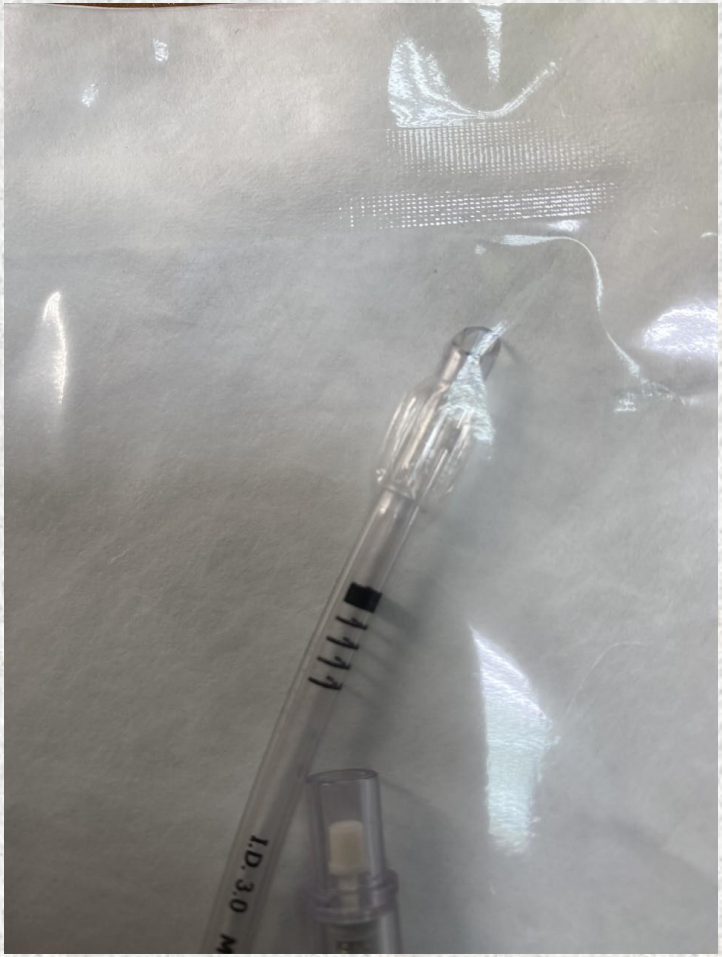


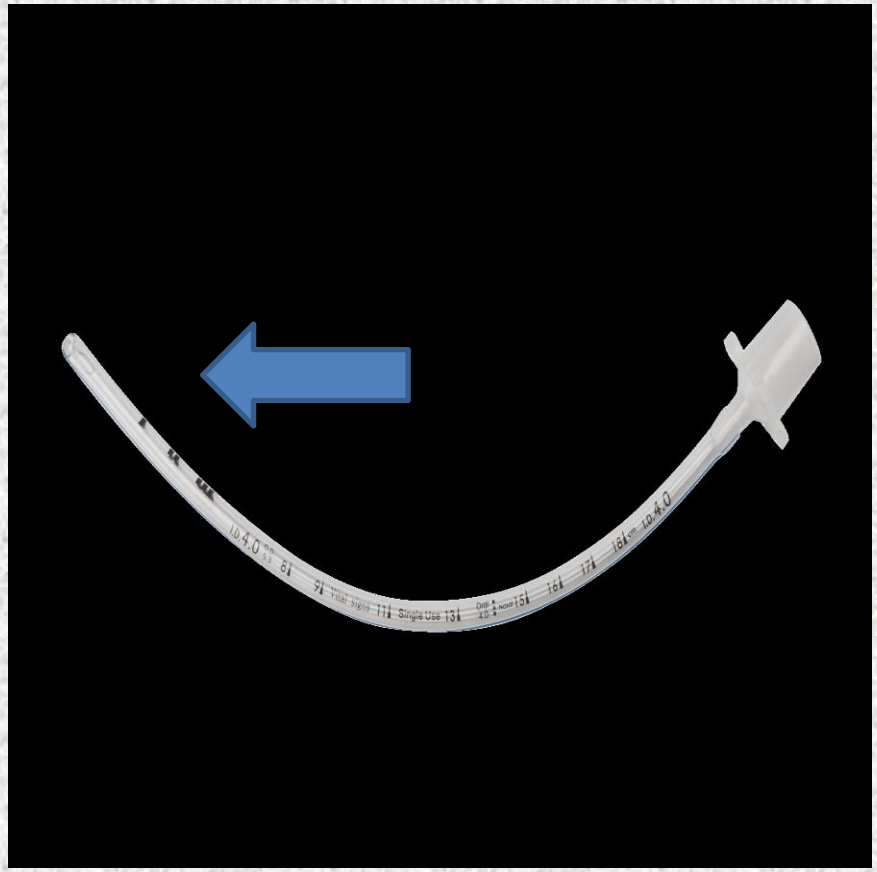
The Microcuff tracheal tube (Microcuff; PET; I-MPEDC, Microcuff GmbH, Weinheim, Germany, Kimberly-Clark USA) (right) has a soft polyurethane cuff that symmetrically inflates and is located more distally than standard tracheal tubes (left). This configuration results in more even pressure applied to the mucosa of the trachea, less potential for edema formation in the subglottic region because the cuff is located below the cricoid cartilage, and a reduced risk for ventilator-associated pneumonia.

