LMAs: Airway Management and Inhalant Anesthetics

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LMA: History

- First described by Dr. A. Brain.
- Introduced in the 1980’s in UK
  - In US in 1992
- Alternative to mask and endotracheal intubation.
- Estimated over 200 million surgeries performed with LMA worldwide

LMA: History

General Safety and Efficacy of the LMA

- 39,824 patients underwent GA; 11,910 (30%) airways were managed with LMA
  - 99.8% successful placement (LMA abandoned in 23 patients)
  - 44% underwent PPV
  - 44 critical incidents; 18 related to airway (none serious)

LMA Use in Pediatrics

- Mason & Bingham. Anaesthesia; 45:760, 1990
  - 200 children
  - Difficulties encountered in 47 cases (23%), but LMA use abandoned in only 5 cases (2.5%).
  - Down folding of epiglottis over laryngeal inlet identified in 8 out of 24 patients where flexible laryngoscopy was performed; clinically all had unobstructed airways.
LMA: Advantages

Advantages over ET tube and face mask:

- Improved hemodynamic stability at induction & during emergence.
- Maintenance of airway while freeing hands & reducing fatigue of Anesthetist.
- Avoidance of facial nerve & eye injuries due to face mask.
- Decreased frequency of coughing during emergence.
- Decreased incidence of sore throat.
Decreased Coughing with LMA

- **79 patients undergoing cataract surgery, randomized to ETT or LMA.**
  - Greater incidence of coughing prior to, during, & after extubation in ETT group.
    

- **29 patients undergoing elective eye surgery under GA randomized to ETT or LMA.**
  - 13/14 ETT pts. coughed in immediate postop period; none coughed with LMA.
    
Laryngopharyngeal Complaints Following LMA and Endotracheal Intubation

- Prospective study of 202 patients
- Less dysphonia with LMA (25 vs. 47% - POD 0; 16 vs. 27% - POD 1).
- More discomfort with swallowing with LMA (24 vs. 12% - POD 0; 22 vs. 10% - POD 1).
- Severity of symptoms & degree of patient satisfaction was comparable.

LMA: Advantages

Advantages over ET tube and face mask:

- Decrease anesthetic requirements for airway tolerance
- No requirement for muscle relaxation.
- Minimal CV/stress responses with insertion of LMA.
- Improved O₂ saturation during emergence
LMA: Advantages

Advantages over ET tube & face mask:

- Less pollution in OR than with mask anesthesia.
- Tolerated at lighter levels of anesthesia.
- Latex free airway device.
- Increased speed & ease of placement by both anesthetists & inexperienced personnel.
- Decreased airway resistance.
Placement by Non-anesthesia Providers

2 studies:

- Comparison of Placement of LMA with ETT by Paramedics and Respiratory Therapists

- Combat Trauma Airway Management: Endotracheal Intubation vs. LMA vs. Combitube Use by Navy Seal and Reconnaissance Combat Corpsmen
  - Calkins MD & Robinson TD. *J Trauma*; 46:927, 1999
LMA and Ventilation

- Work of breathing lower than breathing spontaneously through 8.0 ETT

- Low levels of pressure support ventilation well tolerated without leak; decrease end-tidal CO2, increase SaO2 slightly
  - Brimacombe J et al. *Anesthesiology*; 92:1621, 2000
Devitt et. al.: *Anesthesiology*, 1994
- 48 patients undergoing elective surgery
- General anesthesia with paralysis & controlled ventilation
- Randomized assignment of four different peak pressure settings: 15, 20, 25, & 30 cm H$_2$O
- Leak & gastroesophageal insufflation increased with increasing pressures
LMA vs ETT Insertion and Reversible Bronchoconstriction

- Kim & Bishop. *Anesthesiology;* 90:391, 1999
  - 52 pts. randomized to ETT or LMA. Respiratory resistance measured immediately after placement & again after 10 mins. of 1% isoflurane.
  - Airway resistance increased immediately after ETT placement, but not after LMA.
LMA: Disadvantages

- Low sealing pressure.
- Increased frequency of gastric insufflation.
- Possible aspiration of gastric contents.
- Coughing and laryngospasm.
- Difficulty positioning.
- Trauma to the airway.
LMA: Contraindications

- Inability to extend neck or open mouth >5cm.
- Pharyngeal pathology.
- Airway obstruction at or below larynx.
LMA: Contraindications

- Low pulmonary compliance & high airway resistance.
- Inadequate depth of anesthesia.
- Increased risk of regurgitation.
- One-lung ventilation.
LMA: “Most Important Use”

- Difficult or Failed Intubation!
  - Aid to intubation
- Listed on the ASA Difficult Airway Algorithm.
**LMA & Difficult Airway**

- Primary airway adjunct when mask ventilation is difficult or impossible (case reports).

