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Pediatrics, What have we forgotten?

Objectives

List the differences between adult and pediatric airway anatomy and understand their implications for intubation

Discuss the implications of upper respiratory tract infections for anesthesia

List physiologic differences between adults and children by organ system

This is Hard

- There is a fine line in this presentation....
- Maybe we are addressing this at a good time since the process for maintaining certification is about to change????

Definitions:

- New Born: First 24 hours
- Neonates: 24 hours to 30 days
- Infants: 30 days to 12 months
- Children 12 months to 12 years
- Beyond 12 years... Headache..

Always keep in Mind...

Cardiac output is dependent on????

When compared to adults:

- Non compliant Left ventricle
- Residual Fetal Circulation
- Large Head, Large Tongue
- Anterior and Cephalad Larynx
- Long Epiglottis, Short Trachea and Neck
- Prominent Tonsils and Adenoids
- Immature Hepatic Biotransformation
- Decreased Protein Binding
- Rapid induction and Recovery
- Large Volume of distribution for water soluble drugs
- Immature Neuromuscular junction

Pre-Operative Work Up

In small children, it is important to ascertain a short pregnancy and birth history. Your history should include the number of weeks gestation of the pregnancy. Less than 37 weeks is considered preterm. We use a construct called post conceptual age to stratify risk in infants.

Post conceptual age (PCA) = Weeks gestation + weeks of life.

Infants are at increased risk of apnea and must stay overnight in the hospital for monitoring up to 55 weeks PCA. Events during pregnancy such as maternal hypertension or diabetes may also impact the child's health and management.

Pre-operative

- Additional history to be obtained includes the condition requiring surgery, any coexisting medical conditions, medications, allergies, and recent illnesses. Upper respiratory tract infections are very common in children, and can significantly increase the risk of postoperative respiratory complications
- Second hand Smoke.... And a RTI.....
- Is this a reason to cancel?

- Upper respiratory tract infections are a dilemma which faces the pediatric anesthetists on a daily basis.
- They increase the incidence of laryngospasm, bronchospasm and desaturation.
- It is important to ask about the duration and severity of the URI, as well as its course.
- Children with URI symptoms are at increased risk for **four to six weeks** after the onset of symptoms. Reasons to cancel a case might include fever, concurrent wheezing or lower respiratory tract infection, and productive cough.
- So is it a reason to cancel?

Airway

- Located at C4 vs C6 in adults
- Narrow Nares—resistance is 12 times that of an adult
- Obligated Nose Breathers....OB—New Born
- High Glottis
- Slanting Vocal Cords
- Narrow Cricoid ring
- Cricoid cartilage is the narrowest point of the airway in children younger than 5.
- ?? Post glottic stenosis.....

- Because the airway is cone shaped, with the narrowest point at the cricoid cartilage, an uncuffed tube is adequate to seal the trachea. Using an uncuffed tube allows us to maximize the inner diameter of the tube, decreasing airway resistance and turbulence. (Remember Poiseuille's Law—resistance is proportional to $1/\text{radius}$ to the fourth power)
- After placement of the endotracheal tube, we look for a leak of air around the tube at 15 to 25 cm of water pressure. If there is no leak at high pressures, the tube is too tight and may exert pressure on the tracheal mucosa, causing edema and postoperative croup.

Do you remember

- Tube inside diameter, less than 2 yr olds
- $4 + \text{age}/4$ (4yr old/ $4 + 4 = 5$)
- Risk of tracheal stenosis is minimal with modern low pressure cuffs and cuffed tubes may be used when indicated
- Length of tube:
- $10 + \text{age}/2 = \text{length}$ ($10 + 4\text{age} / 2 = 7 \text{ cm}$)

Cardiovascular

- Children have a higher cardiac output and oxygen consumption per kilogram than adults.
- They support this higher output with a higher baseline heart rate.
- Infants are heart rate dependent for their cardiac output. In other words, they have a fixed stroke volume, and must increase their heart rate to increase cardiac output.
- They may respond to stress, such as hypoxia, by becoming bradycardic, and therefore decreasing CO.
- This can make resuscitation quite difficult. Normal vital signs for children include higher heart rates and lower blood pressures than adults.

