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Rapid Sequence Intubation & Emergency Airway Support in the Pediatric Emergency Dept.

Michele M. Nypaver, MD

UMHS Pediatric Emergency Medicine Fellowship Lecture Series

July 2009

Objectives

A is for airway!

- Basics Review
- The 7 P's of RSI
- RSI Pharmacology
- Procedure
- Indications/Complications of RSI
- Advanced Airway options
- Resources for skill maintenance and help

Definitions

Rapid Sequence Intubation:

- **Describes a sequential process of preparation, sedation, and paralysis to facilitate safe, emergent tracheal intubation.**
- **Pharmacologic sedation and paralysis are induced in rapid succession to quickly and effectively perform laryngoscopy and tracheal intubation.**
- **At the same time, careful preparation (including pre-oxygenation) and the use of specific techniques (such as applying cricoid pressure and avoiding positive pressure ventilation) minimize the risks of hypoxia and aspiration.**
- **Assuming a patient with full stomach.**

The Evidence for RSI

"NEAR" data: n=156 pediatric intubations
Success Rates for intubation

METHOD	FREQ. (%)	FIRST ATTEMPT (%) *	FIRST PERSON (%)	OVERALL SUCCESS (%)	COMPLI C-ATION (%)
RSI	**81**	**78**	**85**	**99**	**1**
NO MEDS	**13**	**47**	**75**	**97**	**5**
SED, NO NMBA	**6**	**44**	**89**	**97**	**0**

* May be due to size and age

Sagarin et. al., 2002

Basic Pediatric Anatomy: Size

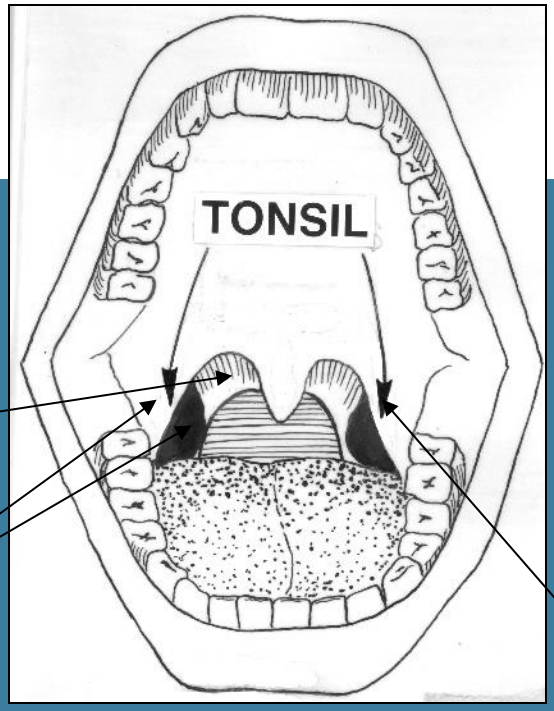
	NORMAL	EDEMA 1mm	RESISTANCE (R proportional to 1/(radius^4)	X-SECT AREA
INFANT			Increase 16x	Decrease 75%
ADULT			Increase 3x	Decrease 44%

Take home point: Small changes in pediatric airways cause large incremental increases in airway resistance

PEM BOARD QUESTION!

23) In this picture taken during DL, the arrow is pointing to which of the following anatomic structure(s)?

a) Arytenoid cartilages
b) Epiglottis
c) Vallecula
d) Vocal cords
e) Aryepiglottic fold

