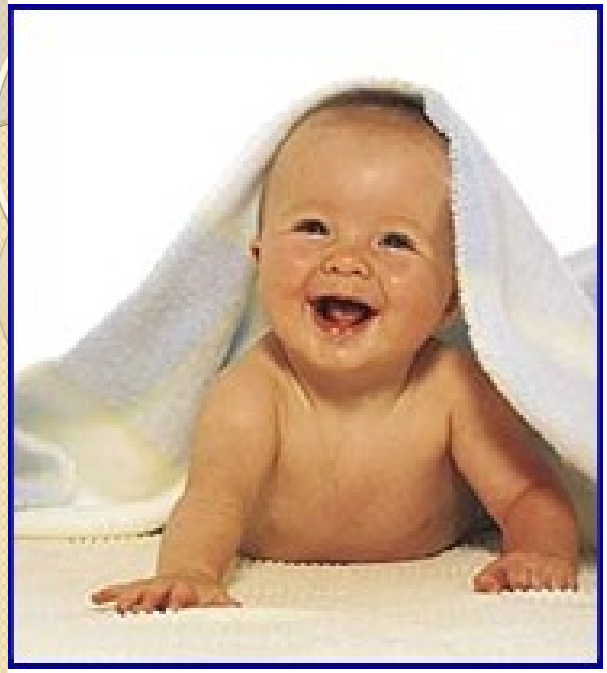


Pedeatric anesthesia

Presented by
Dr.Sana Abdulwali Antar

- The provision of safe anesthesia for pediatric patients depends on a clear understanding of the physiologic, anatomical, and pharmacologic differences between children and adults

outline

- Anatomic & Physiological Development
- Pharmacological Differences
- Pediatric Anesthetic Techniques

- Infants are at much greater risk of anesthetic morbidity and mortality than are older children; risk is generally inversely proportional to age, neonates being at highest risk.

- **DEVELOPMENTAL PHYSIOLOGY OF THE INFANT**

Age-Related Changes in Vital Signs.

		Arterial Blood Pressure		
Age	**Respiratory Rate**	**Heart Rate**	**Systolic**	**Diastolic**
Neonate	40	140	65	40
12 months	30	120	95	65
3 years	25	100	100	70
12 years	20	80	110	60

Cardiovascular System

- Stroke volume is relatively fixed by a noncompliant and poorly developed left ventricle in neonates and infants.
- The cardiac output is dependent on heart rate which is higher than in adults
- Activation of the parasympathetic nervous system, anesthetic overdose, or hypoxia can cause bradycardia and profound reductions in cardiac output.
- Sick infants undergoing emergency or prolonged surgical procedures appear particularly prone to episodes of bradycardia that can lead to hypotension, asystole, and intraoperative death.
- The sympathetic nervous system and baroreceptor reflexes are not fully mature.

Respiratory system

- Neonates have high metabolic rates, resulting in an elevated oxygen consumption (6 to 9 mL/kg/minute compared with adults (3 mL/kg/minute).

- To meet the higher oxygen demand, infants have a higher respiratory rate and minute ventilation
- Respiratory rate /age for age 1-3years= (RR = 24 – age/2)

- Muscles of ventilation are easily subject to fatigue due to low percentage of Type I muscle fibres in the diaphragm

Respiratory system

- The alveoli are thick walled at birth. There is only 10% of the total number of alveoli found in adults. The alveoli clusters develop over the first 8 years of life.

- The characteristics of the infant's pulmonary system contribute to rapid desaturation during apnea

- Apnoeas are common post operatively in premature infants.

Most hospitals agree that infants who are less than 45 to 55 weeks postconceptual age are

Central Nervous System

- Neonates can appreciate pain and this is associated with increased heart rate, blood pressure and a neuro-endocrine response.
- Narcotics depress the ventilation response to a rise in $PaC0_2$
- The blood brain barrier is poorly formed. Drugs such as barbiturates, opioids, antibiotics and bilirubin cross the blood brain barrier easily causing a prolonged and variable duration of action.
- The cerebral vessels in the preterm infant are thin walled, fragile. They are prone to intraventricular haemorrhages.
- The risk is increased with hypoxia, hypercarbia, hypernatraemia, low haematocrit, awake airway manipulations, rapid bicarbonate administration and fluctuations in blood pressure and cerebral blood flow
- Cerebral autoregulation is present and functional from birth.

Renal System

- Renal blood flow and glomerular filtration are low in the first 2 years of life due to high renal vascular resistance.
- Tubular function is immature until 8months, so infants are unable to excrete a large sodium load.
- Dehydration is poorly tolerated.
- Premature infants have increased insensible losses as that have a large surface area relative to weight

- There is a larger proportion of extra cellular fluid in children (40% body weight as compared to 20% in the adult).

Hepatic System

- Liver function is initially immature with decreased function of hepatic enzymes. Barbiturates and opioids for example have a longer duration of action due to the slower metabolism.

Glucose Metabolism

- Hypoglycaemia is common in the stressed neonate and glucose levels should be monitored regularly.
- Neurological damage may result from hypoglycaemia.
- Hyperglycaemia is usually iatrogenic