- Provide routine airway management with anticipated difficult intubation.
  - LMA placement successful in 29 of 30 pts. with known abnormal airways

- Aid to endotracheal intubation.
Difficult Airways Managed with LMA

- Ankylosing spondylitis
- Facial burns
- Failed OB intubation
- Limited mouth opening
- Hemifacial microsomia
- Percutaneous tracheostomy
- Rheumatoid arthritis
- Obesity
- Neck contractures
- MVA
- Multiple difficult intubations
- Unstable neck
- Cervical halo
- Sitting & prone position
LMA Insertion & Difficult Airway

- Initial reports suggested that LMA placement may be easy when larynx is “anterior.”
  - Brain. *Anaesthesia*; 40:353, 1985

- Ease of insertion & accuracy of position unrelated in Mallampati classification (272 placements reviewed).
  - Brimacombe & Berry. *Anaesthesia*; 48:347, 1993

- In prospective study of 100 pts., difficulty encountered in 28 pts. (all Mallampati Class II or III); LMA could not be placed in 2 pts. (both Class III). Mallampati class was significantly associated with difficulty placing LMA.
LMA: Pressure Exerted Against Cervical Vertebrae

Keller, Brimacombe & Keller: Anesth Analg 1999

- Pressures exerted against cervical vertebrae by standard & intubating LMA
  - 20 cadavers
  - 3 microchips in area of C_{2-3}
  - Size 5 ILMA & LMA
  - Neutral head position
LMA & Immobile Cervical Spine


- 28 gynecologic surgery pts. with LMA & ETT placed (random order) with & without rigid Philadelphia collar in situ.
- Patients ha no cervical spine disorders; were anesthetized & paralyzed.
- Mean time to insertion
  - LMA 32 sec
  - ETT 44 sec
- Success rate (1st try)
  - LMA 91%
  - ETT 79%
Types of LMAs

- Standard LMA - classic
- Reinforced LMA - flexible
- Intubating LMA - fastrach
- Single use LMA - unique
- LMA – proseal
- LMA CTrach
- LMA Supreme
- McGrath video Laryngoscope
LMA Supreme

- Bite block
- Reinforces tip & molded distal cuff resists folding
- Larger pre-curved cuff
McGrath Video Laryngoscope

- Simplify intubation of difficult airways
- Minimize lifting forces
LMA as Aid to Intubation

- Blind insertion
- Fiberoptic techniques
- Intubating LMA
- LMA & ASA Algorithm for Difficult Airway
LMA as Aid to Intubation

- Blind insertion
  - 6.0 ETT max (#3 & #4); 7.0 ETT (#5)
  - Length of ETT and removal of LMA are issues
LMA as Aid to Intubation

- Fiberoptic placement
  - Higher rate of success
  - Passage of fiberoptic and ETT may be difficult
LMA as Aid to Intubation

- Intubating LMA (Fastrach)
  - Success rate ~70-98%
LMA as Aid to Intubation

- Difficult intubation
  - Fiberoptic with intubating LMA; bougie or tube exchanger.
Key Features of the LMA CTrach™

The LMA CTrach™ Viewer weighs less than eight ounces, and is totally wireless and portable. The Viewer provides controls for focusing and image adjustment. The battery provides 30 minutes of uninterrupted viewing and is rechargeable in a dedicated cradle.

A dedicated ET tube with an atraumatic tip is designed to enter the trachea at the correct angle through the LMA CTrach™.

Two fiberoptic bundles emerge at the distal end of the airway tube, under the modified Epiglottic Elevating Bar, which optimizes the light source and enables uninterrupted image transmission to the viewer, while protecting the airway tube from obstruction and raising the epiglottis out of the way for an ET tube to pass through.

Magnetic latch connector correctly positions and secures the viewer to the LMA CTrach™.

Anatomically curved airway tube with integrated fiberoptic technology.