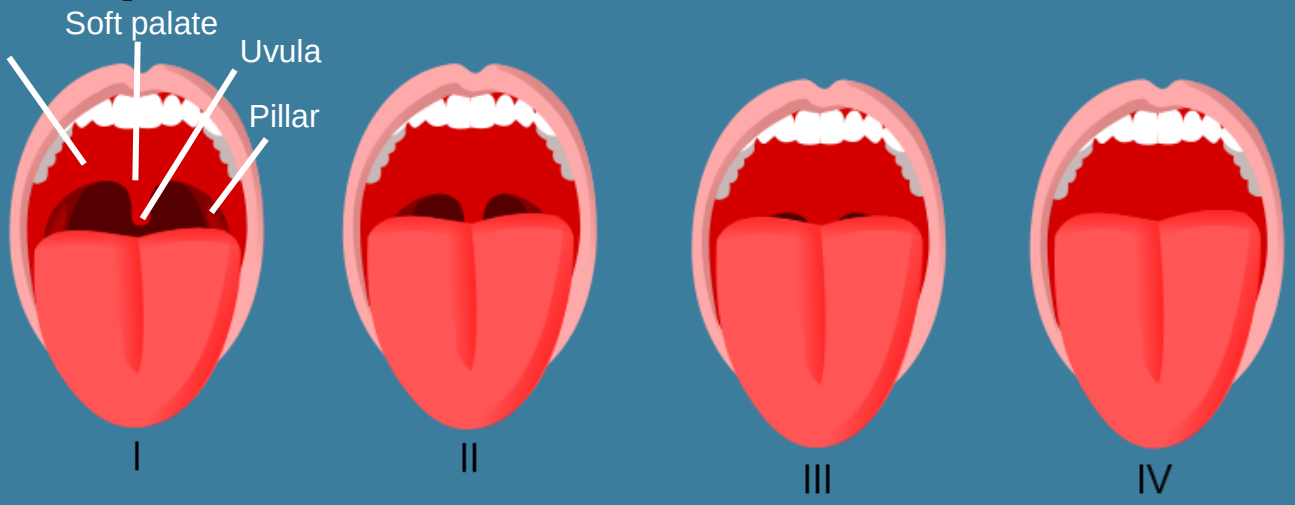


True Vocal Cords

Physical Assessment to identify signs of a real/potential difficult airway in children

- Prominent or misshapen occiput
  - short neck
  - poor neck mobility
- Facial trauma (including burns)
- Facial anomalies:
  - Small mouth
  - Small mandible/recessed chin
  - Abnormal palate
  - Large tongue
  - Loose teeth
- Signs of upper airway obstruction
  - hoarseness, stridor, drooling, upright position of comfort

Airway Assessment: Malampati & ASA Classification



Malampati Score

Jmarchn, Wikimedia Commons

Table 7 American Society of Anaesthesiologists (ASA) Classification	
ASA I	Healthy
ASA II	Mild systemic disease – No functional limitation
ASA III	Severe systemic disease – Definite functional limitation
ASA IV	Severe disease – Constant threat to life
ASA V	Moribund

Source Undetermined

UMHS / CES requires documentation of these on all procedural sedation consents

Physical signs	Less difficult airway	More difficult airway
Look externally	• Normal face and neck • No face or neck pathology	• Abnormal face shape • Sunken cheeks • Edentulous • "Buck teeth" • Receding mandible • "Bull-neck" • Narrow mouth • Obesity • Face or neck pathology
Evaluate the 3-3-2 rule	• Mouth opening > 3F • Hyoid-chin distance > 3F • Thyroid cartilage-mouth floor distance > 2F	• Mouth opening < 3F • Hyoid-chin distance < 3F • Thyroid cartilage-mouth floor distance < 2F
Mallampati	• Class I and II (can see the soft palate, uvula, fauces +/- facial pillars)	• Class III and IV (can only see the hard palate +/- soft palate +/- base of uvula)
Obstruction	• None	• Pathology within or surrounding the upper airway (e.g. peri-tonsillar abscess, epiglottis, retro-pharyngeal abscess)
Neck mobility	• Can flex and extend the neck normally	• Limited ROM of the neck

The Lemon Pneumonic

Mouth opening > 3 cm

Chin to neck distance > 3 finger breadths

TheCulinaryGeek, Flick

http://archive.ispub.com/journal/the-internet-journal-of-anesthesiology/volume-10-number-1/the-dilemma-of-airway-assessment-and-evaluation.html#sthash.TmMgasnc.dpbs

