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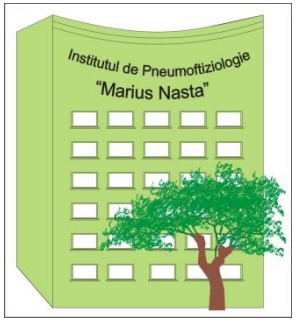
Speaker: (*Radu T. Stoica)*

CEEA



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Dificulties in Pediatric Thoracic Anesthesia

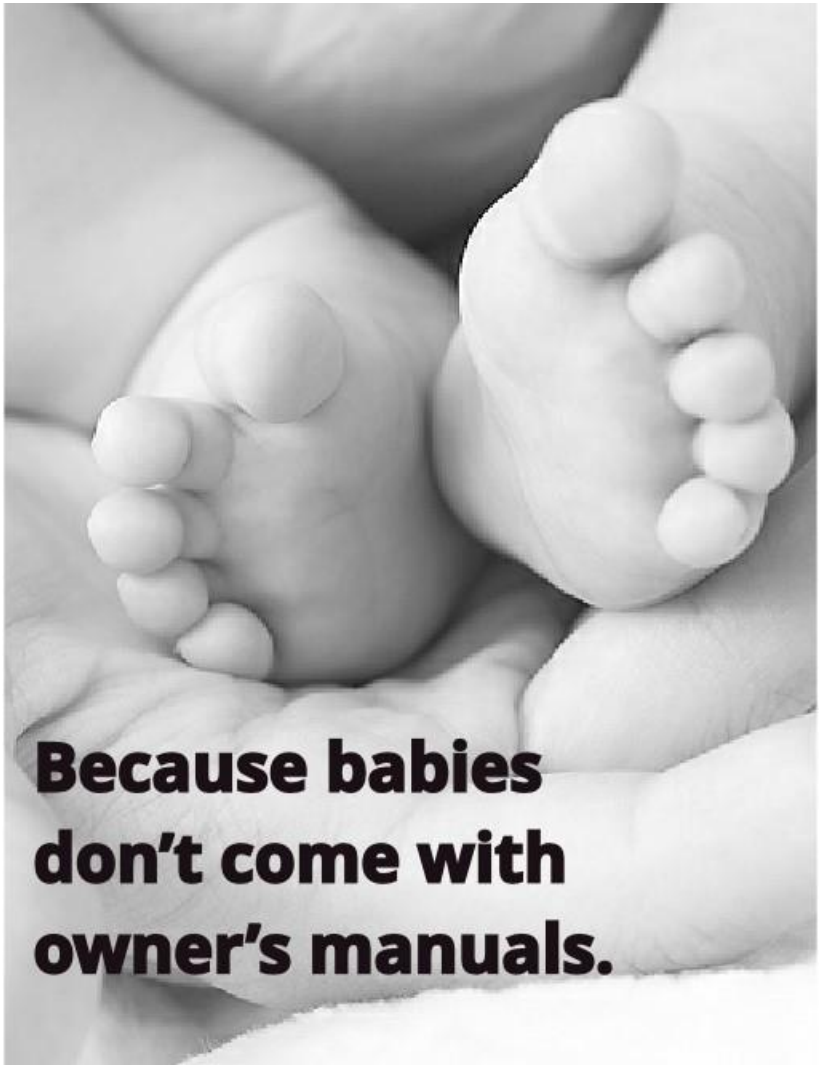
Dr. Radu T. Stoica

Thoracic Anesthesia and Respiratory ICU

European Society of Anaesthesiology ESA

World Federation of Societies of Anaesthesiologists

Why is so difficult?



Pediatric Vitals

	RR	HR	BP	KG
Newborn	30–60	100–160	60–80	3–5
6 mos	25–40	90–120	80–100	7
1 yr	20–30	90–120	80–100	10
18 mos	20–30	80–120	80–110	12
3 yrs	20–30	80–120	80–110	15
5 yrs	18–24	70–110	80–110	20
6 yrs	18–24	80–100	80–110	20
8 yrs	18–24	70–110	80–110	25
10 yrs	16–20	70–110	90–120	30
12 yrs	16–20	60–110	90–120	40
14 yrs	16–20	60–105	90–120	50
16 yrs	16–20	60–80	80–120	60
18 yrs	16–20	60–80	80–120	70

Anathomy

Physiology

- High metabolic rate (5-8 mlO_2/kg/min) (2-3ml/kg/min adult)
- Tidal volume (6-7 ml/kg/min)
- High respiratory rate (40-60 breaths/min)
- High alveolar ventilation (130 ml/kg/min)
- Lung compliance is less while chest wall compliance is more than those in adults (reduced FRC and atelectasis) ►PEEP.
- Diaphragm has less oxidative type I fibers ► susceptible for fatigue.
- The work of breathing is composed of compliance and resistive components. The compliance work relative to tidal volume is nearly the same as in adult. The resistive work increases when breathing through ETT (4th radius), and through circle system.