Airway is fully Autoclavable
LMA & ASA Algorithm

Always consider calling for help (e.g., technical, medical, surgical etc.) when difficulty with mask ventilation and/or tracheal intubation is encountered

++ Consider the need to preserve spontaneous ventilation
LMA & Anesthesia

The most common problems encountered with insertion or tolerance of the LMA are due directly to inadequate depth of anesthesia – regardless of the anesthetic agent in use.
LMA: Anesthesia Options

- Inhalational anesthetics
- Intravenous anesthetics
- Combination of intravenous and inhalational anesthetics
Inhalation Anesthesia

- Depth of anesthesia determined by concentration of anesthetic in CNS
- Concentration of individual gas in mixture of gases proportionate to partial pressure or tension
- Important factor influencing transfer of anesthetic from lungs to arterial blood is **solubility**!
Effects of Inhaled Agents on Respiratory System

- Depress ventilation in a dose-related manner
  - Depress ventilatory response to ↓ in oxyhemoglobin saturation
  - Depress ventilatory response to an ↑ in CO₂
- At some concentration: increased arterial partial pressure of CO₂
  - Cause apnea despite ↑ arterial carbon dioxide partial pressure
Effects of Inhaled Agents on Respiratory System

- Potent inhaled agents relax bronchial muscles
  - Distal airways more sensitive
  - Desflurane & sevoflurane: equals or exceeds relaxation of halothane

- Bronchodilation partially mediated by cyclooxygenase product & nitric oxide
<table>
<thead>
<tr>
<th></th>
<th>Gas/blood</th>
<th>Brain/blood</th>
<th>Fat/blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desflurane</td>
<td>0.42</td>
<td>1.29</td>
<td>27.2</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>0.69</td>
<td>1.70</td>
<td>47.5</td>
</tr>
<tr>
<td>Isoflurane</td>
<td>1.43</td>
<td>1.57</td>
<td>44.9</td>
</tr>
<tr>
<td>Halothane</td>
<td>2.3</td>
<td>1.9</td>
<td>51</td>
</tr>
<tr>
<td>N₂O</td>
<td>0.47</td>
<td>1.1</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Metabolism of Inhaled Agents

% of Uptake Recovered as Urinary Metabolites

- Desflurane 0.02
- Isoflurane 0.2
- Sevoflurane 5
- Halothane 15-20
<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Duration of Anesthetic Administration (min)</th>
<th>90% Decrement Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enflurane</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Isoflurane</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>Desflurane</td>
<td>00</td>
<td>100</td>
</tr>
</tbody>
</table>

Intravenous Anesthetics

- Propofol - “induction agent of choice”
- Opioids
- Barbiturates
Induction Agent: Propofol

- Obtunds upper airway reflexes
- Produces appropriate relaxation of airway.
- Antiemetic effect.
- Additive effect with opioids, sedatives, & anesthetic agents.
Airway
Airway Reflexes

- Prevent foreign substance from entering lungs
- Receptors are mechanical / chemical
Airway Responses

- Laryngospasm
- Bronchoconstriction
- Swallowing
- Coughing
- Cardiovascular Stimulation??
Pharyngeal Reflex

- Pharyngeal (throat) Stimulation
  - Gagging
  - Swallowing

- Abolished with General Anesthesia
  - Stage III plane 1
Laryngeal Reflex

- Laryngeal (voice box) stimulation
  - Coughing
- Abolished with deeper General Anesthesia
  - Stage III plane 2
How to Reduce Irritation Response

- Reduce or Eliminate the:
  - Irritation itself
  - Sensitivity of the receptors
  - Physiologic response to irritation
Reduce the Irritation

- Lowest practical % of agent*
  - MAC reduction
- Dilute with N₂O
- Least irritating agent

*unimportant when deeply anesthetized
Reduce Receptor Sensitivity

- IV agents
- Topical Agents
Reduce Physiologic Response

- Continue Inhalers
- Deepen General Anesthesia
- Reduce Preoperative Anxiety
LMA
### Comparison of Desflurane Versus Propofol and Sevoflurane with an LMA