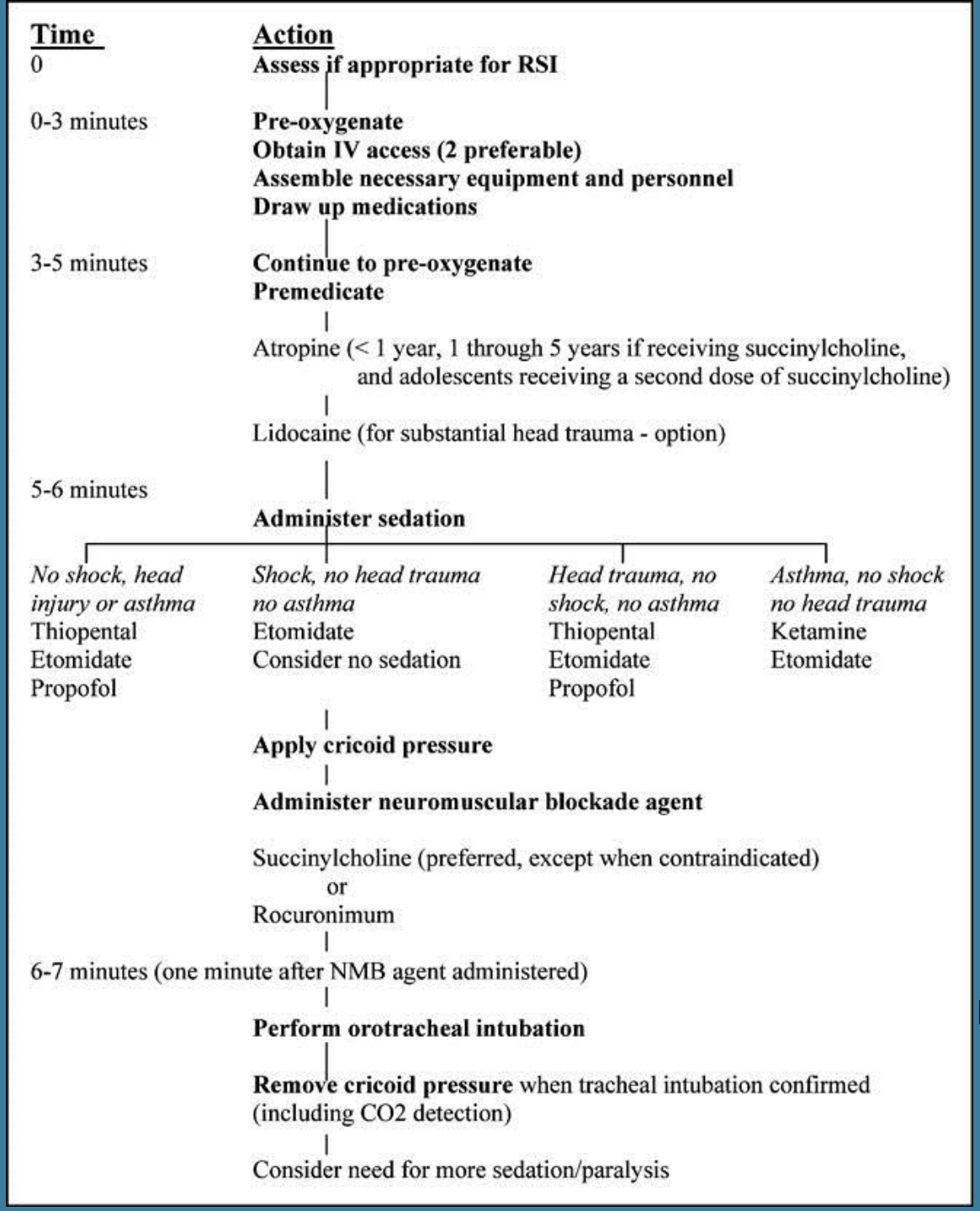
RSI Procedures

The 7 “P”s of RSI

Preparation
Pre-oxygenation/Positioning
Pre-treatment
Protection (Pressure)
Pharmacology
Placement of the tube
Post intubation management

RSI Timeline/Protocol

- Preparation: Zero-10 Min
  - Monitors, Patient position, Assess for difficulty
  - Equipment and Meds
- Pre oxygenate: Zero-5 Min
- Pre treat: Zero-3 Min
- Time Zero: Inject Paralytic with induction
- Protection: Zero-30 seconds
- Placement: Zero-45 seconds
- Post intubation management: Zero-90 seconds



http://www.ijciis.org/viewimage.asp?img=IntJCritIllnInjSci_2012_2_3_143_100891_u2.jpg

*P*reparation for RSI:

- **Equipment**
  - **Type/Size Specific**
  - **Airway/Difficult Airway Cart**
- **Monitors**
  - **Pulse Oximetry**
  - **CR monitoring**
  - **CO2 monitoring**
- **References: Broslow Tape, Harriet Lane**
  - **Doses**
  - **Sizing**
- **Personnel**
  - **Nurses/Tech's/Housestaff: Assign roles**
- **Walk thru**

Prepare for rain!