Temperature Control

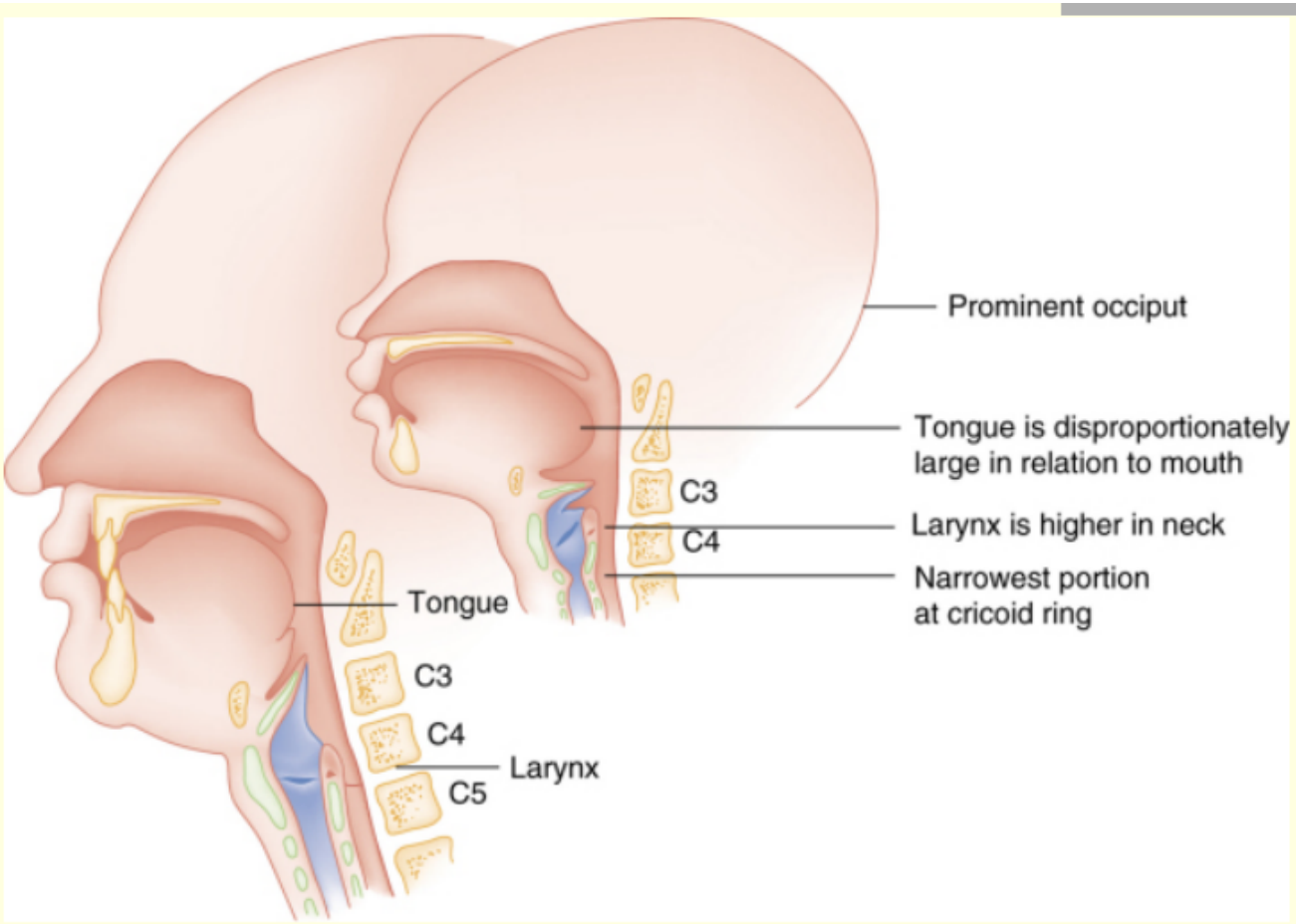
- Babies and infants have a large surface area to weight ratio with minimal subcutaneous fat. They have poorly developed shivering, sweating and vasoconstriction mechanisms.

  Brown fat (located in small amounts around the scapulae, the mediastinum, the kidneys and adrenal glands) metabolism is required for non-shivering thermogenesis. It comprises 2-6% of neonatal body weight. More oxygen is required for the metabolism of these brown fat stores.

  Heat lost during anaesthesia is mostly via radiation but may also be lost by conduction, convection and evaporation. The optimal ambient temperature to prevent heat loss is 34ºC for the premature infant, 32ºC for neonates and 28ºC in adolescents and adults.

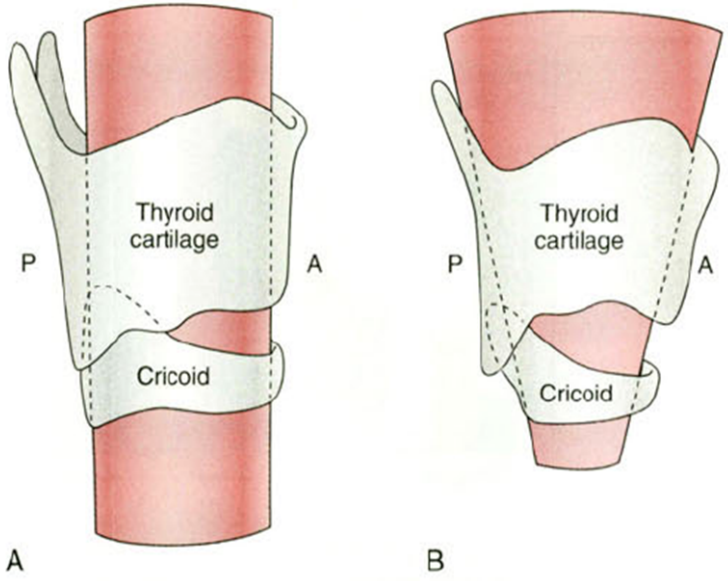
  Low body temperature causes respiratory depression, acidosis, decreased cardiac output, increases the duration of action of drugs, decreases platelet function and increases the risk of infection.

Anatomical changes


Prominent occiput
Tongue is disproportionately large in relation to mouth
C3
C4
Larynx is higher in neck
Narrowest portion at cricoid ring
Tongue
C3
C4
Larynx
C5

Compared to the adult airway, pediatric airway

- is more anterior and higher
- has a floppier, U-shaped epiglottis
- is narrowest at the cricoid ring
- has a more “funnel-shaped” larynx
- has a more flexible trachea



Difficult Neonatal Airways

Difficult Neonatal Airways

- Congenital malformations
  - Things you can see”
  - Predictable from looking at the patient
    - Cleft lip and palate
    - Pierre Robin syndrome
    - Down’s Syndrome,....
  - Things you may find”
    - Laryngomalacia
    - Tracheal web
    - Laryngeal atresia
    - Subglotic stenosis

Pharmacological Differences

Pharmacological Differences

- Total body water content decreases as fat and muscle content increase with age.
- Thus, volume of distribution for IV drugs is higher, and the dose (per kilogram) is usually higher in neonates and infants than in older children and adults.
- A smaller muscle mass prolongs clinical termination of action by redistribution to muscle for drugs as thiopental and fentanyl.
- Relatively lower GFR and hepatic blood flow, immature renal tubular function and immature hepatic enzyme systems..

Inhalational Anesthetics

- The blood pressure tends to be more sensitive to volatile anesthetics:
- Undeveloped compensatory mechanisms vasoconstriction & tachycardia
- Immature myocardium that is very sensitive to myocardial depressants
- As with adults, halothane also sensitizes the heart to catecholamines.
- Cardiovascular depression, bradycardia, and arrhythmias are significantly less with sevoflurane than with halothane.

Non inhalational (iv) agents

- **Sedative agent**

Propofol

Thiopentone

Ketamine

Midazolam

- **Analgesic**

Opoids,..

