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2nd Edition



Principles of Anesthesia Equipment

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Contents

1. Applied Physics **1**
Archana Areti, Hariharan Seetharaman
- Compressed Gases *1*
- Vapors *6*
- Fluids *8*
- Diffusion/Osmosis *14*
- Heat *17*
- Humidity *19*
- Electromagnetic Spectrum *24*
- Laser *27*
- Electricity *28*
- Ultrasound *34*

2. Medical Gas Supply, Vacuum, and Scavenging **40**
Yasodananda K Areti
- Medical Gases and Supply *40*
- Medical Gas Cylinders *44*
- Manifold and Pipeline Network *47*
- Other Medical Gases of Interest to Anesthesiologist *51*
- Vacuum *53*
- Scavenging Systems *54*

3. Anesthesia Machine or Workstation **58**
Yasodananda K Areti
- Structure of Anesthetic Machine *59*
- Components of the Machine *60*
- Flowmeters *67*
- Vaporizers *71*
- Anesthesia Information Management System *78*
- Summary of Safety Mechanisms to Prevent Administration of Hypoxic Gas Mixture *79*
- Operating Room Protocol in the Event of Failure of Pipeline Oxygen Supply *80*

4. Anesthesia Breathing Systems 82
Yasodananda K Areti
- Components *82*
- Apparatus Dead Space *84*
- Classification of Breathing Systems *84*
- Systems With Unidirectional Flow Using Absorbents to Remove CO_2 (Circle System) *85*
- Systems with Bidirectional Flow Using CO_2 Absorbent *91*
- Unidirectional Systems Using Nonrebreathing Valves for CO_2 Elimination *91*
- CO_2 Elimination Systems with Bidirectional Flow (No CO_2 Absorbent) *93*
- Monitoring *101*

5. Anesthesia Ventilators 104
Yasodananda K Areti
- Modes of Ventilation in the Anesthesia Ventilators *105*
- Classification of Anesthesia Ventilators *111*
- Challenges Specific to Anesthesia Ventilators *112*
- Commonly Used Current Models of Anesthesia Ventilators *118*
- Typical Ventilator Alarms *122*

6. Equipment for Airway Maintenance 125
Aruna Parameswari, Akilandeswari Manickam, Archana Areti
- Endotracheal Equipment *125*

Devices for Normal Airway Management *125*
- Face Mask *125*
- Artificial Airways *129*
- Laryngoscopes *132*
- Tracheal Tubes *139*
- Aids for Intubation *153*
- Stylets *155*
- Magill's Forceps *157*

Devices for Difficult Airway Management *157*
- Fiberoptic Bronchoscopic Intubation *157*
- Supraglottic Devices *165*
- Cuffed Perilaryngeal Sealers *166*
- Newer Supraglottic airway devices *183*
- Videolaryngoscopes *185*
- Anatomically Shaped Blades with Channels for Endotracheal Tube *189*
- Macintosh Type Blades *191*

- Recent Advances in Laryngoscopes—The Vie Scope *194*
- Retrograde Intubation (Translaryngeal-Guided Intubation) *196*
- Transtracheal Ventilation *198*
- Cricothyrotomy *200*
- Tracheostomy Tubes *205*
- Percutaneous Dilational Tracheostomy *206*
- Adjunct for Guided Extubation *209*
- Difficult Intubation Trolley *210*

7. Monitoring Technology 213
Ahalya Kodali, Bhavani Shankar Kodali
- Inspired Oxygen *213*
- Capnography *215*
- Inhalational Agent Measurement *220*
- Spirometry and Gas Flow Sensors *221*
- Pulse Oximetry *227*
- Noninvasive Arterial Blood Pressure Monitoring *230*
- Invasive Arterial Pressure Monitoring *231*
- Monitoring Cardiac Output *233*
- Temperature Devices *244*

8. Preuse Check of Anesthesia Equipment 248
Yasodananda K Areti
- Automated Checkout *249*
- Checking Various Components *252*
- Circle Breathing System *253*
- Check Final Status of Machine *257*

9. Electrical Safety, Cautery, and Lasers 259
Hariharan Seetharaman
- Electrical Safety *259*
- Surgical Diathermy *261*
- Lasers *263*

10. Equipment for Regional Anesthesia 267
TVS Gopal
- Peripheral Nerve Stimulation *267*
- Ultrasound-guided Regional Anesthesia *273*