Age	Weight (kilograms)	Pulse	Respirations	Systolic BP	Diastolic BP
Premature	1	145	< 40	42 +/- 10	21 +/- 8
Premature	1-2	135	--	50 +/- 10	28 +/- 8
Newborn	2-3	125	--	60 +/- 10	37 +/- 8
1 month	4	120	24-35	80 +/- 16	46 +/- 16
6 month	7	130	--	89 +/- 29	60 +/- 10
1 year 10	120	20-30	96 +/- 30	66 +/- 25	--
2-3 years	12-14	115	--	99 +/- 25	64 +/- 25
4-5 years	16-18	100	--	99 +/- 20	65 +/- 20
6-9 years	20-26	100	12-25	100 +/- 20	65 +/- 15
10-12 years	32-42	75	--	112 +/- 20	68 +/- 15
Over 14 years	> 50	70	12-18	120 +/- 20	75 +/- 15

- ## Respiratory
- Neonates Smaller FRC = faster induction
 - Increased closing volumes and decreased FRC make the neonate prone to atelectasis and hypoxia
 - Neonates are diaphragmatic breathers
 - Intercostal muscles are underdeveloped
 - Diaphragm is high
 - Chest cavity is small

- Minute volume is increased, corresponding with the increased cardiac output. This is supported by an increased respiratory rate.
- Tidal volume and dead space are equivalent to adults on a per kilogram basis.
- Children desaturate rapidly because of increased utilization of oxygen per kilogram, and because their FRC is decreased under anesthesia.
- FRC decreases under anesthesia because of small alveoli, and a very compliant chest wall. (No rigid box effect like adults have.) Both of these things lead to increased atelectasis.

- ## Temperature
- Pediatric patients lose heat to the environment more readily than adults.
 - This is due to an increased surface area per kilogram. This is compounded by cold intravenous fluids, dry anesthetic gases, and wound exposure.
 - Hypothermia is a serious problem which can result in delayed awakening, cardiac irritability and respiratory depression.
 - Infants cannot shiver, but must metabolize brown fat to maintain temperature. It is important to PREVENT heat loss with a warm operating room
 - Increase your room temp... to bad for the surgeon. YOU run the room when it comes to pt safety. Bair Hugger below patient

- ## Fluids
- Maintenance fluid
 - For the first 10 kg of weight give 4cc/kg/hr
 - For the second 10 kg, ADD 2cc/kg/hr
 - For the remaining kg, add 1cc/kg /hr
- 35 kg child requires 40+20+15 =75 cc/kg/hr
- 5 kg child requires only 5x4=20cc/kg/hr

- Preoperative deficit.
 - This is simply maintenance fluid x hours NPO. Half is replaced in the first hour of surgery, one quarter in the second hour, and the remaining quarter in the third hour

- Third space losses:
Superficial procedures 2-4 cc/kg/hr
Moderate procedures 4-6 cc/kg/hr
Major procedures 6-8cc/kg /hr

This is given in addition to maintenance and deficit fluids to account for loss of fluid to the environment from open wounds

Blood Replacement

- Replace each cc of blood lost with 3 cc of crystalloid or 1 cc of colloid or PRBC

Estimated allowable blood loss is calculated as follows
 $ABL = EBV \times HB \text{ (current)} - HB \text{ (acceptable)} / HB \text{ (mean)}$

EBV is estimated blood volume

- Premature 90-100 cc/kg
- Infant 80 cc/kg
- Toddler 75 cc/kg
- Child 70 cc/kg
- Adult 65-70 cc/kg

Cardiac

- Infants are born with an anatomically patent foramen ovale and ductus arteriosus.
- The ductus closes in the first day of life.
- The foramen ovale may remain probe patent for life, but physiologically closes in the first day of life.
- This can be important, because bubbles in IV fluid can cross the PFO and go directly to the brain.

Bubble trap? Downs Patient? Patent PFO?
Thoughts???

Pharmacological

- Neonates are more sensitive to opiate analgesics during the first four weeks of life, leading to an increased risk of apnea.

Inhalational anesthetics reach the brain faster in children, allowing us to perform inhalation inductions more easily.

The volume of distribution for most drugs, including muscle relaxants, is increased in children, so a standard dose leads to a lower plasma level than in adults. However, children are more sensitive to the effects of muscle relaxants, so a lower plasma level leads to the same effective dose.

Congenital Diaphragmatic Hernia

- 1 in 5000 births
- Occurs at 5-10 weeks of fetal life.
- Guts herniate into the thorax via the right or left Foramen of Bochdalek....most often the left. Rarely the right or anterior foramen of Morgagni.
- Mortality is estimated 50%
- Hypoxia, scaphoid abdomen with the bowel in the thorax
- SEVERE respiratory insufficiency and persistent pulmonary hypertension
- Maintain preductal saturation about 85%. Using peaks pressures below 25cm water and allowing PCO2 to rise to 45-55 mm/hg
- Stabilize and sedation, paralysis and moderate hypercapnia
- Ecmo??? NO for pulmonary hypertension