Neonates have reduced incidence of subglottic stenosis:

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

Cuffed and uncuffed tracheal tubes



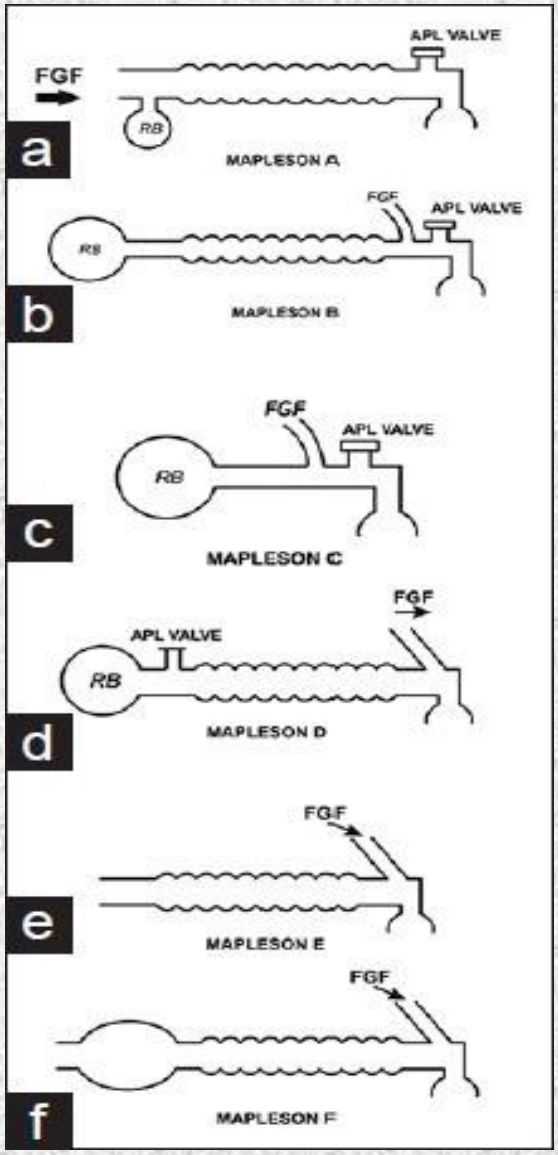


Breathing system

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

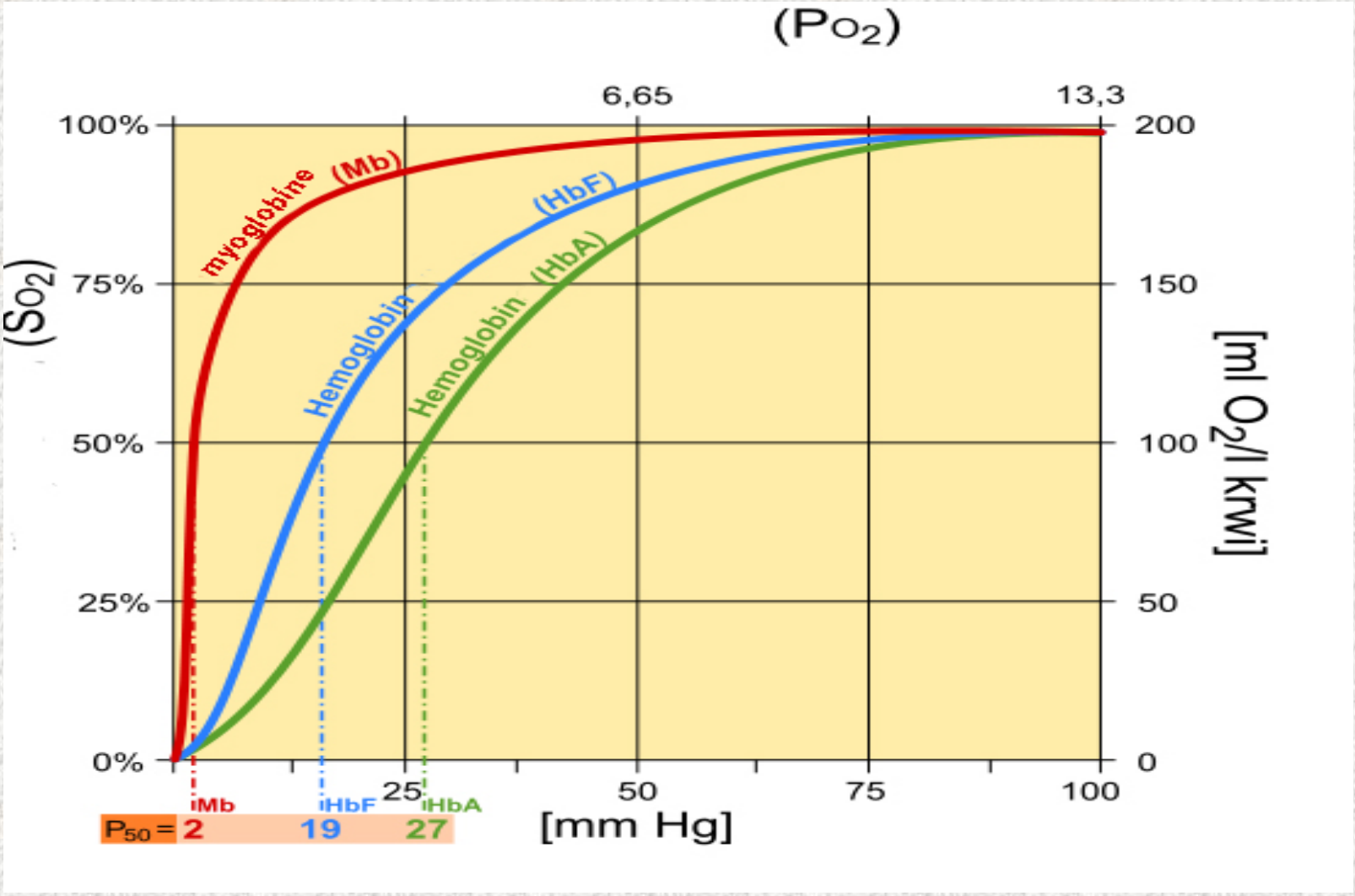
Encourage water intake within two hours

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 O2 ……P50 is ….. HBF decline with age, HBA peaks at 9 month

NOTE : NEONATAL BLOOD IS A MIXTURE OF HBF + HBA

< 2 months is about 24



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


37.0°C

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)