- **Muscle relexation**

NDMR

Scoline

ketamine

Useful in hypovolemic child

- Spontaneous respiration

Adv efec

- Secretions- atropine0.02mg/kg im
- Post op hallucination/delirium-
- Laryngospsm/apnea

CI-

active URTI, increase icp,open globe injury, psychiatric/ seizure disorder, full stomach/ hiatal hernia

- **Iv**

1-2mg/kg(sedation/ analgsia)

2-4mg/kg (induction)

- **Im**

4-5mg/kg(sedation)

10mg/kg (induction)

- **Rectal**

6-10mg/kg

- **Intranasal**

3-6mg/kg

Muscle relexants

- Infants generally more sensitive
- Muscle relaxants often are used to facilitate endotracheal intubation. Muscle relaxants may be contraindicated in infants and children with abnormal airway anatomy

succhinylcoline

- Ultra short acting depolarising MR
- Highly water soluble-large vol of distribution
- In elective pedeatric surgery some avid the use of scoline routinly

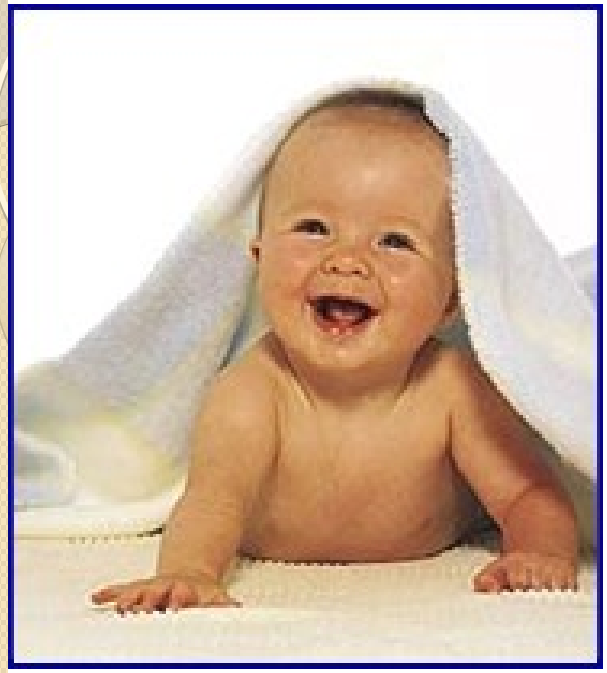
- 2.0 mg/kg IV;
- 4.0 mg/kg IM
- Consider Atropine 10-15 mcg/kg given prior SUX
- Potential side effects:

Rhabdomyolysis

Hyperkalemia

Masseter spasm

MH



Pedeatric anesthesia and Techniques

Anesthesia for Pediatric Surgery

- Preoperative managment
- Intraoperative management
- Postoperative pain managment

Preoperative managment

- Assesment and evaluation
- Premedication and fasting guidelines

Evaluation and assessment

It is important to take a medical and anaesthetic history.

o Any previous problems with anaesthetics including family history
o Allergies
o Previous medical problems including congenital anomalies
o Recent respiratory illness
o Current medications
o Fasting times
o Presence of loose teeth.

Children must be weighed. All drug doses relate to body weight.

Conduct a physical examination as appropriate

ASA Classification

- ASA class only roughly predicts anesthetic risk. The six classes are:
- Class 1: A normal healthy patient.
- Class 2: A patient with mild systemic disease.
- Class 3: A patient with severe systemic disease.
- Class 4: A patient with severe systemic disease that is a constant threat to life.
- Class 5: A moribund patient who is not expected to survive without the operation.
- Class 6: A declared brain-dead patient whose organs are being removed for donor purposes.
- An “E” is added to the status number to designate an emergency operation.

Investigations may occasionally :be necessary

- Elective minor :CBC, S glucose
- For neonates with / chronic illness:

CBC, electrolytes (renal or metabolic disease, intravenous fluids, dehydration) , albumin, coagultion profile

- CXR – active respiratory disease, scoliosis, congenital heart disease

Preoperative Sedatives in Children

- **Oral**

Midazolam (0.5–0.75 mg/kg; onset, 30 minutes; lasts approximately 30 minutes)

Ketamine (5–6 mg/kg)

- **Transmucosal**

fentanyl (facial pruritus, nausea and vomiting, oxygen desaturation)

Clonidine (4 µg/kg)

Dexmedetomidine (1 µg/kg transmucosally or 3–4 µg/kg orally)

- **Nasal**

Midazolam (0.2 mg/kg; rapid absorption because it avoids first-pass metabolism; a disadvantage is transient nasal irritation)

- **Rectal**

Midazolam (0.5–1.0 mg/kg)

- **Intramuscular**

Midazolam (0.3 mg/kg; anxiolysis in 5–10 minutes)

Ketamine (3–4 mg/kg)

premedications

- Premedication with intramuscular (IM) anticholinergics is not recommended. If vagolytic drugs are indicated, they are usually administered IV at the time of induction of anesthesia
- In the presence of gastroesophageal reflux, ranitidine (2 to 4 mg/kg PO, 2 mg/kg IV) along with metoclopramide (0.1 mg/kg) can be administered 2 hours before surgery to increase gastric pH and reduce gastric volume
- If schedule delays occur, clear fluids may be given. Some patients may need to have an IV started for hydration

Pre-operative Fasting and fasting guidelines

- 6 hours for solids and milk if greater than 12 months of age
- 4 hours for breast milk and formula feeds if less than 12 months of age
- 2 hours for unlimited clear fluids (as this decreases gastric acidity and volume)
- There is an increased incidence of nausea and vomiting with long fasting periods

Intraoperative management

- Operating Room Preparation
- monitoring
- Induction
- Maintenance
- Emergence and recovery

Preparation of the operating room

- **Have your equipment ready and checked:**
- **Airway equipment**:
- **Face masks**
- **Oropharyngeal airway**
- **Laryngoscope and blades**
- **Endotracheal tube**
- **Laryngeal mask**
- **Breathing circuit**
- Temperature control