Molly DG, flickr

RSI *P*reparation: Airway equipment for Pediatric patients

Supplemental oxygen

Nasal cannula (infant, child, and adult)

Clear oxygen masks (non-re-breathing - infant, child, and adult)

Suction

Suction catheters (6 through 16 French)Yankauer suction tip (two sizes)

Bag-mask ventilation

Masks (neonate, infant, child, adult)

Self-inflating resuscitator bag (450 and 1000 mL)

Artificial airways

Oro-pharyngeal airways

Intubation equipment

Endotracheal tubes (uncuffed and cuffed, 2.5 through 8.0 mm internal diameter) Stylets (infant, pediatric, and adult) Laryngoscope handle (pediatric and adult) Laryngoscope blades: straight (sizes 0, 1, 2, and 1.5 straight and and curved (sizes 2 and 3) Miller, Mac, Phillips & Wis-Hipple

Rescue airway devices

Laryngeal mask airway (sizes 1, 1.5, 2, 2.5, 3, 4, and 5) Combitube (37 and 41 French)

Miscellaneous

Pulse ox, End-tidal CO2 detector, Magill forceps (pediatric and adult), Bulb suction

Endotracheal Tube Sizes

- Predicted Size Tube = (Age / 4) + 4
- $\frac{16 + age}{4}$

PEM BOARD QUESTION!

Which is the most appropriate equipment and position for the provided patient age?

a) 1 mo: Miller 1 blade, 4.5 uncuffed tube inserted to 14 cm, 8 Fr NG tube
b) 1 mo: Miller 2 blade, 4.5 uncuffed tube inserted to 11 cm, 8 Fr NG tube
c) 3 yo: Miller 1 blade, 4.5 uncuffed tube inserted to 14 cm, 12 Fr NG tube
d) 3 yo: Miller 2 blade, 4.5 uncuffed tube inserted to 11 cm, 12 Fr NG tube
e) 7 yo: Miller 2 blade, 5.5 uncuffed tube inserted to 16 cm, 12 Fr NG tube

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PEM Board Question!

14) Which of the following is true regarding laryngoscope blades?

a) Miller blades are designed to sit in the vallecula
b) Miller blades are available in sizes from neonates to large adults
c) Macintosh blades are used more commonly in infants/children than in adults
d) Macintosh blades provide a better laryngoscopic view
e) Macintosh blades should not be used to lift the epiglottis because of increased risk of epiglottic trauma

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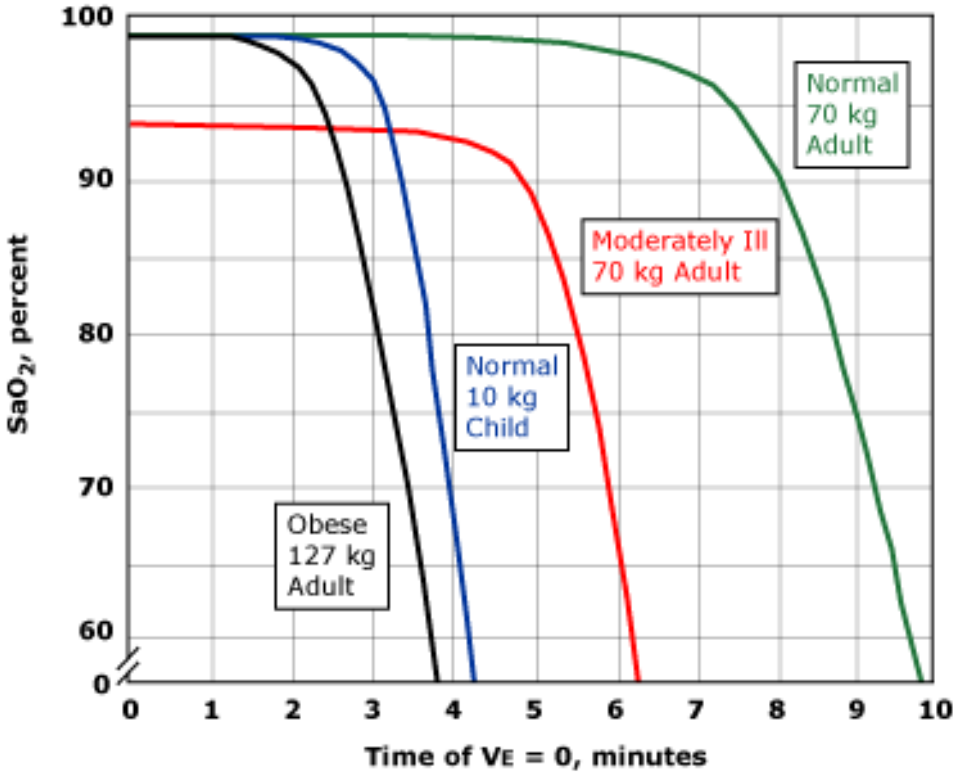
RSI: *P*re-oxygenation