<table>
<thead>
<tr>
<th></th>
<th>Desflurane</th>
<th>Propofol</th>
<th>Sevoflurane</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tang¹ (N=75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (Time to Orientation)</td>
<td>4 min</td>
<td>6 min</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Recovery (Ambulation)</td>
<td>14 min</td>
<td>23 min</td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Absence of Airway Irritation (Coughing)</td>
<td>91%</td>
<td>90%</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Mahmoud² (N=63)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (Time to Orientation)</td>
<td>4.8 min</td>
<td>9.8 min</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Recovery (Left Recovery Room)</td>
<td>15.5 min</td>
<td>23.7 min</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Absence of Airway Irritation (Total)</td>
<td>92%</td>
<td>95%</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Eshima³ (N=127)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (Time to Orientation)</td>
<td>7.6 min</td>
<td>9.4 min</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Recovery (Modified Aldrete Score = 13)</td>
<td>24 min</td>
<td>29 min</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Absence of Airway Irritation (Coughing)</td>
<td>98.4%</td>
<td>98.4%</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:** Desflurane consistently demonstrated better recovery rates without significant airway irritation in 3 comparative studies with an LMA.¹⁻³ (N=265)

Recovery Characteristics

- Early recovery indicators:
  - Time to eye opening
  - Time to orientation

- Late recovery indicators:
  - Ready to leave recovery room
  - Ready to go home

- 24 hour post recovery:
  - Full activity next day

Desflurane or Sevoflurane with Spontaneous Respiration?

- Gynaecological day-case surgery (N=63)
  - ASA I or II
  - Between 16 and 75 years

- Results:
  - Similar incidence of airway occurrences in both groups
  - Early & late recovery faster in desflurane group
  - Discharge sooner in desflurane group
  - 24 hour post recovery – full activity next day greater in desflurane group

Results

Similar incidence of airway occurrences in both treatment groups

- Sevoflurane
- Desflurane
- Laryngospasm
- Hiccoughs
- Coughing
Results

Percentage of patients who returned to full ambulant activity the day following surgery

- Sevoflurane: 50%
- Desflurane: 90%
Comparison of Airway Responses

- During desflurane and sevoflurane administration via LMA during maintenance of anesthesia
- Coughing, breath holding, laryngospasm, & SpO₂: no difference even with smoking history
- Desflurane group: responded to commands sooner, oriented sooner, greater DSST and Aldrete scores
- Time to discharge fitness: no difference
- Pain & sore throat scores: no difference
- Antiemetic therapy: no difference

### Observations

<table>
<thead>
<tr>
<th>Table 3. Respiratory Characteristics</th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients Without Coughing</td>
<td>98.4</td>
<td>98.4</td>
<td>NS</td>
</tr>
<tr>
<td>Patients Without Breath holding</td>
<td>89.1</td>
<td>95.3</td>
<td>NS</td>
</tr>
<tr>
<td>Patients Without Laryngospasm</td>
<td>100</td>
<td>100</td>
<td>NS</td>
</tr>
<tr>
<td>Average $\text{SpO}_2$ (%)</td>
<td>97.8 ±2.1</td>
<td>98.2 ±1.4</td>
<td>NS</td>
</tr>
<tr>
<td>Average end-tidal vapor %</td>
<td>4.5 ±1.4</td>
<td>1.57 ±0.55</td>
<td></td>
</tr>
<tr>
<td>% of patients given &gt;1.0 MAC</td>
<td>27</td>
<td>48</td>
<td>0.05</td>
</tr>
<tr>
<td>Nitrous oxide %</td>
<td>43 ±8</td>
<td>44 ±6</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values are provided as percentage or mean ± SD.  
MAC = minimum alveolar anesthetic concentration; NS = not significant.  
$P$ values are equal to or less than the indicated value.
Airway Reflexes Recover More Rapidly After Desflurane Than After Sevoflurane Anesthesia

Rachel Eshima McKay, M.D. and Warren R. McKay, M.D.
Department of Anesthesia and Perioperative Care
University of California, San Francisco
Abstract, 2004
Study Design

- Protective airway reflexes measured after anesthesia with desflurane vs. sevoflurane.

- The return of protective upper airway reflexes was measured by an ability to swallow 20 ml of water and not cough when swallowing is attempted.

- An LMA was placed, lubricated with ky-gel.

- Measurements were taken exactly 2 min., 14, 22, and 30 minutes after patient opened eyes to command.
Conclusions

- Eshima concludes that the awakening from anesthesia to the point of the ability to respond to commands does not necessarily predict the resumption of protective airway reflexes.