Congenital Diaphragmatic Hernia

- Avoid barotrauma and ensure adequate oxygenation
- Decrease gastric distention
- Right sided Pneumo....i.e. hypotension, pressure changes
- Intubate the patient awake
- No nitrous..
- Paralysis and Narcs
- The peak pressures should be kept low... to decrease risk of pneumo

Intestinal Malrotation

- Abnormal rotation of the gut and mesentery causing acute ischemia to the gut... THIS IS A SURGICAL EMERGENCY
- Presents early with 30% presenting in the first few days post birth
- Presents as: bilious vomiting with progressive distention and tenderness, metabolic acidosis, hemodynamic instability
- NG to decompress the belly, antibiotics, fluids, high risk for aspiration, awake intubation, fluids,,,, fluids,,,,

Multiple medical management issues... But remember a surgical emergency.

Tracheoesophageal Fistula

- 1:3000 live births, multiple variations, most common ends in a blind pouch with the esophagus lower portion attaches to the trachea
- Feeding is the cardinal sign, leads to choking, coughing, cyanosis and hypoxia and bradycardia
- Diagnosis with attempting to pass a catheter
- Aspiration is very common
- Associated with VATER syndrome NOW called VACTERL
- Copious secretions, needing frequent suctioning
- No positive pressure ventilation prior to intubation
- Awake intubation without muscle relaxants
- Patient will be dehydrated and malnourished
- Do not extend the neck.....

Tracheoesophageal Fistula

- Complications; Aspiration is very common
- Severe Dehydration
- Very aggressive treatment of pneumonia
- Multiple other defects
- Frequent suctioning related to thick and copious secretions
- NO positive pressure ventilations
- Positive pressure ventilations increase the risk of gastric distention
- treat the dehydrated pt
- No neck distention
- Avoid anything in the esophagus

Acute Epiglottitis

- What do we remember???
- High Fever, difficult swallowing, INFECTION>>> Drooling, Sitting forward. Cyanotic emergency... AIRWAY emergency...
- Treatment ... Antibiotics – Ampicillin
- H-Flu Type B vaccine.
- Oxygen, no Nitrous, no Paralysis, induce in the sitting position, small tube with leak...
- TUBE NOW>>> INTUBATE NOW>>> extubate in the OR

Croup

- Low fever with slow onset and less airway obstruction
- Barking cough... with inspiratory stridor
- Treat with cool humidity and oxygen... may need racemic epinephrine
- THIS is the common cold
- Para-influenza virus type 1 or 2
- Dry out for emergency surgery, does not require intubation most of the time.

Prune Belly Syndrome

- 1 in 40,000 births, mostly male
- Congenital disorder of the urinary system leading to bladder problems, ureter problems and back flow of urine
- High risk of aspiration with a thin weak abdominal wall
- Little cough, with pulmonary complications
- Awake intubation, full stomach treatment,
- This a renal issue.. Watch the use of drugs excreted by the renal system.

Cystic Fibrosis

- Hereditary diseases of exocrine glands of pulmonary and gastrointestinal systems.
- Thick and viscous secretions and decreased ciliary activity lead to pneumonia and wheezing
- Dehydration and electrolyte abnormalities

- Anticholinergics are controversial
- Deep intubation
- Aggressive suctioning
- Antibiotic therapies
- Planning for surgeries
- Salt therapy...

Tonsillectomy and Adenoids

- This is an airway issue....
- Perfect conditions should be present ask about 2nd and 3rd hand smoke and URI's
- LMA vs ETT
- Use of a pre-op anticholinergic
- Post-op bleeding..
- Pain control is very important

- OSA>>> increased improvement in school and focus post tonsils

Malignant Hyperthermia

- Do you want to talk about it?

- This is up to you?

- If we do it will be short 5 min talk related to peds...

Neonate

- Indications for Positive pressure ventilations... apnea, heart rate less than 100/min, central cyanosis on 100% oxygen
 - Initial breaths may be at a higher pressure then lower
 - If heart rate is below 60 the neonate is intubated and failure in increase heart rate about 80 is a indication for chest compressions

 - Small tube should have a leak with 20 of pressure
- Vascular access... consider umbilical vein if needed

Neonate Drugs

- Epinephrine 0.01-0.03 mg/kg or 0.1-0.3 ml/kg of 1-10,000 soln
- Atropine 0.03 mg/kg
- Calcium 30mg/kg of calcium chloride
- Narcan 0.01 mg/kg IV or 0.02 mg/Kg IM (last 4 hours of labor)
- Glucose 4ml/kg of 10% soln for documented hypoglycemia

- Story Time.....

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Questions

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- THANK YOU

Thank you