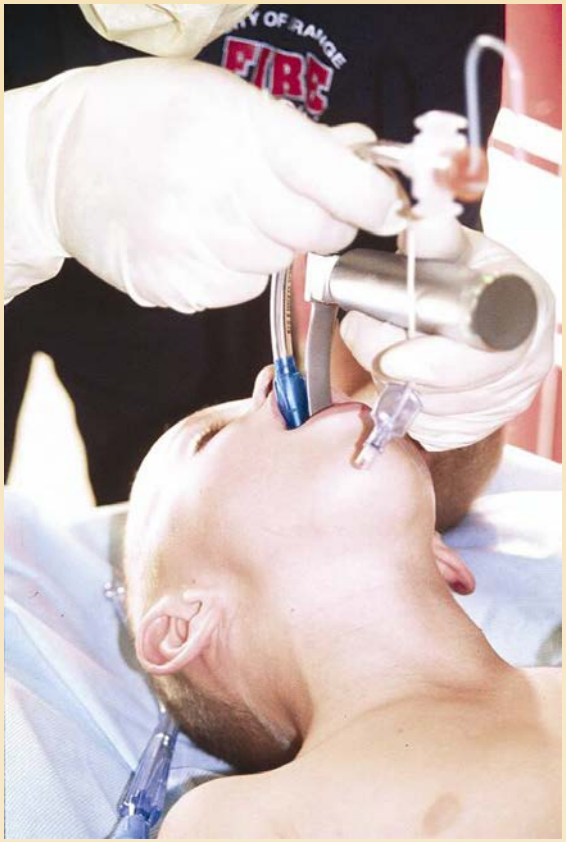
Rapid Sequence Intubation (RSI)



Objectives

- Outline the advantages of RSI.
- Describe the utility of adjunctive agents.
- Decide on a preference for a paralyzing agent.
- List the factors determining the selection of a sedative.
- Select a proper tracheal tube size.
- Recognize complications of RSI.

Case Study 1: "Severe Head Trauma"

- 10-year-old girl is brought to ED after being struck in the head by a baseball (no helmet).
- EMS placed her in spinal precautions.
- She is breathing spontaneously.
- She is not responsive.
- Her color and perfusion are normal.

Initial Assessment

PAT:

- Abnormal appearance, normal breathing, normal circulation

Vital signs:

- HR 70, RR 30, BP 105/75, O_2 sat 100% on face mask

Case Progression

- Oxygen administration and IV access are already established by EMS.
- Pupils are equal and reactive.
- Severe deformity noted on right side of skull.
- RSI is initiated for airway control.

Rapid Sequence Intubation

- RSI (sometimes called rapid sequence induction)
- Administration of sedative and paralyzing agent to rapidly render patient unconscious and paralyzed to facilitate endotracheal intubation.

Advantages of RSI

- Facilitates intubation by improving visualization during laryngoscopy
- Avoids pain, anxiety, and noncooperation of an “awake” intubation
- Redues harmful effects of intubation (e.g., bradycardia, pain, intracranial pressure increase, hypertension)
- Minimizes risk of pulmonary aspiration during intubation

RSI Alternatives

- Awake intubation – not advantageous
- Nasotracheal intubation – difficult in children, and advantages are lacking
- Orotracheal intubation using a sedative alone – shown to be more prone to complications than RSI
- Advanced airway or surgical airway methods – less experience with these
- Airway alternatives (LMA, Combitube)

Basic RSI

- Airway assessment
- Preoxygenation
- Optional adjunctive agents (atropine, lidocaine)
- Sellick maneuver (cricoid pressure)
- Paralyzing agent
- Sedative agent
- Intubation and confirmation

Equipment: SOAP-ME

- **S**uction
- **O**xygen
- **A**irway equipment
- **P**harmacologic agents
- **M**onitoring **E**quipment

Airway Assessment (1 of 2)

- Difficult airway conditions
  - Down, Goldenhar, Pierre-Robin, Turner syndromes
  - Epiglottitis, peritonsillar abscess
- Facial or airway trauma
- Neck anomalies, masses, edema
- Cervical spine injury requiring immobilization

Airway Assessment (2 of 2)

- Assess your ability to perform bag-mask ventilation (BMV) on the patient.
- BMV will be necessary as a rescue procedure if intubation is not achieved during RSI.
- If you anticipate that BMV is not possible, do not proceed with RSI until help arrives.