- Eshima further concludes that the recovery of protective upper airway reflexes is delayed more after sevoflurane than after desflurane anesthesia.
Two minutes after responding appropriately to command, each patient was asked to swallow 20 mL of water. All patients given desflurane could swallow water without coughing or drooling, but less than half the patients given sevoflurane could do so.
LMA: Airway Responses in Smokers

- McKay et. al.: Anesth Analg, 2006
  - Desflurane vs. Sevoflurane
  - Random assignment of 110 smokers
  - Results:
    - Most coughing occurred during induction (33%) & emergence (56%).
    - Desflurane – 5 patients coughed (9%)
    - Sevoflurane – 9 patients coughed (16%)
    - Rate of breath holding, laryngospasm, & desaturation were similar.
  - Conclusion:
    - Cigarette smoking not choice of anesthetic places patients at increased risk of respiratory complications
Clinical Technique: Preinduction

- Preanesthetic assessment:
  - Comprehensive system by system review
  - Airway status
  - Pulmonary status
  - Gastrointestinal history: GERD, PONV

- Pretreatment with inhalers if patient has an irritable airway.

- Anticipated difficult airway – special equipment available

- Sedation:
  - Midazolam 1-2 mg
  - Minimal to none if difficult airway
Clinical Technique: Induction

- Preoxygenation
- Lidocaine 1 mg/kg
- Propofol 2-2.5 mg/kg
  - Additional propofol 0.5 mg/kg as needed
- Placement of LMA with loss of lid reflex and mandible relaxation
  - Ensure adequate anesthetic depth prior to manipulating airway
  - Placement of bite block
- Fentanyl 25-50 mcg IV
Clinical Technique: Induction Difficult Airway

- Airway equipment prepared
- Consider an awake LMA insertion
  - Localize airway.
  - Sedation
- Consider mask induction – keep patient breathing
  - Vital capacity.
  - Sedation doses of propofol as inhaled agent concentration is increased.
  - Insertion of LMA.
Clinical Technique: Maintenance

- Fresh gas flow 4-6 L initially
- Desflurane vaporizer 6-8%
  - “Rule of 24”
  - Watch for equilibrium of inspired & expired concentrations on agent analyzer
- Incremental doses of Fentanyl
  - 25 mcg IV slowly keeping respirations 8-10/minute
- Fresh gas flow ↓ 1-2 L every 2 min to 1.0 L/min:
  - 100% O₂
  - 50% O₂ and 50% N₂O
  - O₂ – Air combination
Clinical Technique: Late Maintenance

- Postoperative pain control plan
  - Local
  - Ketorolac
  - Opioids

- Postoperative nausea & vomiting plan

- Suction while patient is deep under anesthesia with soft suction catheter
  - Allow a quiet emergence
  - Residual mucus can cause coughing

- Progressive ↓ in Desflurane concentration
Two wake-up techniques:

- Faculty closure
  
  Turn off Desflurane as closure starts
  “Coast” on Desflurane remaining in tubes & bag

- Resident closure:
  
  Leave Desflurane concentration at 2.5-3% until closure complete
Clinical Technique: Emergence

- Turn off Desflurane.
  - Turn off N₂O or air if used
- ↑ FGF of 100% oxygen to 6-10 L.
- Flush anesthesia system with oxygen to clear Desflurane from system.
- Remove LMA after patient awakens, especially if difficult airway.
Summary
Summary: Inhaled Anesthetics, LMA & Difficult Airway

Desflurane:

- Faster emergence & recovery
- Less respiratory depression
  - Improved ventilation; less hypoxia
  - Less chance for reintubation
  - Less chance for post-obstructive pulmonary edema
- Less risk for aspiration
- Less window for nausea
- Less OR time (decrease expensive)
Desflurane Advantages

- Lowest solubility of inhaled agents
  - More rapid wash-in
  - Greater anesthetic control & precision
  - More rapid emergence from anesthesia
  - More rapid return of cognitive function
- Least metabolized inhaled agent
Desflurane Advantages

- Safe & economical with low flows
  - No restrictions on fresh gas flows
- Eliminate N2O without kinetic disadvantage
Summary: LMA

- **Advantages:** convenient; hemodynamic stability; mild reduction in sore throats; avoids neuromuscular blockade; permits easy spontaneous ventilation and easy placement

- **Disadvantages:** incomplete seal; aspiration remains risk; can displace cervical spine

- **Important Adjunct** for failed mask ventilation and difficult or failed intubation
Summary: Efficacy

**LMA:**

- In appropriate patients and cases, LMAs are dependable airway adjunct with smooth insertion.
- Most important application is use with difficult airway or failed intubation.