- A critical step
  - Reservoir of oxygen for apnea time
  - Time varies by patient/condition
- Begin pre-oxygenation immediately
- Administer 100% oxygen
  - If spontaneously breathing:
    - Non Rebreather Face mask FIO2 100% X 5 min
  - Avoid bagging sponteously breathing pt
  - If need to bag: Selick maneuver
  - If assisted ventilation or BVM req'd: 8 effective VC
  - breaths provides best pre oxygenation.
- Goal: O2 sat > 90% duration of procedure

Time to desaturation during RSI



Mean time to recovery of twitch height from 1 mg/kg succinylcholine IV

SaO_2, percent	10	50	90
Time of VE = 0, minutes	6.8	8.5	10.2

Children have a short interval to desaturation after paralyzation

Source Undetermined

RSI Pharmacology:
The perfect pharmacologic recipe?

Medical

Trauma (ICP?)

Special Cases

(Asthma)

RSI Pre-treatment: Prevent adverse effects of laryngoscopy and /or succinylcholine

- **Lidocaine**
- **Atropine**
- **Defasciculation dose of Non depolarizing ?**

RSI Pretreatment: Lidocaine

- Local anesthetic
- Use in RSI
  - **Theory: Blunt rise in ICP (unknown exact mech)**
  - **No studies available measuring efficacy of lidocaine on neurologic**
    - **Outcome after trauma**
  - **Current recommendations 1-2mg/kg IV 2-5 min before intubation**
- Adverse Effects:
  - Seizure
  - Hypotension

RSI Pre-treatment: Atropine

- **Mechanism of Action:**
  - **Anti cholinergic, Blocks muscarinic ACH receptors**
- **Original Science:**
  - **Milk introduced in lamb = laryngeal reflex:**
  - **Apnea, hypoxia and bradycardia**
  - **Reflex particularly strong in newborn animals and infants**
    - **Wennergren G, Milerad J, Hertzberg T. Laryngeal reflex.**
      - **Acta Paediatr Suppl. 1993;389:53–56.**
- **Limited data to answer question:**
  - **Does atropine prevent bradycardia in children undergoing RSI?**

Does Atropine prevent bradycardia during RSI?

Retrospective cohort study comparing atropine RSI vs no atropine RSI children (0-19y/o)

Rates of bradycardia 4% each group.