FAST DESATURATION

Preoperative assessment

- **Clinical status of the child**: underlying acute or chronic conditions that may impact the perioperative course
- **Infants** have less specific signs: poor feeding, irritability, or change in sleep habits
- **Older children**: dyspnea, cyanosis, wheezing, coughing, weight loss
- If **history of previous surgery**: the perioperative course
- **Thoracic examination**: asymmetric expansion and use of accessory muscles. auscultate for wheezes, rales, rhonchi, and absent breath sounds
- **Pulsoximetry**
- **Venous HCO_3**, elevated in children with chronic CO_2

Golianu B, Hammer GB, Pediatric thoracic anesthesia, Current Opinion in Anaesthesiology 2005, 18:5–11

Preparing for anesthesia…

CEEA

Airway Equipment
Suction catheters
Oral airways
Face masks
Breathing circuit
Miller 0, 1, blades and handles
Uncuffed endotracheal tubes 2.5, 3.0, 3.5, 4.0
Stylet

Environment
Room temperature (80°-85°F)
Underbody warm air delivery device
Warming blanket
Circuit humidifier
Intravenous fluid warmer

Agents
Gases
Air/oxygen/nitrous oxide
Volatile anesthetics
Intravenous anesthetics
Propofol
Thiopental
Ketamine
Muscle relaxants
Succinylcholine
Cisatracurium
Vecuronium
Rocuronium
Pancuronium
Narcotics
Remifentinal
Fentanyl
Morphine
Local anesthetics
Lidocaine (1%)
Tetracaine (1.0%)
Bupivacaine (0.25%)
Emergency drugs:
Atropine
Epinephrine (1:10,000)
Dopamine
Calcium
Bicarbonate
Isoproterenol

Intravenous Fluids
Lactated Ringer's
$D_{10}W$
Normal saline
5% albumin

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+

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Equipment for lung separation

Thoracothomy and VATS

- Single Lumen Endotracheal Tube (ETT), cuffed or uncuffed

intubate a mainstem bronchus

- Balloon-Tipped Bronchial Blockers

- Univent Tube

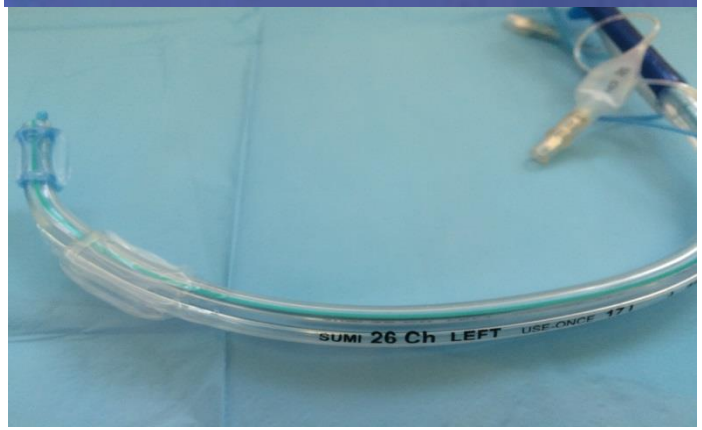
- Double Lumen Tubes (DLT)

