Airway Management

Rapid Sequence Intubation (RSI)

RSI is the currently accepted method of quickly obtaining optimal intubating conditions. It is the delivery of an induction agent (to induce unconsciousness) followed in rapid succession by a paralytic agent.

RSI can be broken down into “The Ritual of P’s.” In this version there are 8 “P’s of Rapid Sequence Intubation.” This paradigm was first described by Drs. Walls and Murphy in the Manual of Emergency Airway Management, now in its second edition. It has reappeared in various forms over the years.

P-Plan B

1. The first P in this series refers to the predetermined plan for dealing with a difficult or failed orotracheal intubation. An article in the anesthesia literature found an unanticipated failed intubation occurred in 0.4% of the cases (44 of 11,621 patients).

Published reports of the emergency department airway management experience at several teaching hospitals found that rate of difficult intubation was less than 5%.

Suggested Plan B Items

- A complete set of RSI drugs
  - Induction/sedation agents: etomidate, ketamine, midazolam, and fentanyl
  - Paralytic agents: succinylcholine, rocuronium, and vecuronium
  - Adjunctive medications: atropine and lidocaine
- Various ET tube sizes and types: pediatric and adult
  - Endotrol tubes
  - Oropharyngeal and nasopharyngeal airways
- Additional laryngoscope parts
  - Miller and Macintosh blades
  - Standard laryngoscope handle
  - Short laryngoscope handle
  - Pediatric laryngoscope handle
  - Spare bulbs
• Airway adjuncts
  ▪ Gum elastic bougie
  ▪ **Laryngeal Mask Airways (LMAs)** and **Intubating Laryngeal Mask Airways (ILMAs)**
  ▪ Combitubes
  ▪ A lighted wand stylet with multiple sizes of stylets
  ▪ Retrograde intubation sets
• Surgical airway tools
  ▪ Percutaneous and open cricothyrotomy kits
  ▪ Scalpels (#10, #11, #15 blades)
  ▪ Extra instruments
• Various size needles and syringes

**P-Prepare**

1. Organize and inventory your working environment directly prior to the actual intubation.
2. Preparation
   • Remove dentures
   • Bring the difficult airway cart to the bedside
   • Have the chosen laryngoscope blades ready (2 sizes of Macintosh blades, 2 Miller blades)
   • Check the light on the laryngoscope blades
   • Verify the integrity of the balloon on the ET tube
   • Have suction ready at the bedside
   • Verify the integrity of your IV access and start a second IV line as needed
   • Have your chosen means to secure the ET tube ready to implement
   • Have color-change capnography device at bedside
3. Thoroughly evaluate the patient for potential difficulty with bag-valve mask ventilation. A recent study identified 5 variables that independently predicted difficult mask ventilation. The presence of any 2 of these was 72% sensitive and 73% specific for predicting difficulty with bag valve mask ventilation.
   • **B** Beard: presence of a beard or moustache
   • **O** Obesity: body-mass index greater than 26 kg/m²
   • **N** No teeth
• **E** Elderly: age >55
• **S** Snoring: history of regular snoring

4. The mnemonic **LEMONS** can help predict a difficult intubation.

#### External anatomical features
- Short muscular neck
- Full dentition
- Protruding upper incisors
- High-arched palate
- Receding mandible
- Severe facial trauma

#### Evaluate internally: the 3-3-2 rule
The rule describes the ideal external dimensions of the airway.
- 3 – the opening of the jaw should be far enough to accommodate 3 fingers (3-4 cm)
- 3 – the distance from the mentum to the hyoid bone should be at least 3 fingerbreadths
- 2 – the distance from the floor of the mouth to the thyroid cartilage should be at least 2 fingerbreadths.

#### Mallampati classification
The Mallampati classification was developed to correlate a simple visual inspection of the patient’s pharynx with the ability to obtain direct visualization of the larynx. Airways are designated as Class I, II, III or IV. Mallampati classes roughly correlate with the Cormack and Lehane direct laryngoscopic views, graded as 1, 2, 3 and 4. Predicted difficulty in obtaining visualization of the cords increases from easy to very difficult as the Mallampati class rises.

#### Saturation
An oxygen saturation < 85% portends an impending desaturation that can occur very rapidly. This does not allow much time to perform the intubation.