Preoxygenation (1 of 3)

- Maximum oxygenation provides patient with oxygen reserve during intubation process.
- Ideally, patient's oxygen saturation should be 100% before starting RSI.
- If patient is spontaneously breathing, avoid positive pressure unless hypoxia is present despite supplemental oxygen.

Preoxygenation (2 of 3)

- Spontaneously breathing patient:
  - Use a nonrebreather oxygen mask.
  - Do NOT use a self-inflating bag since oxygen does NOT flow unless the bag is being squeezed.
  - Avoid positive pressure ventilation to minimize risk of gastric distention.

Preoxygenation (3 of 3)

- Hypoventilating or apneic patient:
  - Use a self-inflating bag with maximum oxygen flow or an anesthesia (Rusch) bag with 100% oxygen.
  - Positive pressure will be necessary.
  - Consider Sellick maneuver (cricoid pressure) or gastric intubation (NG or OG tube).

Adjunctive Agents

- Atropine – anticholinergic
  - Probably useful in all children
  - Prevents bradycardia during intubation
  - Reduces oral secretions (e.g., ketamine)
- Lidocaine – lowers intracranial pressure
  - Given IV
  - Might be beneficial in head trauma cases or when ICP elevation is suspected

Sedative Agents

- No perfect sedative
- All sedatives may cause cardiovascular compromise.
- Selection is dependent upon clinical conditions.
- To simplify things, consider etomidate to be “default” sedative.

Thiopental

- Onset: 30 to 40 sec
- Duration: 10 to 30 min
- Benefits: Lowers ICP, lowers cerebral metabolism and oxygen demand, anticonvulsant
- Cautions: Myocardial depression. Giving this slowly reduces this adverse effect. Avoid in hypotension or patients in shock. May occasionally cause laryngospasm.

Midazolam

- Onset: 1 to 2 min
- Duration: 20 to 30 min
- Benefits: Reversible, amnestic, anticonvulsant, less likely to cause myocardial depression
- Cautions: Variable dose to achieve unconsciousness. Titration is required, which is not suitable for RSI. RSI requires a single dose.

Ketamine

- Onset: 1 min
- Duration: 30 min
- Benefits: Bronchodilator, sympathomimetic, less likely to cause myocardial depression.
- Cautions: Inject slowly to avoid vomiting; increases oral secretions (use atropine as an adjunctive agent), increases ICP, might cause emergence reactions

Etomidate

- Onset: Less than 1 min
- Duration: 10 to 20 min
- Benefits: Lowers ICP, supports blood pressure
- Cautions: Myoclonic excitation (might resemble seizures)

Sedative Selection

- Hypotension: Etomidate
- Status asthmaticus: Ketamine
- Head injury without hypotension: Thiopental or etomidate
- Unconscious in shock: Any agent may adversely affect circulation. Consider using no sedative or a low dose in conjunction with shock resuscitation.

Paralyzing Agents

- Also called muscle relaxants
- Succinylcholine
  - Onset 30-60 sec, duration 3-8 min
  - Shorter duration, higher risk of adverse effects
- Rocuronium
  - Onset 1-3 min, duration 30-45 min
  - Longer duration, but less potential for adverse effects

Succinylcholine

- “Depolarizing” muscle relaxant
  - Depolarizes muscle first (causing “fasciculations”), then paralysis
  - Fasciculations may cause muscle pain and myoglobinuria, more common in muscular adults
- Higher risk of hyperkalemia, especially following burns and/or crush injuries
- Higher risk of malignant hyperthermia
- Fastest onset time, short duration (3-8 min) in case intubation is not achieved

Rocuronium

- “Nondepolarizing” muscle relaxant, no fasciculations.
- Other drugs in group: vecuronium, pancuronium, atracurium, mivacurium. Rocuronium has the fastest onset time and fewest adverse effects.
- Onset time is slower than succinylcholine, but in practice, intubation initiated at 60-90 sec after administration, slightly slower than succinylcholine.
- Longer duration (30-45 min) in case intubation is not achieved. Partially reversible with edrophonium.