11. Central Neuraxial Block (Anesthesia) 283
Athma Prasanna, Yasodananda K Areti
- History *283*
- Definition *283*
- Anatomy *284*

- Indications for Neuraxial Blocks *285*
- Contraindications *286*
- Technique of Performing Neuraxial Blocks *287*
- Subarachnoid Block *291*
- Technique for Spinal *292*
- Medications Used for Subarachnoid Block *294*
- Epidural Block *298*
- Technical Problems During Neuraxial Blocks *308*
- Causes of Failure Encountered with Neuraxial Blocks *310*
- Assessment of the Neuraxial Block *311*
- Effects of Neuraxial Blocks on Different Systems *312*
- Complications of Neuraxial Blocks *313*
- Postoperative Care *315*
- Neuraxial Blocks in Patients on Anticoagulants *316*
- Summary of Current Recommendations *317*

12. Disinfection and Sterilization 321
Karisha Hinkson-LaCorbinière
- Levels of Disinfection *322*
- Spaulding Classification *322*
- Cleaning *323*
- Methods of Disinfection *324*
- Sterilization *326*
- Chemical Sterilization *330*
- Cleaning, Disinfection, and Sterilization of Anesthesia Equipment *334*

13. Simulation in Anesthesia 337
Ramkumar Venkateswaran
- What Makes Anesthesia Uniquely Suited for Simulated Learning? *338*
- What Is Required to Make a Simulation Exercise Successful? *338*
- Airway Management Trainers *339*
- Venous Cannulation and Arterial Cannulation *340*
- Life Support Training Units *343*
- Spinal and Epidural Anesthesia *346*
- Simulation of Emergencies In Anesthesia, Trauma, and Emergency Medicine *346*
- Debriefing *348*

Index 351

CHAPTER 6

Equipment for Airway Maintenance

Aruna Parameswari, Akilandeswari Manickam, Archana Areti

ENDOTRACHEAL EQUIPMENT

Airway management is an important aspect of anesthesia care and resuscitation. Several devices are used for the management of the normal and difficult airway. Over the last few decades, many new devices with different designs have been introduced. The utility of these advantages and disadvantages over other devices are highly variable. Knowledge of the available equipment and the indications for use and their limitations are necessary in choosing the right and safe technique of airway management in a particular patient.

DEVICES FOR NORMAL AIRWAY MANAGEMENT

FACE MASK

This allows administration of oxygen and anesthetic gases and vapor from the breathing system to the patient in a noninvasive manner, by creating a low-pressure airtight seal around the face. Face mask is also used to provide continuous positive airway pressure (CPAP) and noninvasive ventilation. It can be made of rubber, plastic, silicon, neoprene, or polycarbonate. The parts include a body, a seal, and a connector.

Parts of the Face Mask

Body

This is the main part of the mask and can be opaque or transparent **(Figs. 1A and B)**. When transparent, it allows the visualization of secretions, vomit, and blood. Monitoring of spontaneous respiration by visualization of condensation during exhalation is also possible with a transparent mask.

Seal (Edge)

This is the portion of the mask that is in contact with the patient's face and establishes the low-pressure seal and a snug fit. It can be of the cuff or the flap type. The pad, cuff, or the cushion type requires inflation of the seal with air or some other material while the flap is just an extension of the body that is

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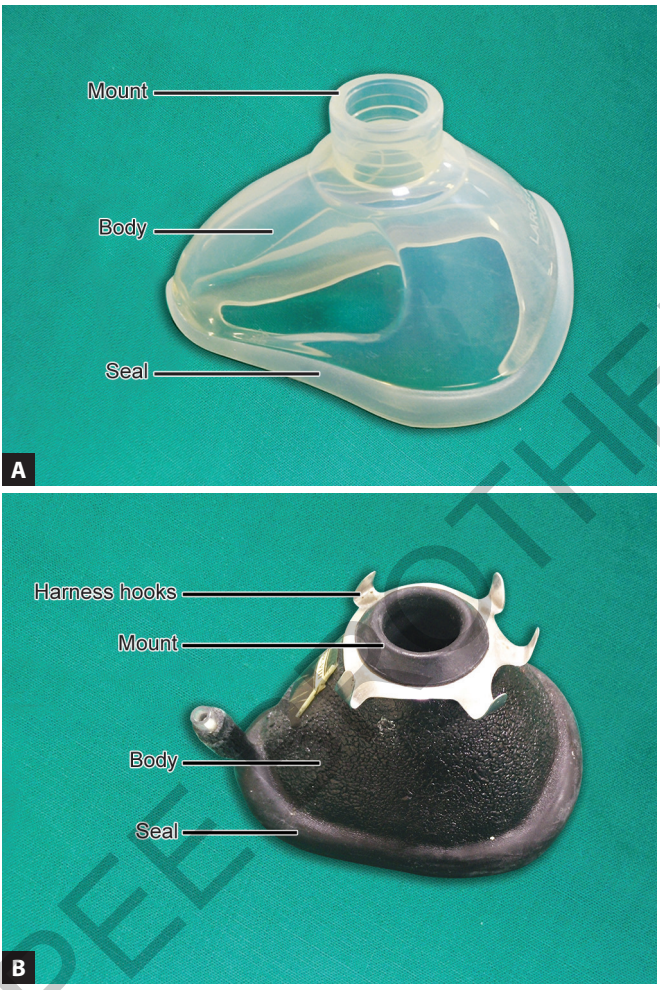