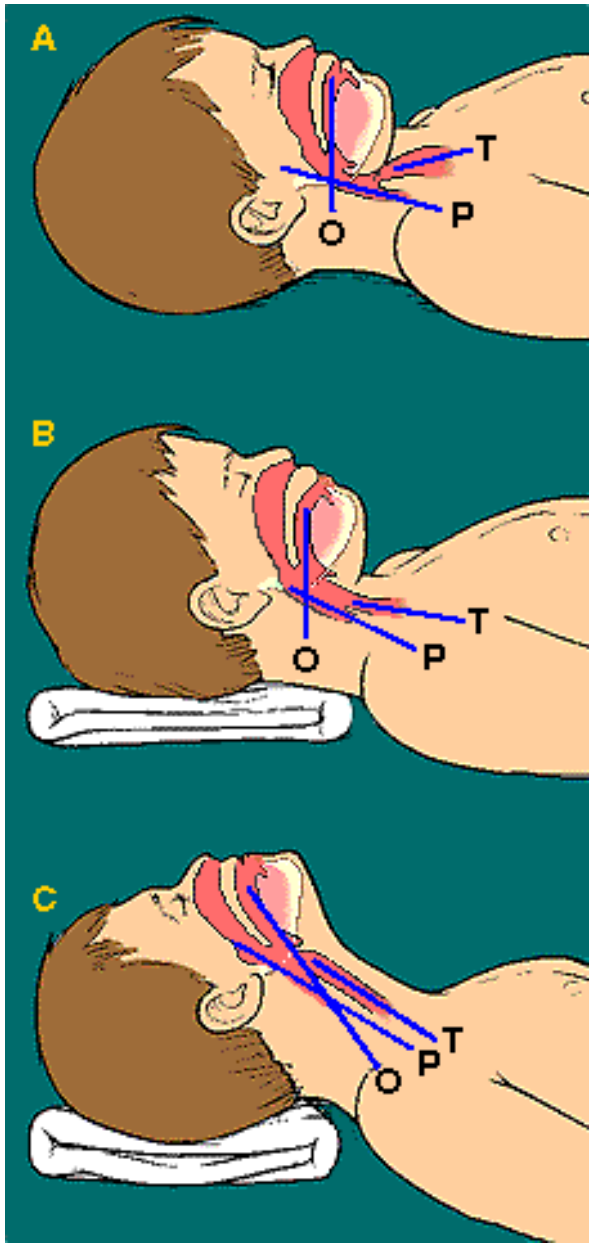
paed equipment

Should have:

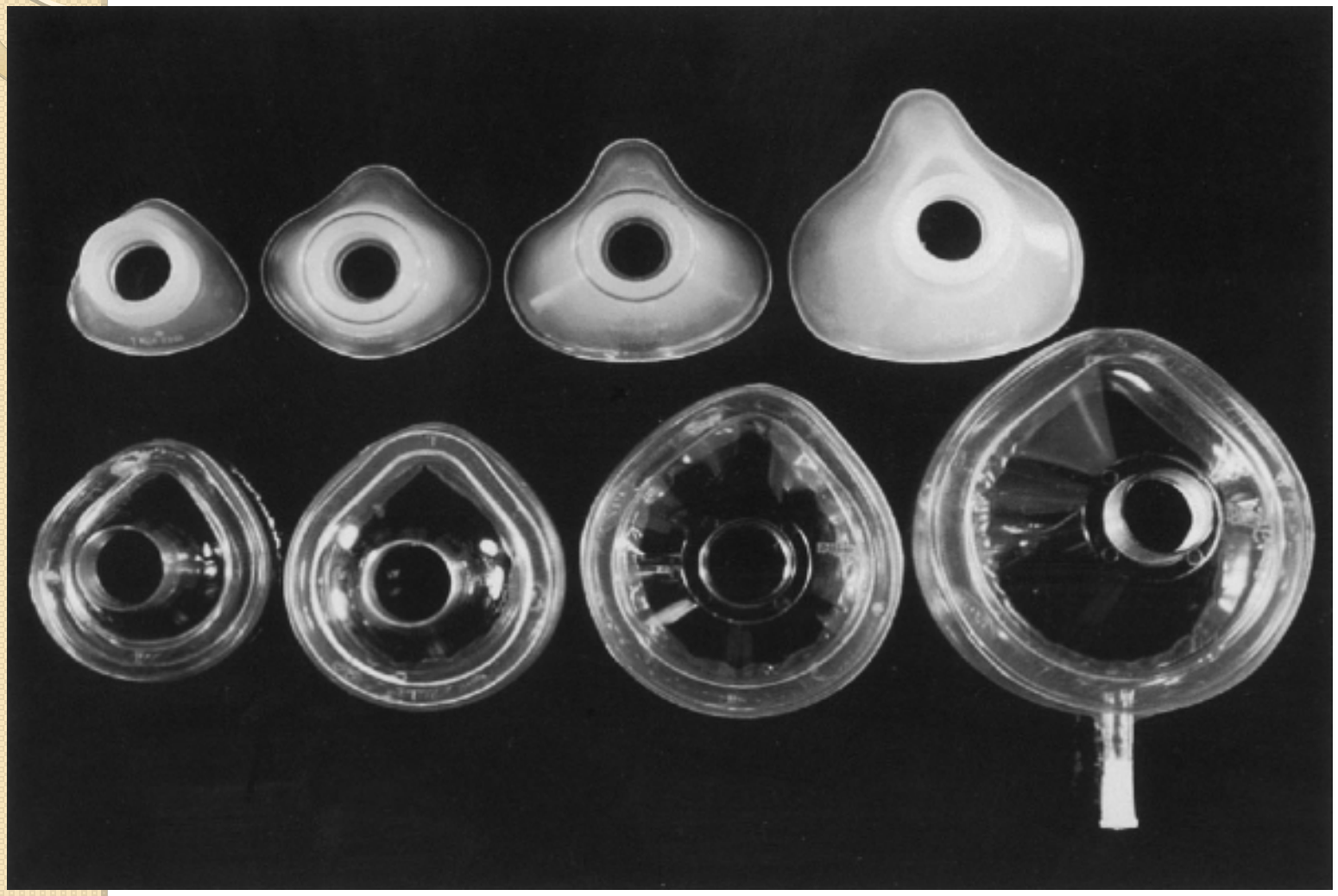
- Minimal resistance
- Minimal dead space
- Light wt
- Easy to use
- able to conserve heat n moisture

Positioning

- Patient Positioning
  - Goal
    - Align 3 planes of view, so
    - Vocal cords are most visible
  - T - trachea
  - P - Pharynx
  - O - Oropharynx