Paralyzing Agent Selection

- Physician preference
- Onset time: Succinylcholine faster
- Duration: Succinylcholine shorter
- Adverse effects: Fewer with rocuronium
- Intubation conditions: Approximately the same

“Rapid Sequence”

- Is it better to give the sedative first, or the paralyzing agent?
- They are given in “rapid sequence.”
- Some prefer to give sedative first to render the patient unconscious before experiencing paralysis.
- Some prefer to give paralyzing agent first since this requires 30 to 90 sec for onset, during which time sedative can be given.

Sellick Maneuver (1 of 2)

- Gentle anterior to posterior pressure on cricoid ring to occlude esophagus
- Reduces risk of passive regurgitation of stomach contents. Does not prevent vomiting.
- Reduces risk of aspiration.

Sellick Maneuver (2 of 2)

- Use with caution if C-spine immobilization is required.
- Initiate as soon as paralyzing agent is given. Do NOT release until tracheal intubation is confirmed.
- Might be beneficial before RSI if positive pressure BMV is required. Sometimes causes gagging and retching.

Intubation

- Maintain Sellick maneuver.
- RSI table or length-based resuscitation tape to determine:
  - Laryngoscope blade size
  - Tracheal tube size
  - Tracheal tube depth
- Confirm tracheal intubation.

Tracheal Tube

- Tracheal tube size = 4 + age/4
  - Example: 6-year-old = 4 + 6/4 = 5.5
- Have several available (one size larger and one size smaller than estimate).
- Tracheal tube depth at lip = 3 x TT size
  - Example: 5.5 TT = 16.5 cm

Laryngoscopes

- Curved blade
  - Insert into vallecula, then lift to expose cords.
- Straight blade
  - Insert into vallecula, then pick up epiglottis with blade to expose cords.
- Selection criteria: Personal preference
  - Most prefer straight blade for small children and curved for larger children and adults.

Prepare for Laryngoscopy

- Select laryngoscope blade type and size.
- Tracheal tube sizes ready
- Optional stylet in TT
- Monitor oxygen saturation.
- Maintain Sellick maneuver.
- Suction ready–An assistant should pass this to you upon request.

Laryngoscopy

- Maintain Sellick maneuver.
- Open patient's mouth with your right hand.
- Expose larynx with laryngoscope.
- Avoid touching patient's teeth with laryngoscope blade.
- Have an assistant pass TT to your right hand.
- Cricoid pressure can be adjusted to bring vocal cords into view.

Intubation

- Advance TT through vocal cords under direct visualization as possible.
- Confirm that trachea is intubated:
  - Colorimetric CO_2 detector
  - $ETCO_2$ monitor
  - Esophageal detection bulb or syringe
  - Auscultation
  - Portable chest x-ray

TABLE 22-6 RSI Drugs, Doses (mg/kg), Sizes, Distances

Age	2 mo	6 mo	1 yr	3 yr	5 yr	7 yr	9 yr	11 yr	12 yr	14 yr	16 yr	Adult
Average weight(kg)	**5**	**8**	**10**	**15**	**19**	**23**	**29**	**36**	**44**	**50**	**58**	**65**
Preoxygenation												
Adjunctive agents (optional):												
Atropine (0.01–0.02 mg/kg): Use in all children or with ketamine.												
	0.1	0.15	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Lidocaine (1.5 mg/kg): Lowers ICP												
	8	12	15	22	28	35	44	54	66	75	90	100
Sellick maneuver												
Sedative												
Hypotension												
Etomidate (0.3 mg/kg):	1.5	2.4	3.0	4.5	6	7	9	11	13	15	17	20
Head trauma without hypotension												
Etomidate (see above) or												
Thiopental (3–5 mg/kg):	15–25	24–40	30–50	45–75	57–95	70–115	90–145	110–180	130–220	150–250	170–290	195–325
Status asthmaticus:												
Ketamine (1–2mg/kg):	5–7	8–16	10–20	15–30	19–38	23–46	29–58	36–72	44–88	50–100	58–100	65–100
Paralyzing agent:												
Succinylcholine (1.0–1.5 mg/kg):	8	12	15	25	30	40	50	55	60	65	70	80
Rocuronium (0.6–1.0 mg/kg):	4	6	9	12	15	20	25	30	40	45	50	60
Intubate (tube size):	3.5	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.0 female, 8.0 male		
Tube depth at lip (cm):	11	12	13	14	15	16	18	19	20	22	22	22
Laryngoscope blade size:	1	1	1	2	2	2	2	2	3	3	3	3–4