Verify with FOB

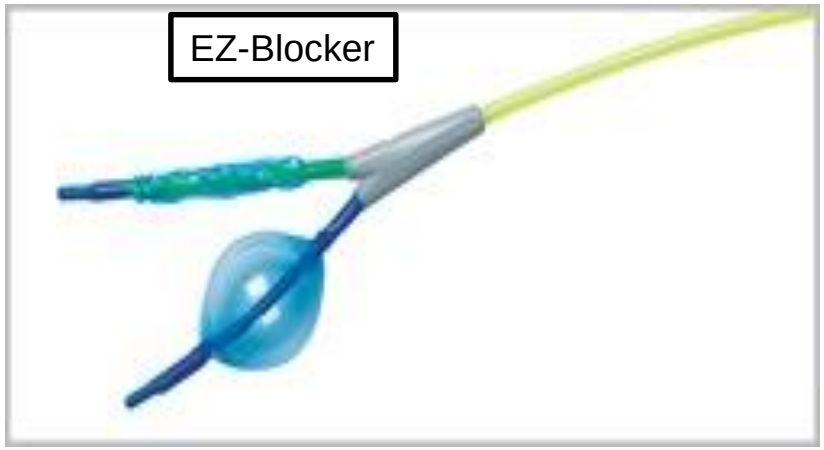
Single lumen

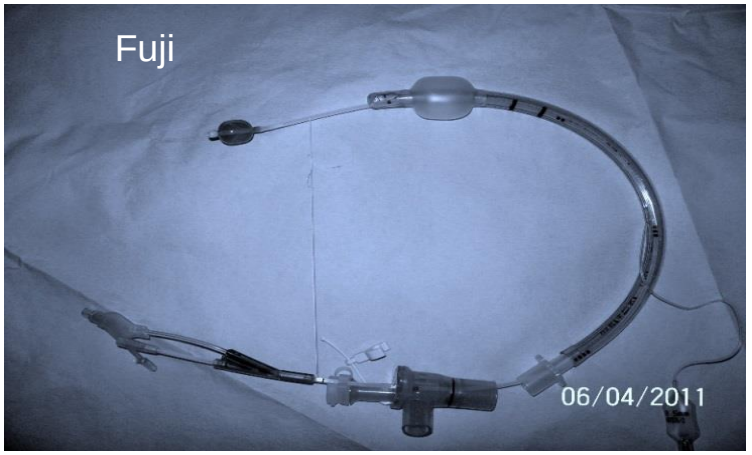
Univent

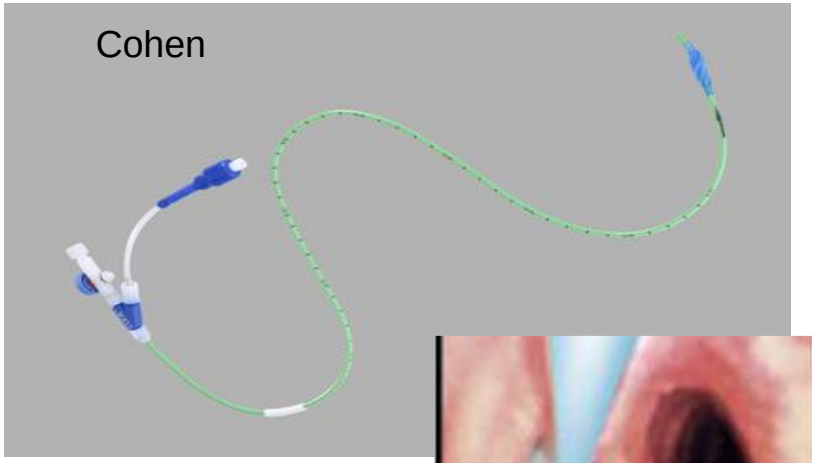
Double lumen

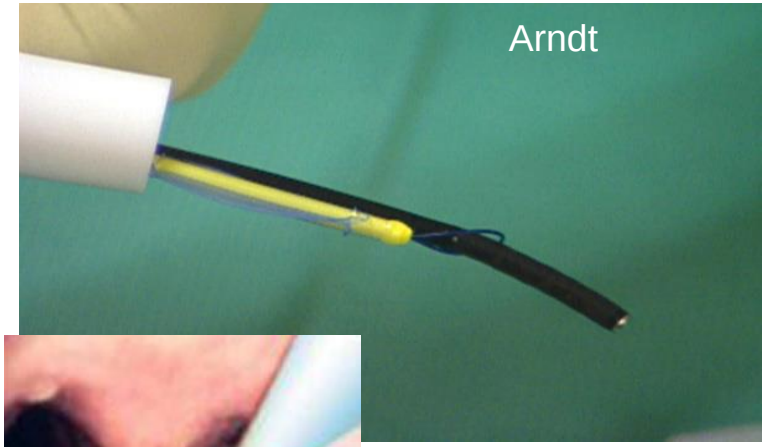


Bronchial Blockers









Tube selection for single lung ventilation in children

Age	ETT (ID)	BB (Fr)	Univent (ID)	DLT
0.5–1	3.5–4.0	2–3		
1–2	4.0–4.5	3		
2–4	4.5–5.0	5		
4–6	5.0–5.5	5		
6–8	5.5–6	5	3.5	
8–10	6.0 cuffed	5	3.5	26
10–12	6.5 cuffed	5	4.5	26–28
12–14	6.5–7.0 cuffed	7	4.5	32
14–16	7.0 cuffed	7	6.0	35
16–18	8.0–8.5 cuffed	7–9	7.0	35