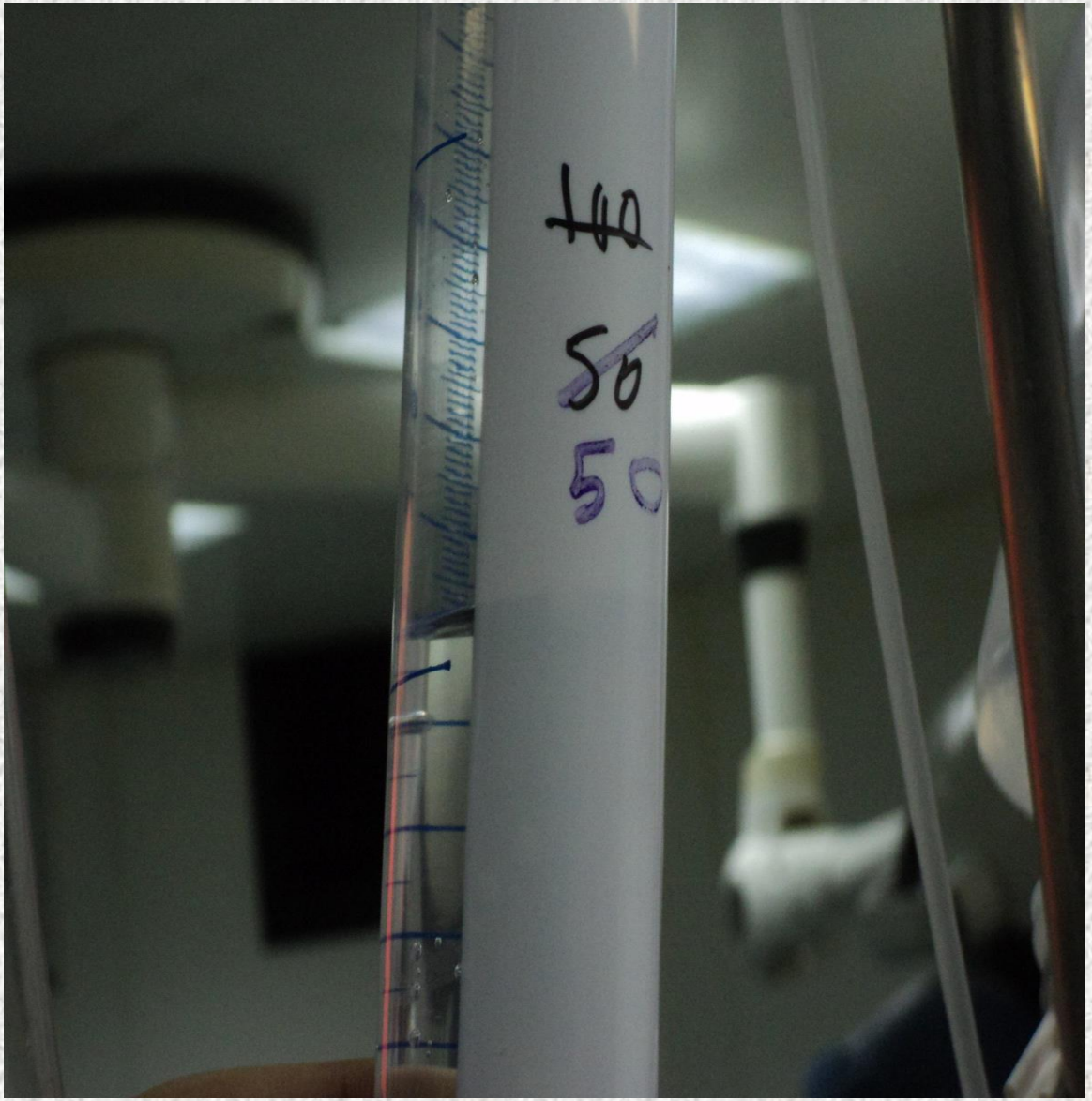
Day 1	50-60 D10W
Day 2	100 D10 1/2 NS
>Day 7	100-150 D5-D10 1/4 NS