Clinical Indicators of Tracheal Intubation (1 of 2)

All of the following are potentially error-prone.

- Observe for bilateral rise and fall of chest.
- Auscultate:
  - Bilateral lung air exchange
  - Absence of gastric bubbling/gurgling with ventilation

Clinical Indicators of Tracheal Intubation (2 of 2)

- Vapor condensation in TT
- Improvement or maintenance of good oxygenation and cardiopulmonary parameters
- Confirm TT depth at lip.

End-Tidal CO_2 Measurement

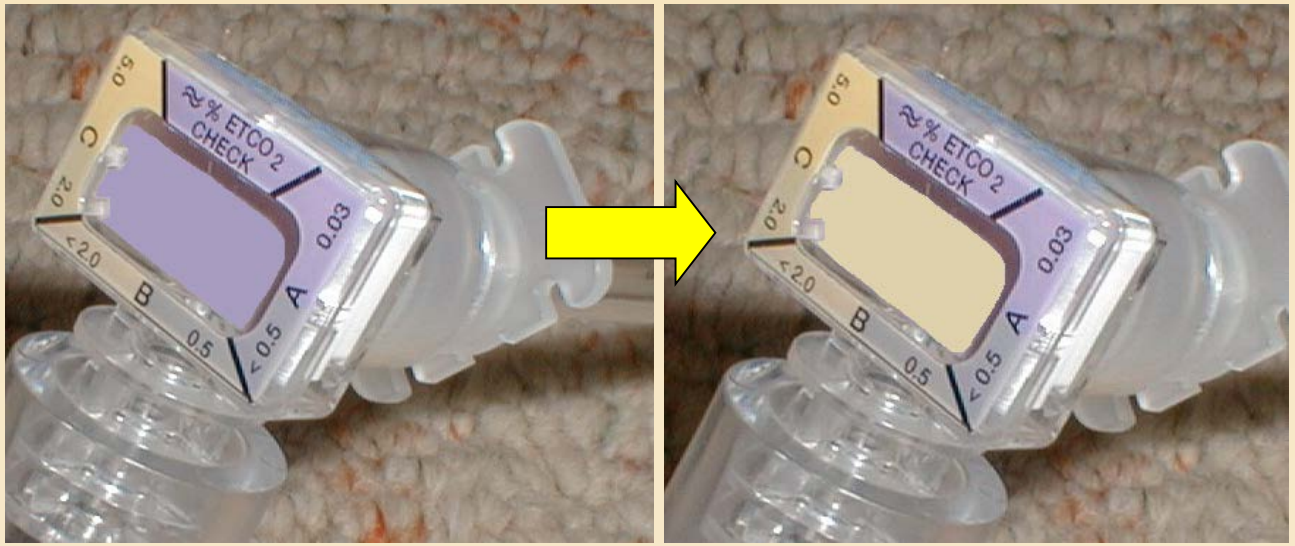
- Best single means to confirm tracheal intubation
- False readings possible:
  - CPR (poor pulmonary perfusion), severe asthma (poor gas exchange): P_{CO_2} may be low or absent even though TT is in trachea.
  - Esophageal/gastric CO_2 production (false tracheal confirmation): Not likely, but possible.