#### Obstruction
- Blood in the upper airway
- Foreign body
- Expanding hematoma
- Abscess
- Swelling of intraoral structures
- Laryngeal edema

#### Neck mobility
- Inability to flex or extend the neck (c-collar, arthritis, etc.)
- Cervical spine injury
P-Preoxygenate

1. As early as possible the patient should be placed on high flow oxygen, as close to 100% FiO₂ as possible. The goal is to “denitrogenate” the patient’s functional residual capacity and replace it with oxygen. This step can afford the intubator some buffer time during the procedure.

2. The patient should breathe high-flow oxygen for 5 minutes prior to attempts at intubation.

3. Alternatively, 8 vital capacity breaths of high-flow oxygen may serve the same nitrogen washout function and effectively retard apnea-induced hemoglobin desaturation.

P-Pretreat

The pretreatment phase of RSI involves the delivery of medications to modify the physiologic response during and after intubation. The mnemonic LOAD is used to remember the pretreatment drugs.

1. L Lidocaine 1.5 mg/kg IV

   - The use of lidocaine in RSI has been advocated to blunt the intracranial pressure rise associated with RSI.
   - The evidence supporting its effectiveness is not clear and conflicting reports of the degree of effect exist.
   - Lidocaine can also be delivered topically to the posterior pharynx and upper airway by nebulization. 4cc of 4% lidocaine can be nebulized in a standard aerosol set with a face mask. This delivers 160 mg of lidocaine. Caution should be used so as not to exceed 5 mg/kg of lidocaine.

- Mallampati Class I: no difficulty: soft palate, uvula, fauces, pillars visible
- Mallampati Class II: no difficulty: soft palate, uvula, fauces visible
- Mallampati Class III: moderate difficulty: soft palate, base of uvula visible
- Mallampati Class IV: major difficulty: hard palate only visible
2. **Opiates**

   *Opiates* can be used to attenuate the sympathetic responses to intubation
   
   *Pretreatment with fentanyl (2 mcg/kg), immediately prior to the induction of anesthesia, significantly reduces the hemodynamic response to endotracheal intubation*

3. **Anticholinergic agents (choose either agent)**

   - Use in children to prevent bradycardia/asystole (seen with *succinylcholine*)
   - Consider in adults who are to be redosed with *succinylcholine* to prevent possible bradycardia
     - *Atropine* children: 0.02 mg/kg IV (min 0.1 mg); adult: 0.5-1 mg IV
     - *Glycopyrrolate* (*robinul*) children: 0.004 mg/kg IV; adult: 0.2-0.4 mg IV

4. **Defasciculating agents (choose one)**

   - Defasciculation refers to decreasing/eliminating the muscle fasciculations (twitches) that occur in response to the initial depolarizing effect of *succinylcholine*. These muscle contractions can produce a rise in intracranial and intraocular pressure.
   - Use defasciculating doses of paralytic agents in patients with head injury or open-globe eye injuries
   - Can use 1/10th the intubating dose of any available paralytic agent
   - Give the drug 3 minutes prior to intubation
     - *Succinylcholine* 0.15 mg/kg IV
     - *Vecuronium* 0.01 mg/kg IV
     - *Rocuronium* 0.1 mg/kg IV

**P-Put to Sleep**

1. The next step involves the induction of anesthesia with a rapid acting induction agent.
2. This step is performed virtually simultaneously with the administration of a paralytic agent (the next step).
   - Induction agents are given simultaneously to or in rapid succession with paralytic agents.
• Apply cricoid pressure (Sellick’s maneuver). Do not release until placement is verified.
• Do not ventilate until patient is intubated or reoxygenation is required as indicated by oxygen saturation falling below 90%.

**Induction Agents**

**Etomidate (Amidate)**

Dosage: IV 0.3 mg/kg  
Pregnancy category: C  
Preparation: 2 mg/ml  
Description: non-barbiturate, sedative hypnotic with anesthetic and amnestic properties (no analgesia)  
Onset: <60 seconds  
Duration: 6-10 minutes  
Reversal agents: none

**Indications**

• Need for rapid induction  
• Excellent for older patients or those with tenuous cardiovascular status  
• Hypotension