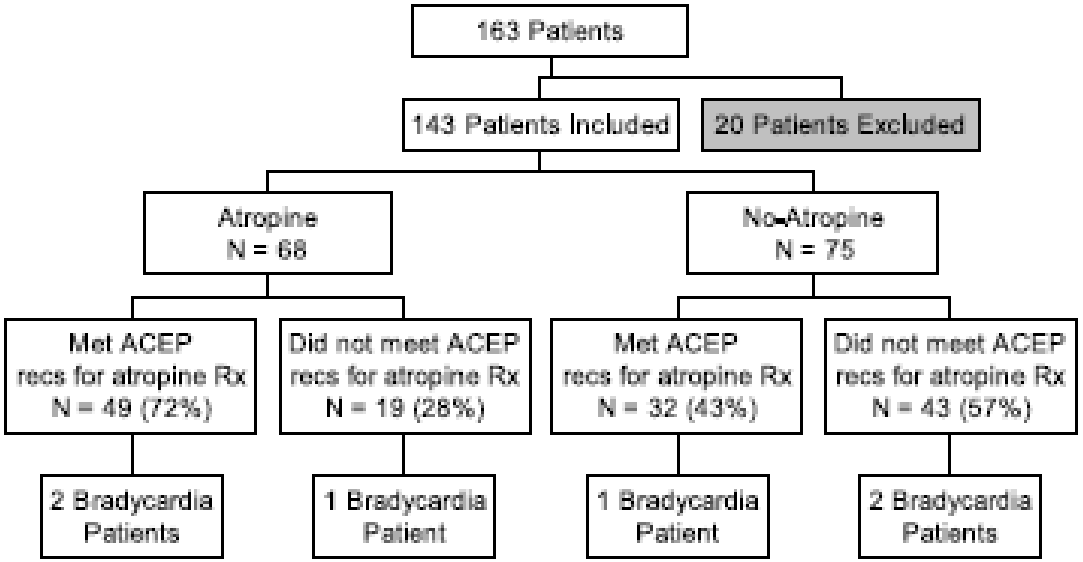


FIGURE 1. Flowchart of patients enrolled.

Fastle RK Roback MG. Pediatric rapid sequence intubation: incidence of reflex bradycardia and effects of pretreatment with atropine. Pediatr Emerg Care. 2004 Oct;20(10):651-5

RSI: Atropine?

Myth: Atropine should be administered before succinylcholine for neonatal and pediatric intubation

Bethany Fleming, BA, BS; Maureen McCollough, MD; Sean O. Henderson, MD CJEM. 2005 Mar;7(2):114-7

Atropine: What can we say?

- **Who**:
  - **All children < 1 year, Children < 5 y/o SCh, AND**
  - **Prior to repeat dose SCh (in adolescent/adult)**
- **Dose**
  - **Current recommendations: AAP ACEP AHA PALS**
  - **"Cannot recommend uniform guidelines based on lack of evidence"**
    - **0.01-0.02mg/kg (min 0.1, max 1.0mg) 1-2 min**
      - **Prior to intubation**
- **Adverse effects**

  Increase HR, Increase IOP

RSI: Pharmacology/Paralytic with Induction

- Agents determined by condition/scenario
- Induction options
  - Etomidate
  - Midazolam
  - Ketamine
  - Propofol (Currently NOT available in UMHS ED)
  - Barbiturates
  - Pentothal

RSI Pharmacology Etomidate

- Non narcotic, non barbiturate hypnotic induction
- Sedative, not analgesic
- Lowers ICP
- Pro:
  - Min CV effects so safe in pts with unstable hemodyn
- Dose: 0.3mg/kg IV, onset 2-30 seconds
- May cause
  - pain on injection
  - myoclonic jerks
  - hiccups

RSI Pharmacology Etomidate….but

- Adverse Effects
  - Inhibits mitochondrial hydroxylase activity
  - Even after single dose
  - Effects seen in PICU population
    - Implications in septic patients
  - Risk of infection may be increased
  - No randomized clinical trials assess outcome
  - Bottom line: Using judiciously

PD-GOV

Arcadian, Wikimedia Commons

RSI Pharmacology: BDZ's Midazolam, Lorazepam, Diazepam

- Sedative, anxiolytic, amnestic NOT analgesic
- Resp depressants
- Reversible with Flumazenil
- Several choices

Midazolam: Dose 0.1-0.3mg/kg (induction)

More potent than diazepam

Rapid onset < 1 min

Caution when used with narcotics, esp in younger children/infants

"Near "data suggest many underdose Midazolam!

RSI Pharmacology: Ketamine

- Dissociative agent; amnestic and analgesia
- Release of catecholamine
  - Increased HR and BP
- Adverse Effects
  - Increased secretions
  - Emergence reactions
  - Laryngospasm
  - May increase ICP (relative contraindication)

RSI Pharmacology: Ketamine

- Bronchodilator: intubation of asthmatics
- Induction dose: 1-2 mg/kg
- Onset 10-15 sec
- Duration 10-15 min

PEM Board Question!

- A 12 yo boy with severe asthma is being treated in the ED. So far he has received 2 hours of continuous nebulized albuterol and ipratropium bromide, methylprednisolone and IV magnesium. He is still in severe respiratory distress. A bedside ABG reveals a pH of 7.12, pCO2 80 torr, and pO2 45 torr on 100% supplemental oxygen. You are getting ready to perform rapid sequence intubation (RSI) and preoxygenate with 100% oxygen with a bag/mask system. During induction with ketamine, he develops stridor with suprasternal retractions. Which of the following would be most appropriate?