Colorimetric CO_2 Detector (1 of 4)

- Select correct size (pediatric or adult).
- Open package (must be new) and check expiration date. Window should show purple/lavender color. If it is yellow or white, it is defective.
- Connect one end on TT and other end to manual resuscitator or ventilator circuit.

Colorimetric CO_2 Detector
(2 of 4)

- A change from purple to yellow and vice versa with inhalation/exhalation confirms tracheal intubation.



Colorimetric CO_2 Detector
(3 of 4)

- Purple to yellow: Secure TT.
- Tan. Think about it.
  - Ventilate patient 6 more times and reassess clinically.
  - Consider tracheal intubation confirmation using alternative method.
  - Attempt to correct cause of low perfusion or hypocarbia.

Colorimetric CO_2 Detector
(4 of 4)

Purple only:

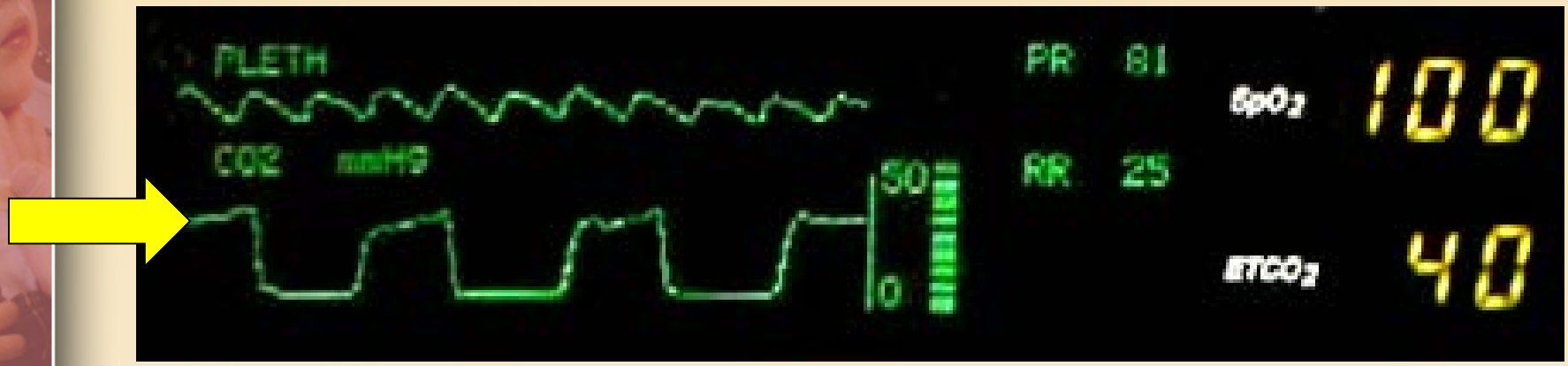
- Patients WITH pulse:
  - Problem exists. Tube incorrectly placed. Extubate and initiate BMV.
- Patients WITHOUT pulse:
  - TT incorrectly placed, or lungs not exhaling CO_2
  - Confirm tracheal intubation with alternative method such as direct laryngoscopy.
  - If TT is incorrectly placed, extubate and initiate BMV.

Colorimetric CO_2 Detector Pitfalls

- Use correct size.
  - Adult CO_2 detectors can be used in infants as small as 2 kg but must be removed because of the large dead space.
- If detector is in use for more than 15 min, vapor might cause detector to become wet and nonfunctional.
  - Not useful for long transports unless periodically replaced during transport.

$ETCO_2$ Monitor (1 of 3)

- $ETCO_2$ monitor shows a **square** wave form. Peak PCO_2 occurs during end of exhalation cycle ("end tidal").