**Contraindications**

• Allergy to etomidate  
• In Addison’s disease, must supplement corticosteroids

**Major Side-Effects**

• Apnea-related to dose and rate of administration is rare and only minor respiratory depression is seen  
• Pain on injection common  
• Decreased ICP and cerebral perfusion pressure  
• Spontaneous myoclonus (not seizure) is seen in up to 30% of patients  
• Transient ACTH-resistant/hydrocortisone-responsive decrease in the production of cortisol  
• Vomiting and hiccoughs are possible during and post-procedure
Ketamine (Ketalar)

Dosage: IV push 1-2 mg/kg
Pregnancy category: unknown
Preparations: 100, 50 & 10 mg/ml
Description: dissociative anesthetic; PCP derivative. May act at multiple receptor sites including opioid and cholinergic. *Ketamine is the only single agent with anesthetic, amnestic and analgesic properties.*

Onset: IV 30-60 seconds
Duration: IV 10-15 minutes
Reversal agents: none proven; *naloxone* & *physostigmine* may have some theoretical effect

**Indications**
- The need for induction in a hypotensive patient
- The need for induction in a patient with bronchospasm

**Contraindications**
- Elevated ICP
- Ischemic heart disease
- Age <3 mo

**Major Side Effects**
Side-effects rarely outweigh the potential benefits of *ketamine* as an induction agent in the hypotensive patient
- Transient 20-30% increase in BP and heart rate
- Increase in ICP has been reported
- Nystagmus
- Nausea – vomiting is rare and usually occurs late after emergence
- Excess salivation – can be controlled with *atropine/glycopyrrolate*
- Hallucinations on awakening (rare in children <13). Hallucinations are much less frequent than previously reported in adults and are virtually eliminated by the addition of 2 mg of *midazolam*.
- Transient apnea is very rare and seen only with rapid-push of high doses
- Laryngospasm in patients with recent URI or history of severe asthma (not a significant concern when used with a paralytic agent)
**Midazolam (Versed)**

Dosage: 0.1 mg/kg/IV adult; 0.05-0.1 mg/kg/IV pediatric  
Onset: 1-5 minutes  
Duration: 30 minutes  
Reversal agents: flumazenil. May induce status epilepticus in benzodiazepine dependant patients.

**Indications:** need for induction  
**Contraindications:** hypotension  

**Major Side-Effects**  
- Hypotension  
- Respiratory depression

**P-Paralyze**

1. This step involves the delivery of a rapid-acting paralytic agent given simultaneously or in close succession with an induction agent.  
2. One technique that can simplify the process of drug delivery and minimize the time to effect is to mix the induction agent and the paralytic agent in the same syringe. Etomidate is compatible with both succinylcholine and rocuronium and can be mixed. Likewise, ketamine can be mixed with either paralytic agent.

**Paralytic Agents**

**Succinylcholine (Anectine/Quelicin)**

Dosage: adult and children: 1.5-2 mg/kg IV rapid push  
Pregnancy category: C  
Preparation: 20 mg/ml  
Description: depolarizing neuromuscular blocking agent  
Onset: IV: 30-60 seconds  
Duration: IV: 6-12 minutes  
Reversal agents: none

**Indications:** first-line paralytic agent in RSI  
**Contraindications**  
- Burn or spinal cord injury patients >48h post injury
• Neuromuscular diseases
• CVA less than 6 months out
• Open-globe ocular injury
• Use can cause bradycardia unless pretreatment with anticholinergic
• Known hyperkalemia

**Major Side-Effects**
• Muscular fasciculations
• Transient hyperkalemia
• Increased ICP and intraocular pressure

*Rocuronium (Zemuron)*
Dosage: adults and children: 0.6-1.2 mg/kg IV rapid push
Pregnancy category: B
Preparations: 10 mg/ml
Description: non-depolarizing neuromuscular blocking agent
Onset: 45-90 seconds
Duration: 15-40 minutes
Reversal agents: *neostigmine*

**Indications**
• Good 2nd line agent for RSI
• Rapid onset but long duration of action

**Contraindications**
• Hypersensitivity to *rocuronium*
• Hypersensitivity to *bromides*

**Major Side-Effects**
• Tachycardia
• Transient hypo/hypertension

**P-Pass the Tube**
1. One of the more common errors seen in novice intubators is failure to adequately sweep the tongue out of the way. By inserting the blade as far to the right as possible the intubator can more effectively force the tongue to the left side of the mouth and out of the way.
2. Another common problem develops when the intubator fails to place the tip of the laryngoscope deep enough into the mouth. Pressure placed too far forward on the tongue (instead of in the vallecula) will not allow adequate lifting of the epiglottis and obstruct the view of the cords.