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


40
50
50

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

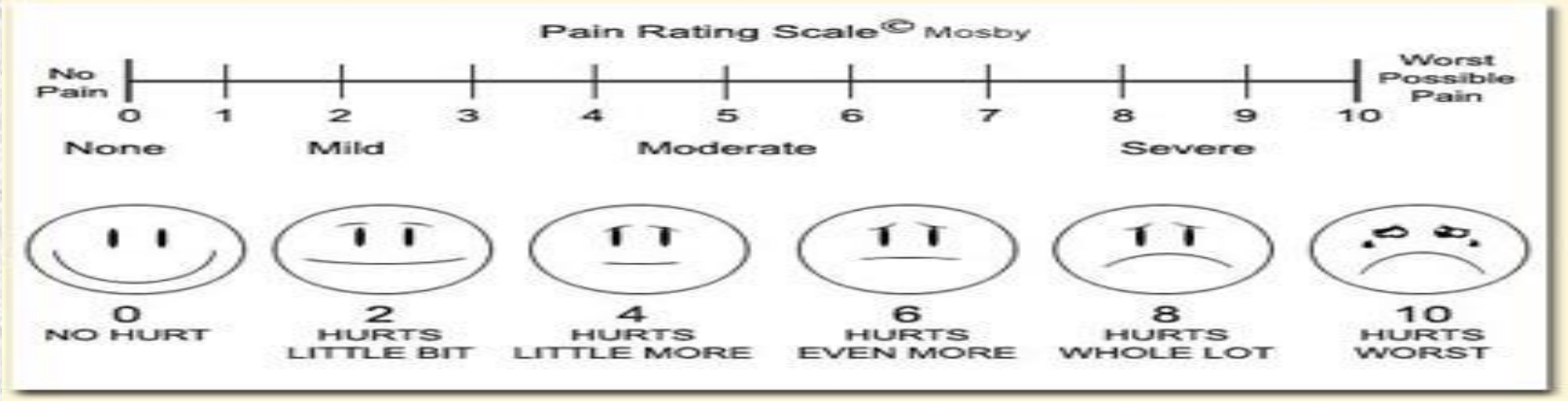
Treatment

- 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:

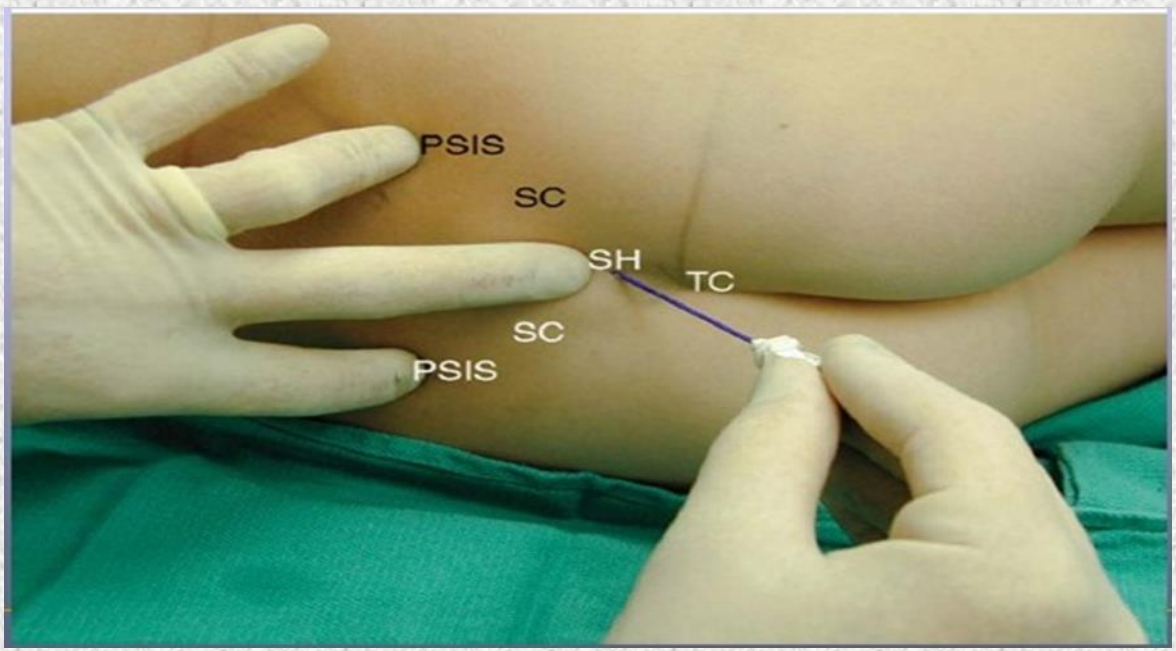
- it decrease anesthetic requirements
- Operative and postoperative utility
- **Caudal block is the most common**
- Options in adults available for children:

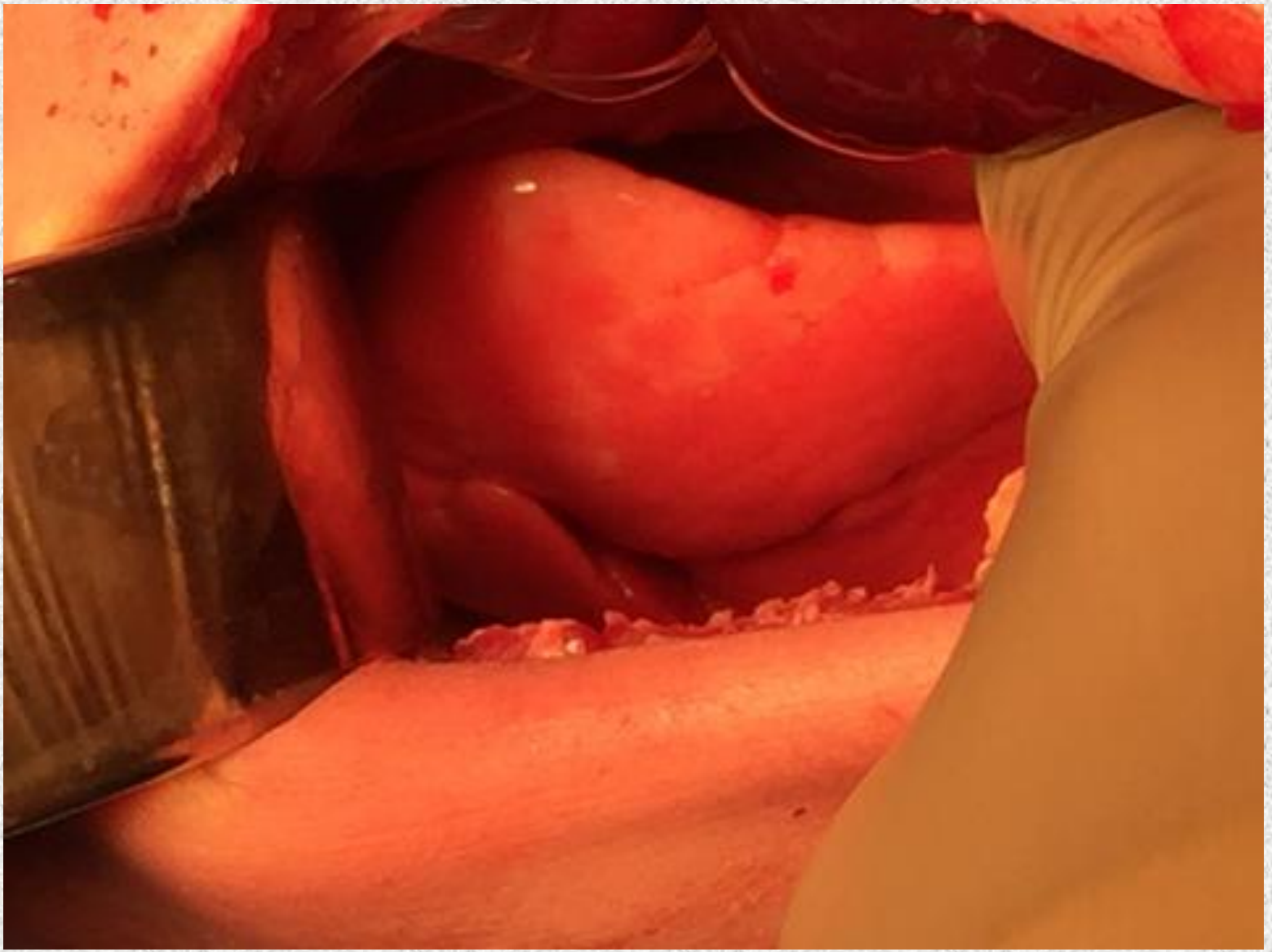
– Peripheral blocks and catheters

- Epidural
- Spinal

Caudal

- Perioperative analgesia
  - **Ropivicaine 0.2% 1 cc/kg (up to 2 mg/kg)**
  - **Bupivicaine 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 to thoracic 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

<u>Increased risk of MH:</u>

- Duchenne's muscular dsytrophy
- 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?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THANK YOU ALL