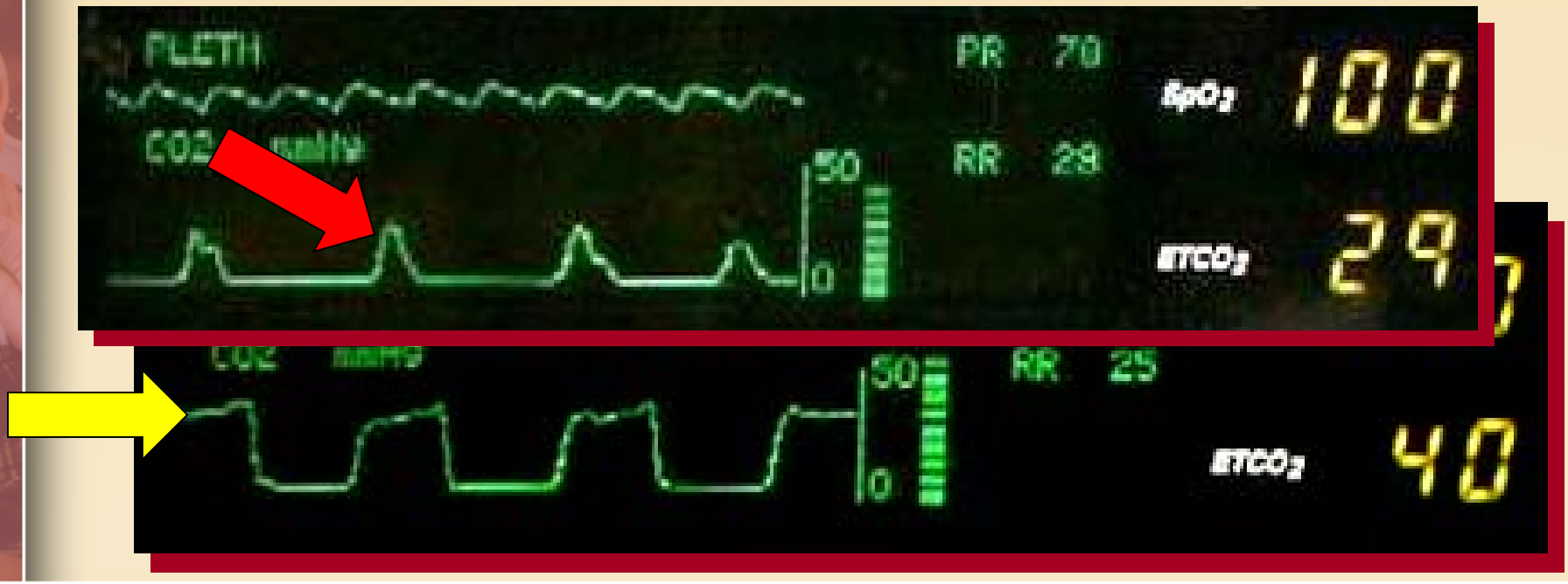
- Normal (square) wave form confirms tracheal intubation.

$ETCO_2$ Monitor (2 of 3)

- Square wave pattern = TT in trachea
- Otherwise, two possibilities:
  - TT not in trachea: Extubate, BMV
  - Lungs not exhaling CO_2
    - Severe air trapping (status asthmaticus)
    - Poor pulmonary perfusion (CPR)
- Consider an alternative means of confirming tracheal intubation, or extubate and initiate BMV if tracheal intubation cannot be confirmed.

$ETCO_2$ Monitor (3 of 3)

- Top tracing shows abnormal $ETCO_2$ wave form (red arrow). Compare this to normal $ETCO_2$ wave form below (yellow arrow), which confirms tracheal intubation.

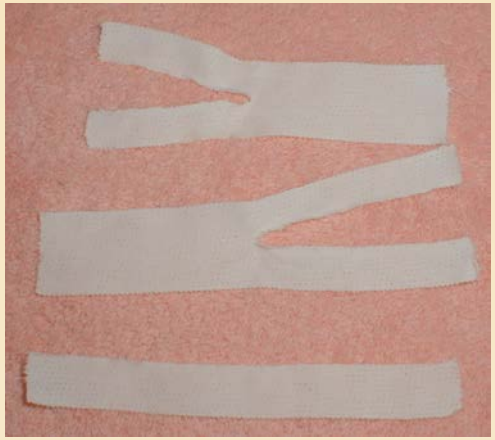


Esophageal Detector Bulb Method

- Squeeze it first.
- Attach it to TT.
- Rapid refill: Trachea
- Slow refill: Esophagus
- Pitfalls: Rapid refill can also occur if TT is in larynx.