Golianu B, Hammer GB, Pediatric thoracic anesthesia, Current Opinion in Anaesthesiology 2005, 18:5–11

General anesthesia

- Monitoring vital signs ± Transcutaneous CO_2 monitoring
- **Induction of anesthesia:** intravenous catheter, and tracheal intubation, arterial catheterization for most patients undergoing thoracotomy as well as those with severe lung disease having thoracoscopic surgery
- Combination of general anesthesia with regional anesthesia and postoperative analgesia is particularly desirable for thoracotomy

Ishibe Y, et al. The effect of thoracic epidural anesthesia on hypoxic pulmonary vasoconstriction in dogs: an analysis of the pressure-flow volume curve. Anesth Analg 1996; 82:1049–1055

- **General anesthesia**: Inhalation an iv anesthesia. Not important interference with HPV. Muscle relaxants

Frequent 100% FiO_2

Physiology of one-lung ventilation

- **Adults**: oxygenation is optimal in lateral decubitus with the healthy lung “dependent” due to increased blood flow (gravitational and HPV)

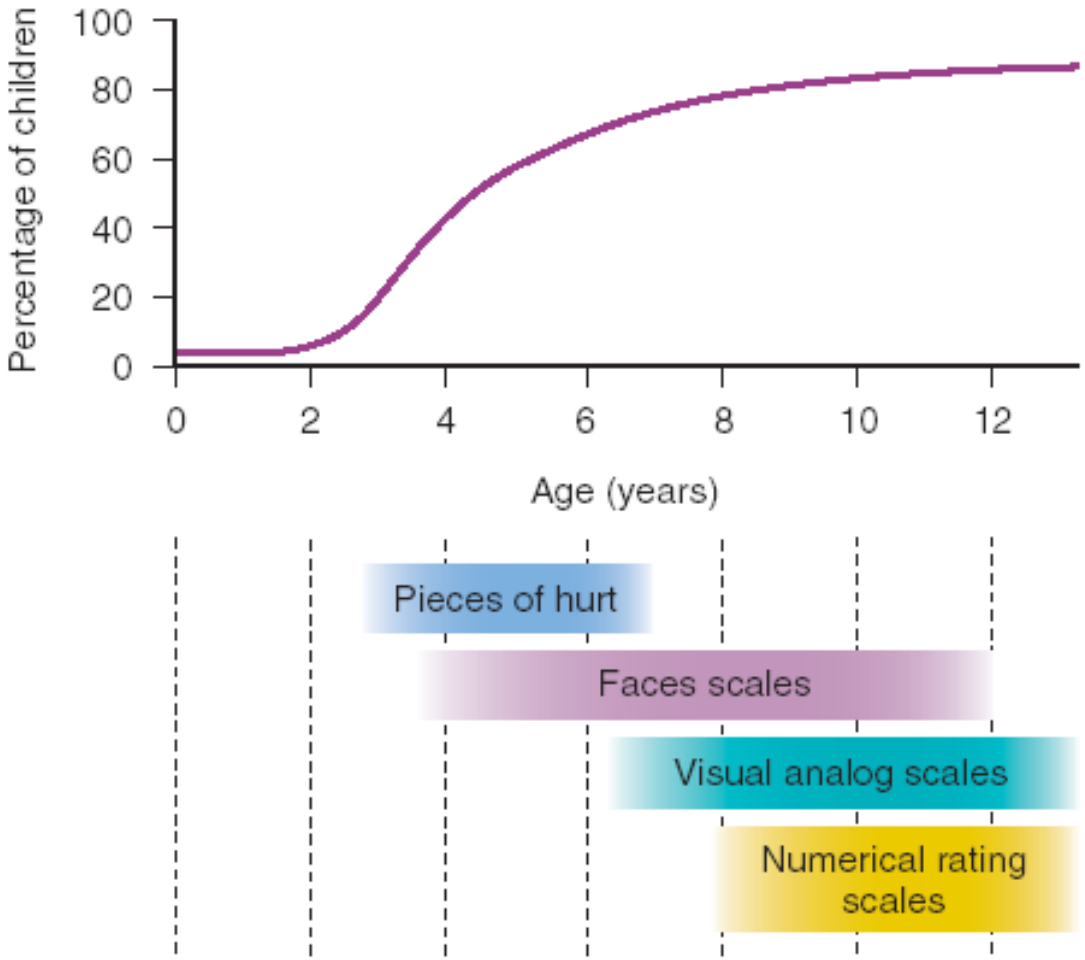
BETTER V/Q MACH

- **Infants**: FRC is closer to residual volume. Airway closure likely to occur in the dependent lung even during tidal breathing. Soft, easily compressible rib cage an lower abdominal pressure *WORST VENTILATION*

Low hydrostatic pressure gradient between the non-dependent and dependent lung. *WORST CIRCULATION*

WORST V/Q MACH

Pain assessment



Thoracic epidural

- Thoracic epidural placement in infants and young children should be restricted to those experienced in the technique.
- The procedure should be abandoned if difficulties are encountered.
- In children 2–10 yr of age, the mean distance of the spinal cord from the dura at T9–10 vertebral level is 4.3 mm.