Commonly used paed mask




000#
00#
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1#
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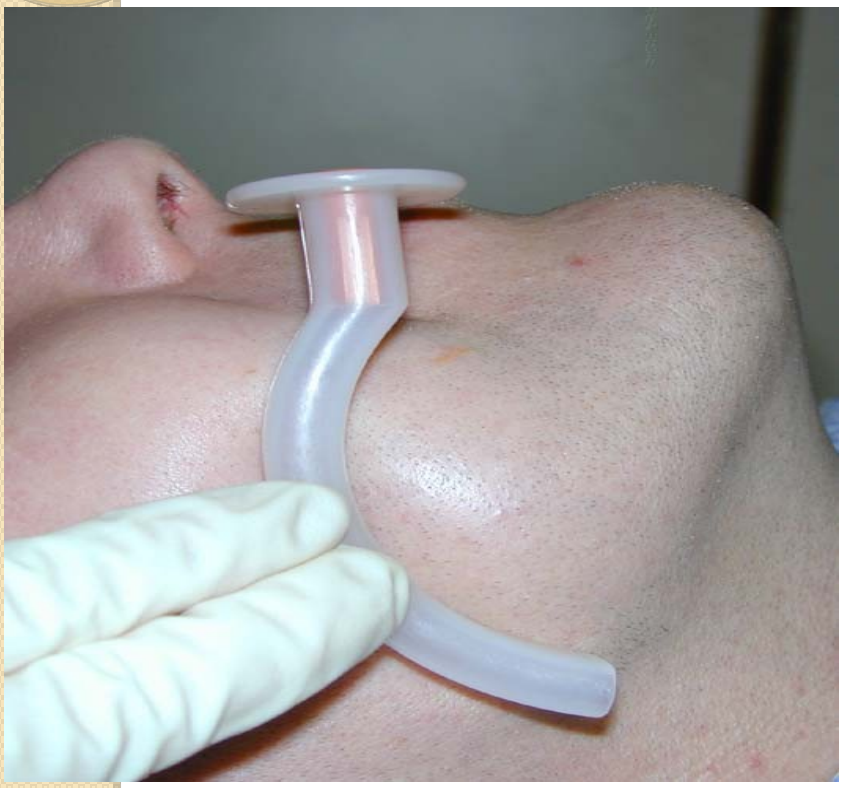
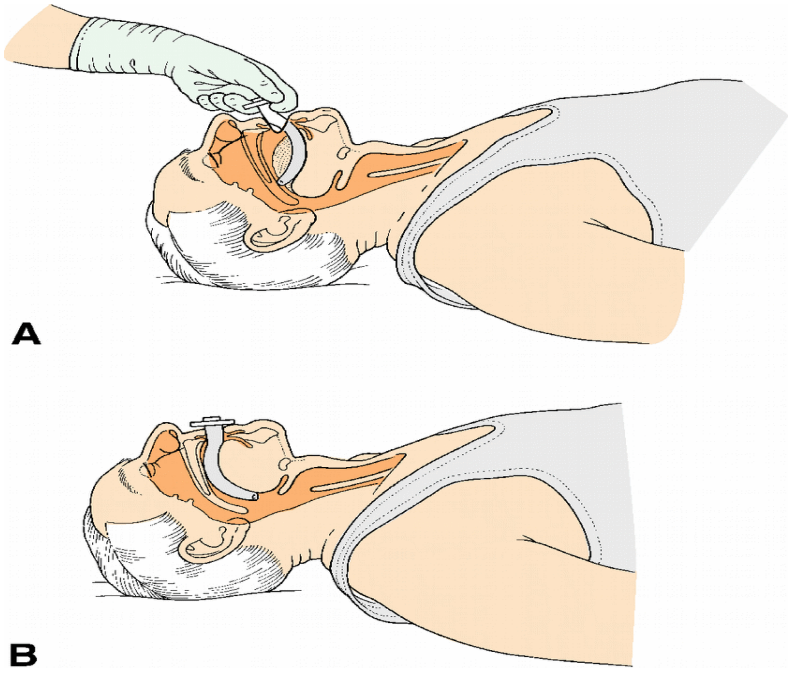
6#