Secure the Tracheal Tube

- Prep skin with benzoin/similar prep. Start with three pieces of tape cut as shown.
- Apply a base tape above upper lip.
- Apply two Y tapes in opposite directions, with one leg of Y attached to TT.



Case Progression (1 of 4)

- 10-year-old girl with head trauma, breathing spontaneously
- Preoxygenation with maximum flow oxygen by nonrebreather
- Pulse oximeter reads 100%.
- Drugs calculated and ordered:
  - Atropine 0.5 mg
  - Lidocaine 50 mg
  - Thiopental 100 mg
  - Rocuronium 30 mg
- Suction ready (large-bore stiff tip)

Case Progression (2 of 4)

- TT size = 4 + 10/4 = 6.5 (check cuff)
- Curved laryngoscope blade size 2
- Nurse arrives with drugs.
- Pulse oximeter reads 100%.
- Atropine given.
- Lidocaine given.
- Rocuronium given.
- Sellick maneuver applied.
- Thiopental given slowly but in rapid sequence.

Case Progression (3 of 4)

- Sellick maneuver maintained.
- 75 seconds after rocuronium is given, patient is totally paralyzed.
- Laryngoscopy, avoid teeth, suction, larynx exposed
- Cricoid pressure adjusted to bring larynx into better view.
- 6.5 TT inserted through cords.
- TT cuff is inflated, and TT is secured.
- $ETCO_2$ monitor shows normal square wave, confirming tracheal intubation.

Case Progression (4 of 4)

- Auscultation demonstrates equal aeration.
- Good chest rise observed.
- Sellick maneuver released
- Oxygen saturation maintained at 100%.
- $ETCO_2$ monitor reads PCO_2 30 mmHg; respiratory therapist slows ventilation rate.
- Chest x-ray ordered to document placement of TT.
- Blood gas ordered to correlate PCO_2 with $ETCO_2$ monitor.

Preventing Complications
(1 of 3)

- Right mainstem intubation: Confirm TT depth at lip, and position with chest x-ray.
- Esophageal intubation: Direct visualization of tracheal intubation. Confirm with CO_2 monitor and other devices. Oxygenation is maintained.
- Hypotension: Choose sedatives based on risk of cardiovascular compromise.

Preventing Complications
(2 of 3)

- Pneumothorax: Overventilation can be prevented by observing $ETCO_2$ monitor to avoid hyperventilation and ventilating just enough for chest to rise.
- Preexisting small pneumothorax may develop into tension pneumothorax once positive pressure ventilation is started.
  - Needle thoracostomy followed by tube thoracostomy is indicated if a tension pneumothorax is suspected.

Preventing Complications
(3 of 3)

- Passive regurgitation and aspiration:
  - Sellick maneuver sometimes released prematurely to tend to seemingly more important task. Person maintaining Sellick maneuver is not permitted to do anything else.
- Dental injury:
  - Observers should advise intubator that blade is touching patient's teeth. A more skilled intubator should perform procedure.

Pitfalls

- Most complications are due to malposition of TT (right mainstem, or no longer in trachea).
- Hypoxia: More commonly due to malposition of TT. Confirm position and proper oxygen flow.
- Bradycardia: More commonly due to hypoxia. Confirm TT position and oxygenation.

Advanced RSI Topics

- Permissive hypercapnia
- Defasciculation
- Priming principle
- C-spine immobilization and RSI
- Reversal of nondepolarizing muscle relaxants

Permissive Hypercapnia

- Not possible to normalize ventilation in asthmatics with respiratory failure. Aggressive attempt to normalize ventilation is likely to result in pneumothorax.
- Permissive hypercapnia is a strategy that focuses on oxygenation. High PCO_2 levels can be tolerated, but hypoxia is not tolerated well.
- Maintaining oxygenation above 90% is focus.