- The thoracic vertebral spines are almost horizontal, which allows a midline approach to the thoracic epidural space. A paramedian approach is often required in adolescents.
- In neonates and infants, catheters can be easily and consistently threaded to higher segmental levels from lower approaches. Insertion at a lumbar level is often possible and safer in infants compared with a direct thoracic approach.

D. Patel, Epidural analgesia for children, Contin Educ Anaesth Crit Care Pain (2006) 6 (2): 63-66.

63 children: 3 months to 18 yr and in weight from 3.2 kg to 78 kg

- **Intravascular placement was excluded** using a test dose that consisted of 1 to 3 ml bupivacaine 0.25% with epinephrine (1:200,000).
- **Postoperative analgesia** was provided by an initial bolus of 0.2 to 0.3 ml. kg - of bupivacaine 0.25% with 0.5 to 1.0 microg/kg $^{-l}$ fentanyl followed by a continuous infusion of bupivacaine 0.1% to 0.125% with 2 microg/ml fentanyl.

Tobias JD, Lowe S, Thoracic epidural anesthesia in infants and children, 1993 Can J Anaesth, 40:872-882

Ganesh A et al, Efficacy of addition of fentanyl to epidural bupivacaine on postoperative analgesia after thoracotomy for lung resection in infantsAnesthesiology. 2008;109:890-894.

Thoracic epidural

HAMMER ANESTH ANALG
PEDIATRIC THORACIC ANESTHESIA 2001;92:1449–64

Author	Indication	Age (yr)	Epidural solution	Infusion rate
Gunter (129)	thoracic/abdominal surgery	1–10	Bupiv 0.125% + Epi 1:200,000	0.15 mL · kg^{-1} · h^{-1}
Cassidy et al. (128)	spinal fusion	11–18	Bupiv 0.125% + Fent 0.025 mg/mL	0.28 mL · kg^{-1} · h^{-1}
Hammer et al. (127)	cardiac surgery	1–6	Bupiv 0.1% + HM .003 mg/mL	0.30 mL · kg^{-1} · h^{-1}
Tobias et al. (130)	thoracic surgery	.25–18	Bupiv 0.1% + Fent .017–.025 mg/mL	0.30 mL · kg^{-1} · h^{-1}