- Paraglottic technique: the laryngoscope blade can be placed as deep as possible into the oropharynx, allowing it to enter the esophagus. When the blade is slowly withdrawn, the first anatomical structure to be encountered is the larynx, followed by the epiglottis.

3. **BURP (Backward-Upward-Rightward-Pressure):** the assistant (standing on the right side of the patient) applies pressure to the thyroid cartilage, first backward (toward the table) then upward (toward the head) and finally rightward. The adult larynx should be displaced backward so as to abut the vertebrae, 0.5-2 cm to the right and about 2 cm cephalad. Meanwhile, the intubator attempts direct visualization of the larynx.

4. **External Laryngeal Manipulation (ELM)** achieves the same backward, upward and rightward airway repositioning as does “BURP,” however the pressure is applied by the intubator with his or her right hand. This allows the intubator to visualize the effects of the manipulations and adjust the pressure accordingly.

- The final position of the larynx can be held by the assistant. ELM consistently provides the intubator with the best view of the cords.

**P-Prove Placement**

1. The final step is to verify the correct placement of the ETT into the trachea. The chest should be auscultated to listen for breath sounds.

2. The detection of CO$_2$ is mandatory for confirmation of correct placement.

- This can be done with either a waveform on a quantitative device or with color change on qualitative detectors.

- The detection of CO$_2$, indicated by a purple to yellow color change is 100% specific for tracheal placement of the ETT, whereas the failure to detect color change strongly suggests esophageal intubation.

- In cardiac arrest, the lack of lung perfusion can lead to the absence of CO$_2$ and a lack of color change despite the correct placement of the ETT in the trachea.
The Surgical Airway

Of all advanced airway techniques, the surgical airway is by far the most important to have well rehearsed and trained as there is no time to review the procedure once it is indicated. It is considered the last resort when all other appropriate attempts to secure the airway have failed. It should be performed by the most experienced physician.

Method 1
1. Swab neck with betadine
2. Hyperextend neck if no suspected cervical spine fracture
3. Grasp thyroid cartilage with the non-dominant hand and locate cricothyroid membrane
4. Incise the skin and cricothyroid membrane with scalpel with one stab taking care to avoid too deep an incision to protect the esophagus
5. Make transverse incision through membrane while keeping scalpel in place
6. Insert tracheal hook and retract larynx superiorly
7. Remove scalpel and insert dilator
8. Place tracheostomy or endotracheal tube

Method 2
1. Steps 1-3 as in method 1
2. Midline vertical incision 3-4 cm long through skin only
3. Transverse incision through cricothyroid membrane
4. Insert tracheal hook and retract larynx superiorly
5. Remove scalpel and insert dilator
6. Place tracheostomy or endotracheal tube

Needle Cricothyrotomy
1. Steps 1-3 as in method 1
2. Puncture cricothyroid membrane with 14-gauge angiocatheter (10- or 12-gauge preferable if available) at 45° to 90° angle aiming toward feet
3. Advance with negative pressure, aspirating air signifies entry into trachea
4. Remove needle advancing catheter at 30° angle toward feet
5. Reconnect syringe to verify placement
6. Connect valve adapter from 3.0 or 3.5 endotracheal tube to angiocatheter and ventilate or to a transtracheal jet ventilator
Mechanical Ventilation

Mode: adults: Assist Control (AC) if paralyzed, otherwise recommend Synchronized Intermittent Mandatory Ventilation (SIMV)

Respiratory Rate: infants 20-30; child 16-20; adult 12-14

Oxygen: start with 100% and titrate FIO2 down as tolerated. FIO2 and P02 should have proportional relationship, such that a 50% reduction in FIO2 results in a 50% reduction of the P02

Tidal Volume: 6-10 ml/kg if volume cycled. Should keep volume on the lower settings as tolerated to reduce risk of pulmonary damage and respiratory distress syndrome. Strongly consider pressure limited ventilation for children and those with lung disease, keeping inspiratory pressures 20-30 mm H2O

PEEP: children 2-3 cm H2O; adults vary based upon need. COPD/Asthma patients frequently “auto-peep,” so be aware of the risk for pneumothorax and barotrauma