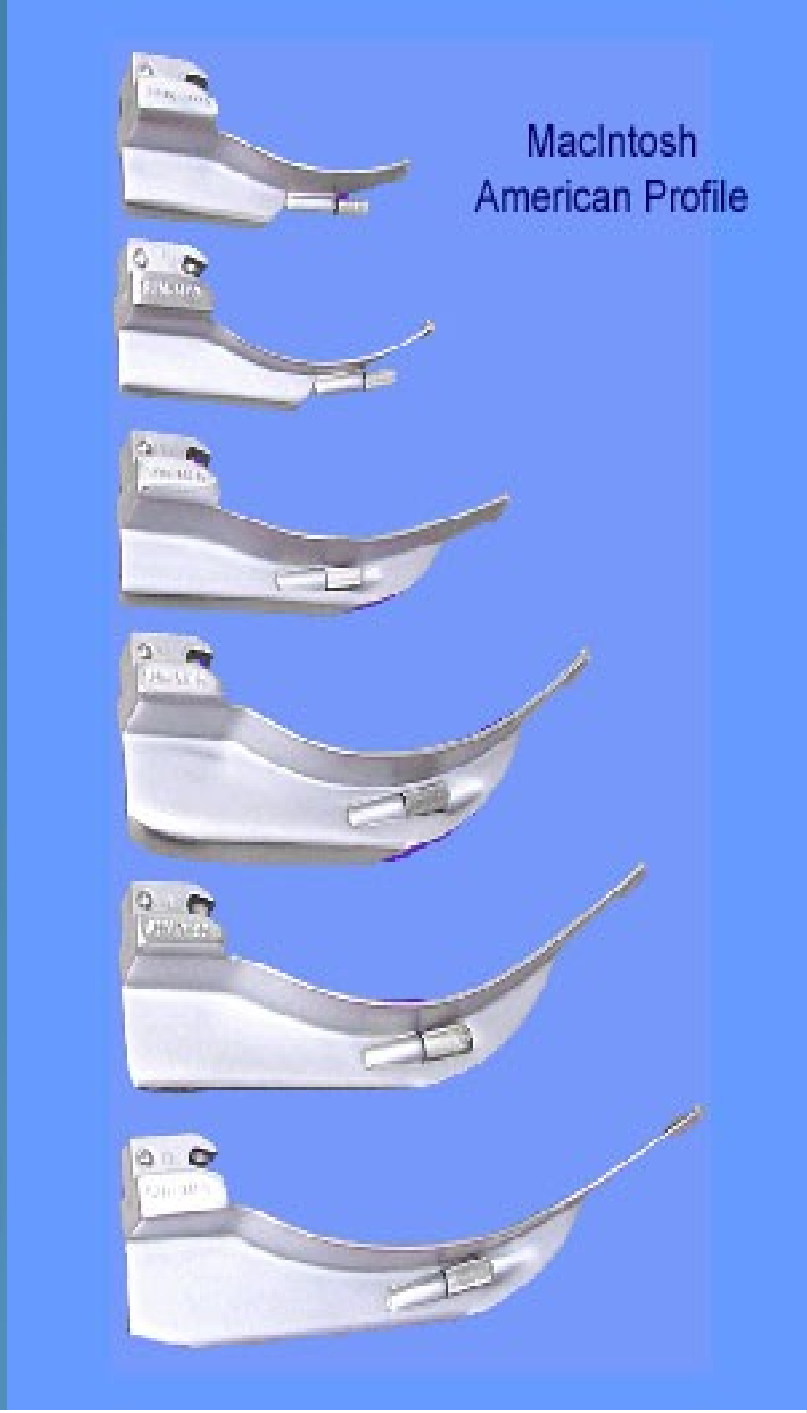
ORAL AIRWAY



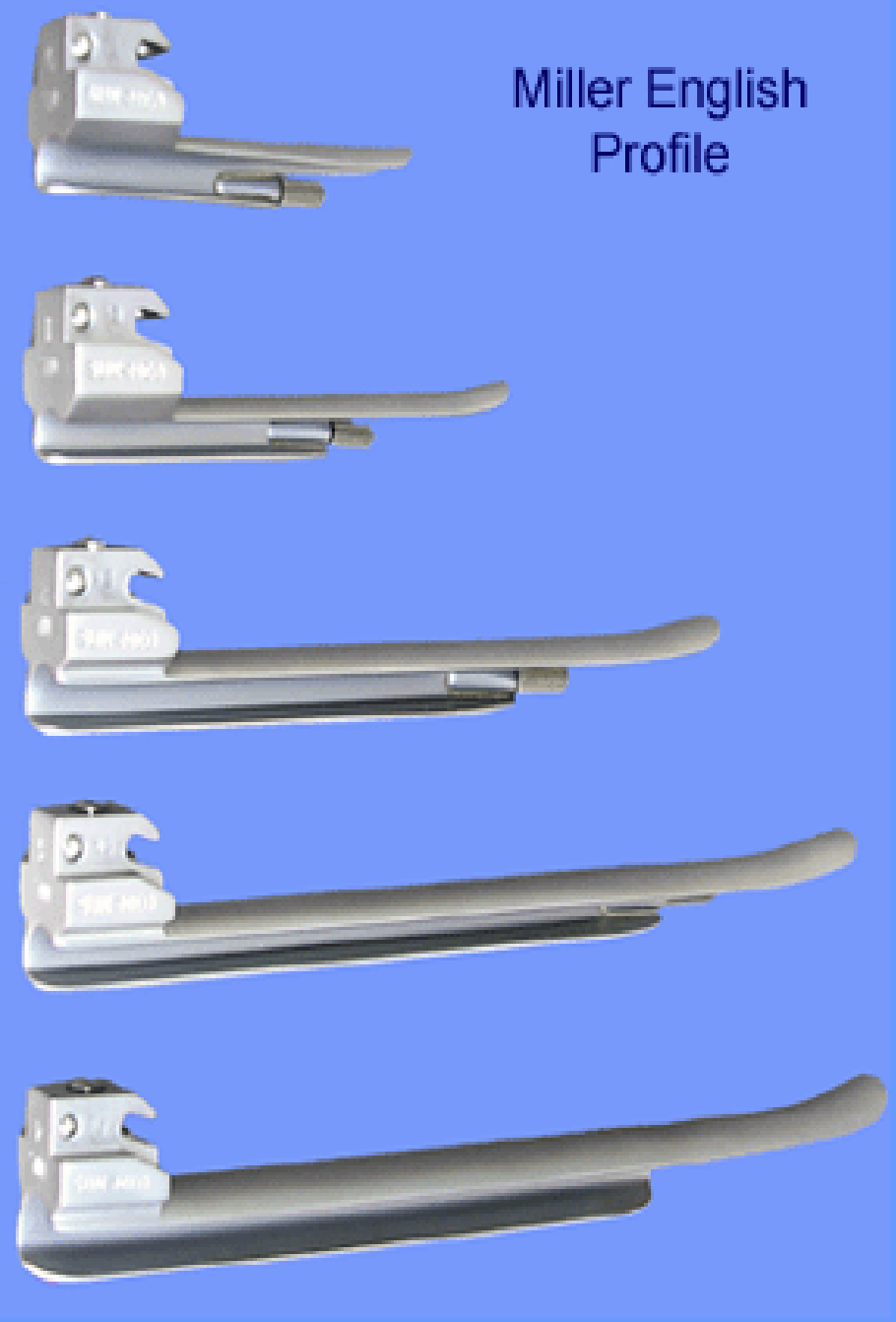



HANDLES
PENLIGHT
STUBBY
MEDIUM


E - Macintosch


MacIntosh
American Profile

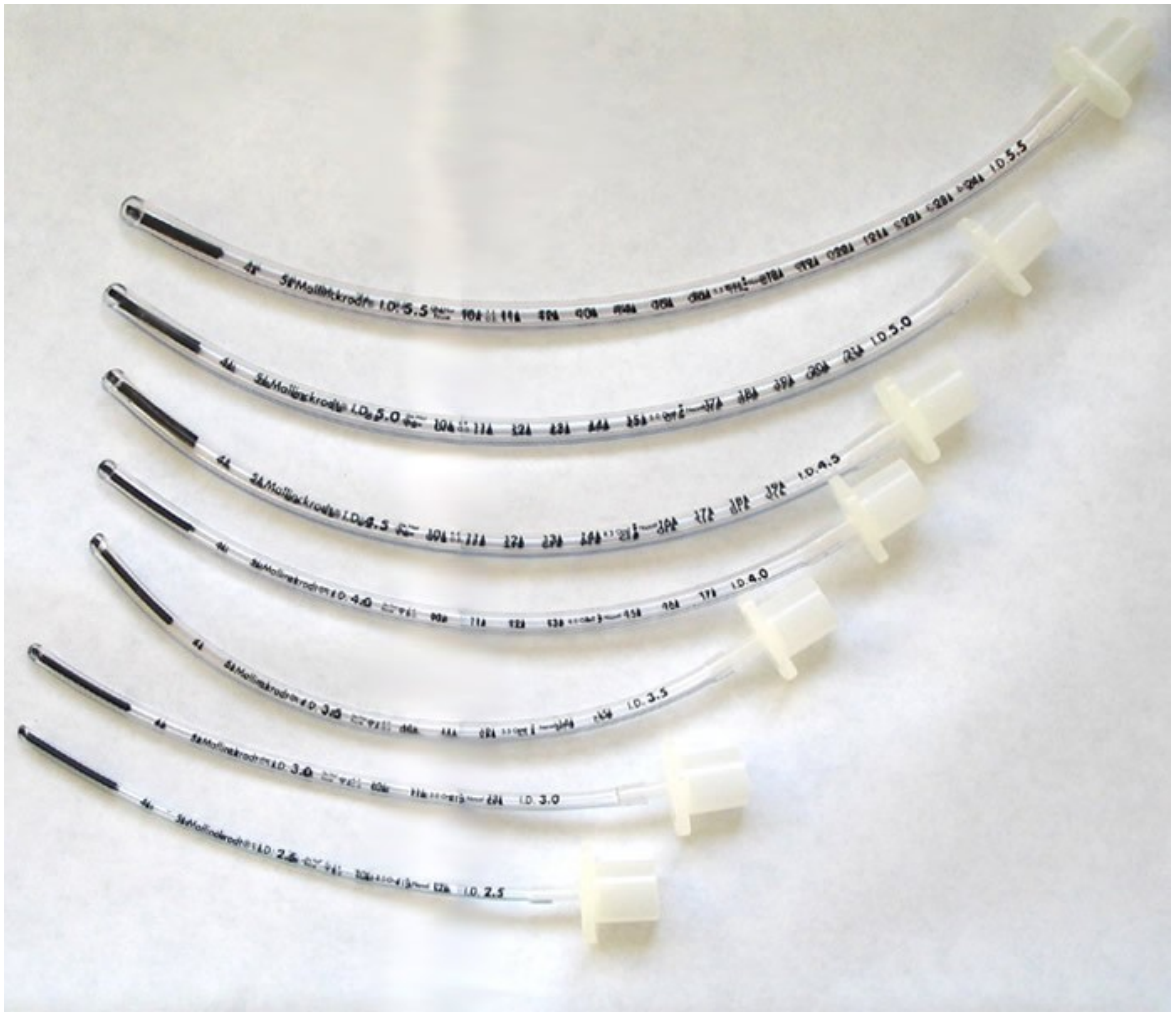
Miller English Profile



Miller American Profile

Straight Blade (Miller)

- Insert from right to left
- Visualize anatomy
- Blade past vallecula and over epiglottis
- Lift up and away
  DO NOT PRY ON TEETH
- Lift epiglottis **directly**