A) Administer nebulized racemic epinephrine
B) Administer IV fentanyl
C) Administer IV succinylcholine
D) Administer IV flumazenil
E) Perform jaw thrust until ketamine wears off

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RSI Pharmacology: Propofol

- Alkphenol
- Sedative hypnotic
- Attenuates ICP rise
  - Dec CPP
- Induction dose 0.5-1.2mg/kg IV
- Adverse problems: BP

RSI Pharmacology: Thiopental

- Barbiturate
- GABA receptor
- Rapid onset sedation (15 sec)
- Decrease ICP
- Cardiac depressant, venodilator: Lower BP
- Dose: Euvolemic child 5-8mg/kg IV
- Hypovolemic child 1-5 mg/kg IV

RSI: Neuromuscular Blocking Agents (NMB's)

- NMB issues to consider
  - Documentation of neuro exam
  - Make sure to sedate too
  - Dosing must be adequate
  - Anticipate complications
    - Failed intubation
    - Adverse effects
    - Prep for surg airway

RSI Pharmacology: Neuromuscular Blocking Agents (NMB's)

- Depolarizing
  - Succinylcholine*
- Non depolarizing
  - Vecuronium
  - Rocuronium
  - Rapacurium
  - Pancuronium
  - Atracurium
  - Curare

RSI: Neuromuscular Blocking Agents (NMB's)

- Depolarizing Agent (Succ)
  - Simulate Ach receptors
  - Reliable paralysis with long track record of use
- Non depolarizing agents
  - Competitively block Ach receptors without
  - Stimulating them

RSI: Neuromuscular Blocking Agents (NMB's): Succinylcholine

Dose: Infants/Young 2mg/kg IVP

Dose: Older children 1-1.5mg/kg IVP

Contraindications:

Personal/Fam with Malignant Hyperthermia

Burn >10% BSA > 24 hr old (not problem in acute)

Crush injury > 1 week old

Denervation > 1 week old

Progressing/ongoing neuromuscular dz; watch for children with suspected myopathies

Side Effects

Bradycardia (esp after >1 dose); reduced with pre tx with Atropine

Hyperkalemia: Pk 5 min, resolves 15 min, rarely sig

Fasciculations

Myotonic syndromes

MH

RSI Pretreatment: Defasciculation?

- Prior Recommendations for defasc dose
- Non depolarizing NMB before Succ
- Enhance effect of succ and reduce side effect
- Not routine in peds RSI but some evidence
  - Of succ induced hyperkalemia.

Theroux MC, Rose JB, Iyengar S, *et al*. Succinylcholine pretreatment using gallamine or mivacuronium during rapid sequence intubation in children: a randomized controlled study. J Clin Anesth 2001; 13:287-292

PEM BOARD QUESTION!

In which of the following patients could succinylcholine be used safely for RSI?

a) 2 yo with 2nd and 3rd degree burns covering 20-30% of the body surface area
b) 4 yo in a cervical spine (c-spine) collar with concern for a c-spine injury
c) 12 yo s/p CVA 2 months ago with residual left hemiparesis
d) 1 yo with Type 1 spinal muscle atrophy
e) 17 yo with renal failure on hemodialysis with known electrolyte abnormalities

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Answer: b. Succinylcholine may be used for RSI given its rapid onset and short duration of action. When succinylcholine binds to acetylcholine receptors, potassium is released, increasing serum potassium concentrations. Therefore, it is contraindicated in patients with known/suspected hyperkalemia, including patients with severe burns and those in renal failure (unless potassium is already known to be within normal limits). In patients with neurological denervation, such as would occur s/p CVA, and those with known or suspected myopathies or neuromuscular disease, acetylcholine receptors are upregulated at motor endplates. Therefore with succinylcholine use, massive amounts of potassium can be released precipitating hyperkalemic arrest even in patients with baseline normal potassium levels.

RSI: Neuromuscular Blocking Agents (NMB's): Non depolarizing Agents

- Competitively block Ach receptor
- Does not stimulate receptor
- Eventually diffuses out of synapse
- Useful for pts who cannot use Succ
- Longer duration of action
- Onset of action may be a little longer than Succ

RSI: Neuromuscular Blocking Agents (NMB's): Non depolarizing Agents

- Vecuronium
  - Dose 0.1-0.2mg/kg/IV
  - Max paralysis: 1-2 min
  - Duration of apnea: 25-45 min
  - Less vagolytic than pancuronium
  - Biliary excretion

RSI: Neuromuscular Blocking Agents (NMB's): Non depolarizing Agents

- Rocuronium
- Dose 1mg/kg
- Onset: 60 sec
- Duration: Up to 35 min
- Little CV effects
- Comparison of Rocuronium vs Succ
  - Equivalent provision of acceptable Int cond.
  - Rates of intubation success similar
  - Succ better at "excellent" condition

AEM 2002 Perry; Metanalysis 1606 pts

RSI: Other controversial Succinylcholine Issues

- Obese Pts?: Use actual body weight
  Rose et al. Anesth Analg 2000

- Is there an optimal dose?
  - Controversial, Rec peds dose stands

PEM Board Question!