Defasciculation (1 of 4)

- Applies only to succinylcholine.
- Succinylcholine results in muscle fasciculations more common in muscular adults.
- Fasciculations result in muscle pain and increase the risk of hyperkalemia, rhabdomyolysis, and myoglobinuria.
- Fasciculations might transiently increase muscle tone and increase ICP.

Defasciculation (2 of 4)

- Defasciculation prevents fasciculations associated with succinylcholine.
- Administer one-tenth dose of nondepolarizing agent (rocuronium, vecuronium, or pancuronium) 2 min prior to succinylcholine.
- Defasciculation has not been shown to reduce rate of adverse effects of succinylcholine during RSI.

Defasciculation (3 of 4)

RSI with no defasciculation:

- 0 sec: Administer succinylcholine
- 30 sec: Administer sedative
- ***60 sec: Intubate***

RSI with defasciculation:

- 0 sec: Administer 1/10th defasciculating dose of rocuronium
- 90 sec: Administer sedative
- 120 sec: Administer succinylcholine
- ***180 sec: Intubate***

Defasciculation (4 of 4)

- Benefit:
  - Prevents fasciculations and their potential consequences
- Risk:
  - Prolongs time to intubation by additional 2-3 min
- Some recommend defasciculation in adolescents or adults. Others don't.

Priming (1 of 4)

- Applies to nondepolarizing muscle relaxants (NDMRs) such as rocuronium and vecuronium.
- Shortens onset time of NDMRs.
- Often confused with defasciculation.
- Requires one-tenth dose of NDMR similar to defasciculation (which is why priming and defasciculation are similar).

Priming (2 of 4)

- Onset of rocuronium is about 90 sec.
- By “priming,” onset time is shortened to 60 sec.
- Administer one-tenth dose of rocuronium, then 5 min later, administer full dose of rocuronium.
- This shortens onset time of rocuronium, but prolongs time to intubation by adding 5 min to RSI.

Priming (3 of 4)

No priming:

- 0 sec: Administer rocuronium
- 30 sec: Administer sedative
- ***90 sec: Intubate***

Priming:

- 0 sec: Administer 1/10th priming dose of rocuronium
- Administer sedative during the wait
- 300 sec: Administer full rocuronium dose
- ***360 sec: Intubate***

Priming (4 of 4)

- Priming has some advantages for anesthesiologists who are managing stable patients for elective surgery.
- For unstable ED patients in need of emergent intubation, adding 5 min to RSI is a serious disadvantage.
- Most would agree that priming is not indicated in ED RSI.

C-spine Immobilization (1 of 2)

- Nasotracheal intubation has not been shown to reduce C-spine movement during intubation compared to orotracheal intubation.
- Nasotracheal intubation is difficult in children.
- Orotracheal intubation with RSI appears to be the best method.

C-spine Immobilization (2 of 2)

- In most instances, C-spine immobilization with stiff collar and spine board can be maintained during RSI. Alternatively, collar can be removed with head/neck manually stabilized.
- Intubation under these circumstances is best done by most experienced intubator.
- Laryngoscopic manipulation and cricoid pressure (Sellick maneuver) must be carefully managed to minimize C-spine movement.

Reversal of Nondepolarizing Muscle Relaxants (1 of 3)

- Nondepolarizing muscle relaxants (NDMRs) such as rocuronium have longer duration than succinylcholine.
- Rocuronium has duration of about 30 to 45 min.
- Cholinesterase inhibitors such as edrophonium (Tensilon) reverse effects of NDMRs, but only after partial recovery has occurred spontaneously.

Reversal of NDMRs (2 of 3)

- If intubation is not successful, BMV or another rescue method is required to maintain ventilation.
- Reversal of rocuronium with edrophonium is not likely to succeed in first few minutes after rocuronium administration.
- Additionally, edrophonium is not likely to be immediately available in EDs. It would have to be ordered from a pharmacy.

Reversal of NDMRs (3 of 3)

- Edrophonium has significant muscarinic effects resulting in potentially severe bradycardia. Premedication with atropine is required to avoid this.
- It is not likely that reversal of NDMR with edrophonium will be clinically useful in most cases.

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