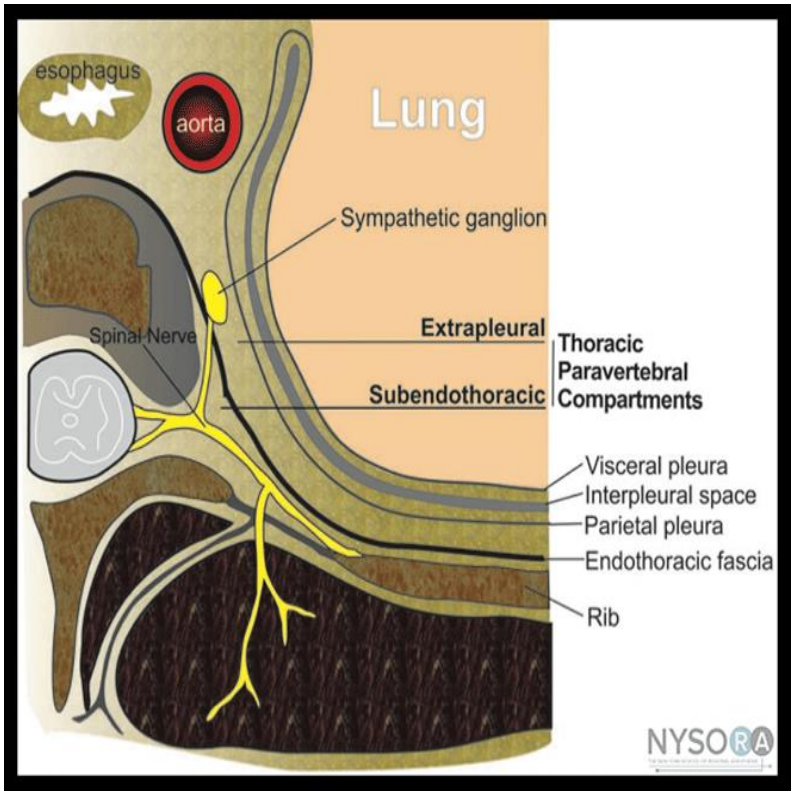
Bupiv = bupivacaine; Epi = epinephrine; Fent = fentanyl; HM = hydromorphone.

Thoracic Paravertebral

-Positioning. Sitting or lateral decubitus.

-Landmarks. Spinous process. Needle insertion point is 1 to 2 cm lateral to the superior aspect of he spinous process.

-Technique.Use a 22-guage Tuohy needle. The insertion point: 0.5 to 1cm past the transverse process. Estimated depth: paravertebral space: 20 + (0.5 × wt [kg]) = depth in mm



Thoracic surgery pathology

- **Lesions of the trachea and bronchi**

Aquired

Congenital

- **Lung parenchyma**

Pulmonary sequestrations (childhood or adult), Extralobar sequestration (< 2years old), Pulmonary hypoplasia, Congenital lobar emphysema, Bronchogenic cysts, Dermoid cysts, Cystic adenomatoid malformations, Metastasis

- **Esophagus**

Tracheoesophageal fistula (TEF), Esophageal atresia

- **Mediastinal** (childhood)

Limphomas, Neuroblastomas

- **Diaphragm**

Hernias

Tracheal surgery

1. **FOB** is used to **evaluate** the severity of the stenosis

General anesthesia with spontaneous breathing, **Local anesthesia** on vocal cords