In addition to direct visualization of an endotracheal (ET) tube passing through the vocal cords, the most rapid and reliable means to confirm tube placement in the trachea after intubation is:

A) Capnography
B) Oxygen saturation
C) Bilateral breath sounds on auscultation
D) Condensation in the ET tube
E) Fiberoptic bronchoscopy

Difficult airway

King Airway Device

Glidescope

DiverDave, Wikimedia Commons

Transtracheal Needle Ventilation

- Alternative to Cric

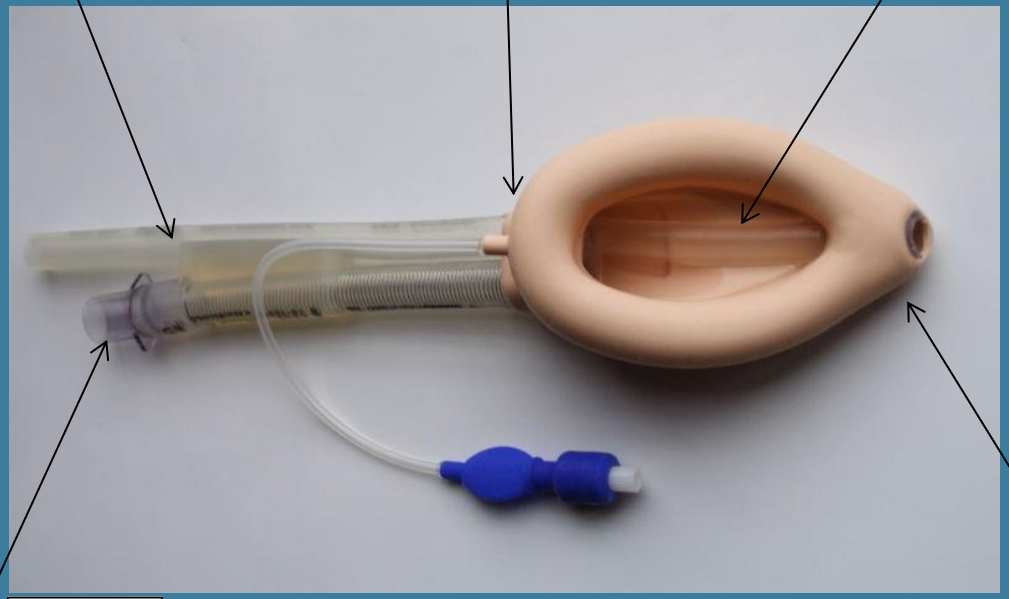
1) Transtracheal ventilation is difficult.10,11

2) Transtracheal ventilation through a catheter must be done with a high pressure, high flow device.10,12

3) Transtracheal ventilation through a catheter cannot be effectively done using a ventilation bag.12

4) The resistance of air flow through a transtracheal ventilation catheter increases as a 4th power function as the diameter of the catheter decreases.13

LMA-Fastrach™



Sizes 3, 4 & 5

Size 3: Children 30-50kg

bigomar2, Wikimedia Commons

Complications: Anticipate Problems before they happen!

- DOPE
  - Displacement
  - Obstruction
  - Pneumothorax
  - Esophageal placement
- Medication complications
- Take the pt off the vent
  - BVM
  - Check connections/Machines

RSI *P*ost Intubation Care

- Secure the tube
- Order the CXR
- Administer sedation
- Reconsider longer acting paralysis as indicated
- Respiratory Care:
  - Vent settings
  - Respiratory Therapy/transport

Resources for help/practice

- American Heart Association: PALS Manual
- UMHS Clinical Simulation Center
- UMHS Annual Anesthesia Airway workshop
- UMHS PEM Airway Workshop
- UMHS Dept of EM Difficult Airway Workshop

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