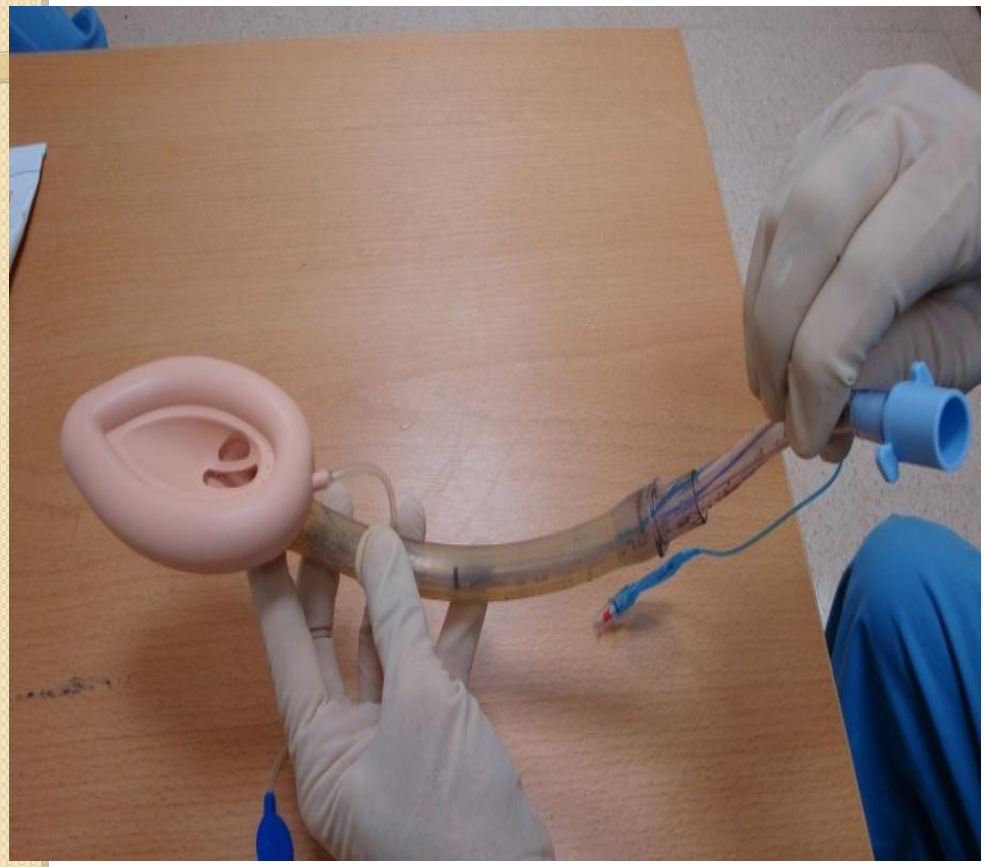

I.D. 5.5
I.D. 5.0
I.D. 4.5
I.D. 4.0
I.D. 3.5
I.D. 3.0
I.D. 2.5

Endotracheal tubes:

Recommended Sizes and Distance of Insertion of Endotracheal Tubes and Laryngoscope Blades for Use in Pediatric Patients			
Age Of The Patient	RECOMMENDED		
	Diameter (internal)	Size of the Blade	Distance
Premature (<1,250 g)	2.5	0	6–7
Full term	3.0	0–1	8–10
1 y	4.0	1	11
2 y	5.0	1–1.5	12
6 y	5.5	1.5–2	15
10 y	6.5	2–3	17
18 y	7–8	3	19