2. ETI, LAM, Rigid bronhoscopy for ventilation

3. Cricoid split procedure or laryngotracheoplasty (rib, auricular), stent

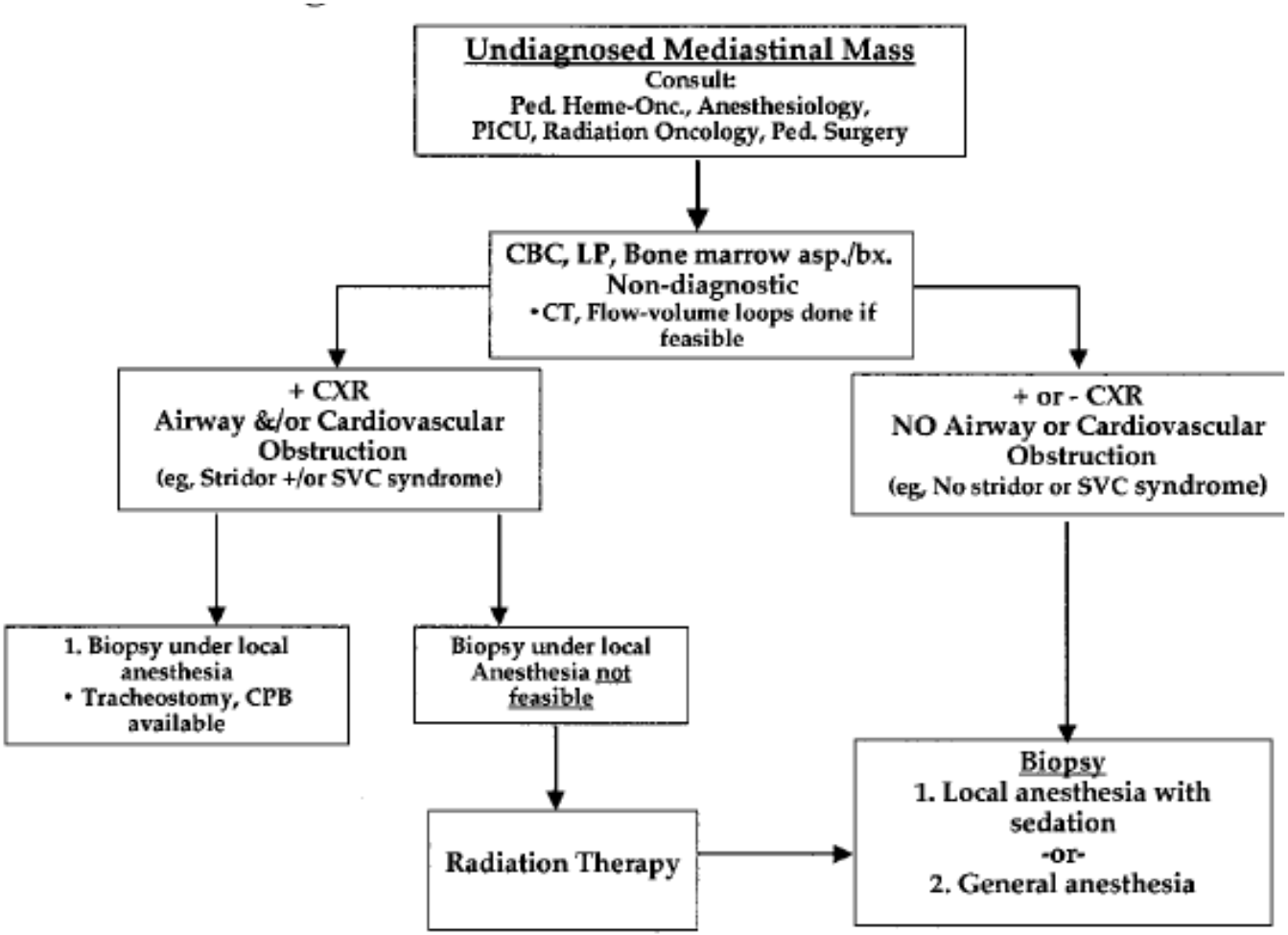
4. **ETT** (half size than tracheoscope**) left in place**

5. May require **postoperative ventilation** for a period of time

6. Rarely, repair of distal tracheal and bronchial stenosis may require **cardiopulmonary bypass**.

Anterior mediastinal mass (AMM)

Danger of respiratory/circulatory colaps at induction!



Anterior mediastinal mass

Preparing General Anesthesia

- **Devices and skilled personel!**

Rigid bronchoscope, FOB available

Prepared for tracheostomy

- **Consider changing patient position**

Head elevated

Lateral decubitus with CPAP for maintaining FRC

- **Anesthesia:**

Adequate IV lane

Mask induction with spontaneous breathing

Intubation without muscle relaxant or succinylcholine

LMA if possible for biopsy of AMM!

Large and symptomatic AMM may need ECMO or CPB

- **ICU bed available!**

Hammer GB Anaesthetic management of children with anterior mediastinal masses, Anaesthesia, 2008;63:837-846

Foreign body

- **Degree of emergency:** tracheal or respiratory distress
  Urgent FOB or rigid bronchoscopy in OR
- **Rigid bronchoscopy in most cases!**
- **Anesthesia induction**:

under the fear *of foreign body relocation!*

Spontaneos breathing: cough!

IPPV: distal dislogement!

under the fear *of gastric aspiration in emergency cases!*

- **i.v general anesthesia anesthesia** during the procedure
- Lateral port ventilation or HFJV
- If spontanos ventilation is chosen: + topical anestesia on vocal cords

Fidkowski CW, et al, The Anesthetic Considerations of Tracheobronchial Foreign Bodies in Children: A Literature Review of 12,979 Cases Anesth Analg 2010;111:1016-1025

Conclusions…

- Knowledge of respiratory physiology and anatomy in pediatric patients
- Devices and skills: special size FOB, Bronchial blockers, LM, one-lung ventilation
- Use of regional anesthetic techniques
- Anesthetic management in specific conditions: anterior mediastinal mass, foreign body

Children are totaly different!