4 + (1/4) (age) = size; || ***12 + (1/2) (age) = depth***

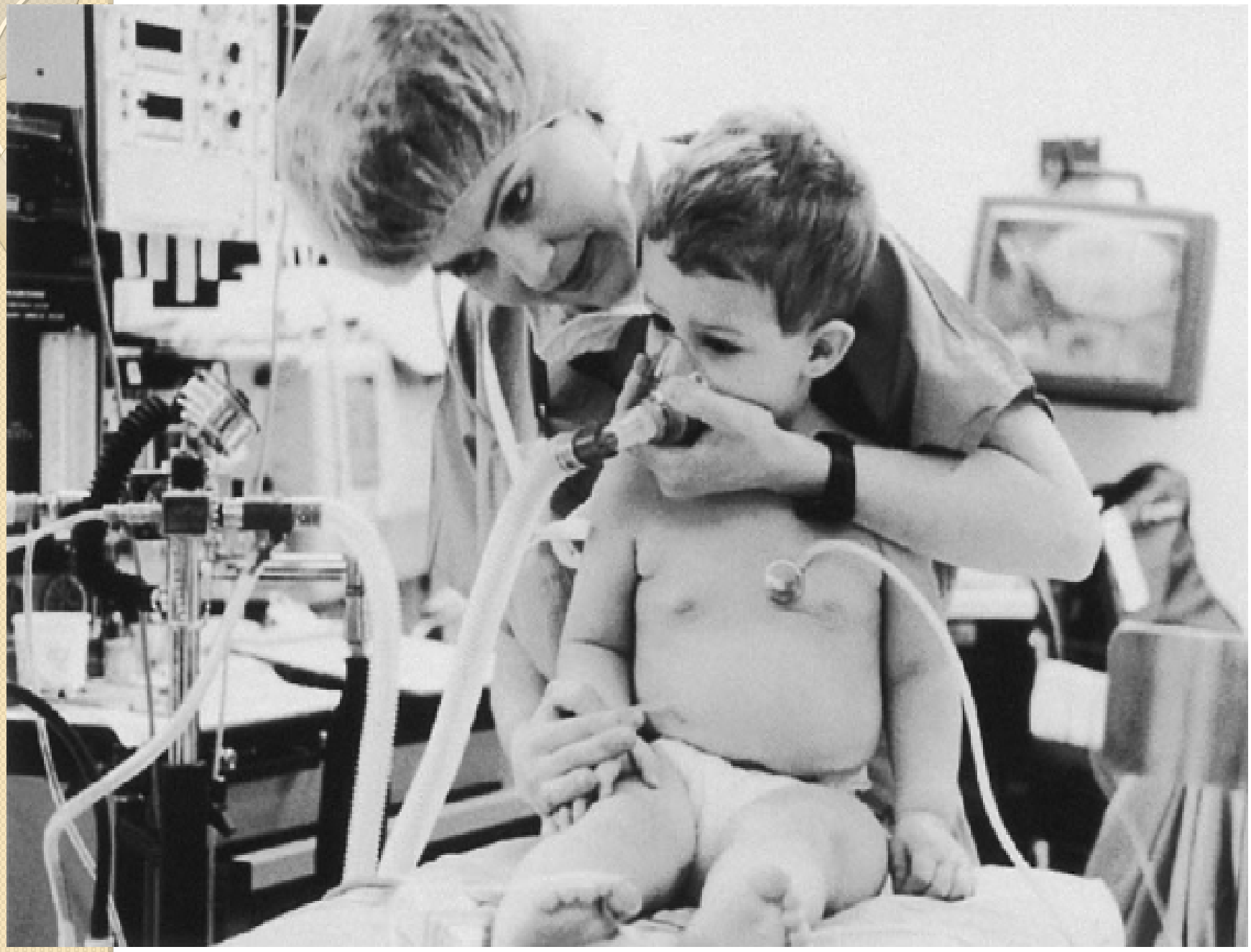
LMA =[W(Kg)+5] /10



- LMA 1= ETT 3.5
- LMA 2= ETT 4.5
- LMA 3= ETT 5.0
- LMA 4= ETT 6.0
- LMA 5= ETT 7.0

Induction techniques

- Infants less than 8 months old can be transported to the operating room without sedation; anesthesia can then be induced by an inhalation technique
- Sedation options for children 8 months to 6 years old include the following:
  - Oral midazolam, 0.5 to 1.0 mg/kg
  - Ketamine, 5 mg/kg given orally produces sedation within 10 to 15 minute and is synergistic with midazolam
  - Oral transmucosal fentanyl
- Pulse oximetry is used routinely once a patient is sedated



Induction techniques

- **Inhalation induction:**
- This is the most common approach for pediatric patients, except when a rapid sequence IV induction is indicated.
- **Halothane and sevoflurane are the agents of choice for gaseous induction**

- **Intramuscular induction :**
- For the extremely uncooperative or developmentally delayed child
- ketamine (4 to 8 mg/kg IM.,Atropine (0.02 mg/kg IM) or glycopyrrolate (0.01 mg/kg IM) should be mixed with the ketamine to prevent excessive salivation. Midazolam, 0.2 to 0.5 mg/kg IM, may also be given to reduce the chance of emergence delirium

Induction techniques

- **IV induction:**
- For children more than 8 years old: Often, older children may prefer an IV technique rather than a mask. Anesthesia can be induced with propofol (3 to 4 mg/kg) or thiopental (4 to 6 mg/kg).
- Awake or sedated-awake intubation with topical anesthesia should be considered for emergency procedures in neonates and small infants when they are critically ill or a potential difficult airway is present
- Muscle relaxants often are used to facilitate endotracheal intubation. Muscle relaxants may be contraindicated in infants and children with abnormal airway anatomy

Fluid management

- Maintenance Fluid Requirements
- Deficits
- Replacement Requirements

Calculation of **Maintenance Fluid** Requirmens

Weight (kg)	Hourly Fluid Requirements (mL)
<10	4 mL/kg
11-20	40 mL + 2 mL/kg for each kilogram above 10
>20	60 mL + 1 mL/kg for each kilogram above 20

- A solution such as D5½NS with 20 mEq/L of potassium chloride provides adequate dextrose and electrolytes at these maintenance infusion rates.
- D51/4NS may be a better choice in neonates because of their limited ability to handle sodium loads.
- Neonates require 3–5 mg/kg/min of a glucose infusion to maintain euglycemia (40–125 mg/dL); premature neonates

Deficits

- **(Wt kg x maintenance rate mL/kg/h x fasting hours h).**
- In contrast to adults, infants respond to dehydration with decreased blood pressure but without increased heart rate.
- 50% in the first hour and 25% in the second and third hours.

Replacement Requirements

- Replacement can be subdivided into
- blood loss and
- third-space loss:

Average Blood Volumes

Age	Blood Volume
Neonates	
Premature	mL/kg 95-100
Full-term	mL/kg 85-90
Infants	mL/kg 80
Adults	
Men	mL/kg 75
Women	mL/kg 65

Transfusion therapy

- Blood loss<10% BV-no replacement or crystalloid
- 10-20%- colloids or blood
- > 20%- blood
- MABL= $\frac{\text{EBV*(starting hct-target hct)}}{\text{hematocrit of PRBC'S}}$

Emergence and recovery

- Extubation
  - Laryngospasm may occur during **emergence**, especially during the critical period of excitemen
  - Coughing is not a sign that the child is ready for extubation. Instead, children should demonstrate purposeful activity (e.g., reaching for the endotracheal tube) or eye opening before extubation
  - In the **infant**, hip flexion and strong grimaces are useful indications of awakening
  - Alternatively, the trachea may be extubated while the patient is still anesthetized **deeply**

Postoperative Pain Control for Neonates and Infants

Intravenous

- Opioids: morphine, fentanyl, methadone
- NSAIDs: ketorolac

Oral

- Acetaminophen(20 mg/kg)
- Ibuprofen(5 mg/kg)
- Hydrocodone(0.1 mg/kg).
- Codeine (0.5 mg/kg)

Rectal

- Acetaminophen(20 to 30 mg/kg)
- Diclofenac

Regional and local anesthesia

Thank you