Figs. 1A and B: Parts of a face mask: (A) Laerdal silicone face mask with a transparent body and a seal of the flap type and (B) Black anatomical face mask with an opaque body and a seal of the cuff type.

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flexible and takes the contour of the face. A good seal is essential to prevent dilution of administered gases by room air during spontaneous respiration and also to provide positive pressure ventilation without gas leak.

Connector (Mount)

This is the portion of the mask on the opposite side of the seal, which has a standard internal diameter (ID) of 22 mm for connection to the breathing system. It is made of thickened rubber, plastic, or metal. It has a ring with hooks for attachment of a harness or mask strap.

Types of Face Masks

Masks are of different types depending on the shape and the type of material from which they are made. These include black rubber anatomical face masks, transparent anatomical face masks, transparent round face masks, Rendell–Baker Soucek face masks, endoscopic face masks, etc. **(Fig. 2)**.

Sizes Available

It is important to have all available sizes of face masks on the airway or intubation trolley as one size would not fit all faces. Masks come in sizes 00 to 6 **(Fig. 3)**.



Fig. 2: Different types of face masks.



Fig. 3: Different sizes of face masks (from size 0 to size 5). Sizes 00 and 6 are not shown in this picture.

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Dead Space

The mask contributes to the apparatus dead space that can assume significance in neonates and infants. The dead space can be reduced by using a smaller mask, increasing the pressure on the mask, or by changing the volume of the cushion. The dead space of an adult face mask can range from 80 to 200 mL.

Technique of Use

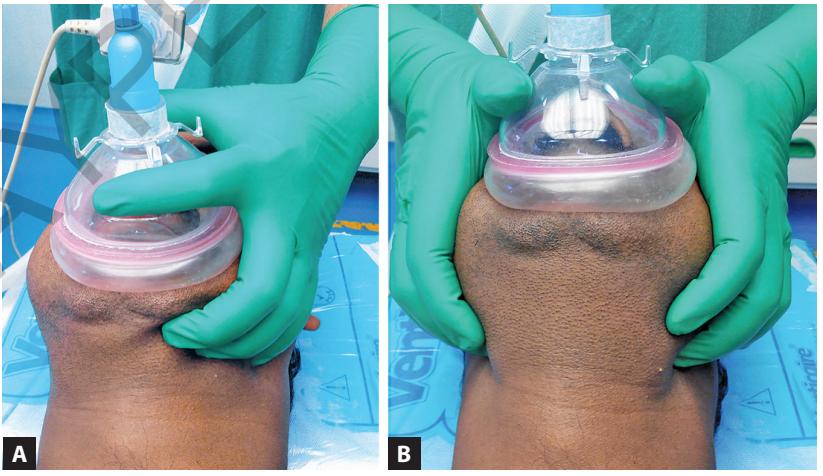
In the one-hand technique, the thumb and the index finger of the left hand should be placed over the body of the mask on either side of the connector with downward pressure to create a seal **(Figs. 4A and B)**. The other three fingers of the left hand are placed over the mandible. It is important to avoid pressure on the eyes. In the two-hand technique, the thumbs are placed on either side of the connector and the fingers of both the hands are placed on the angles of the mandible to lift the mandible. Another person is needed to provide positive pressure by squeezing the reservoir bag.

Advantages of Face Mask

- Lower incidence of sore throat
- Lesser anesthetic depth needed for use
- Cost-effective

Disadvantages of Face Mask

- Anesthesia provider's hands have to be used continuously leading to user's fatigue.



Figs. 4A and B: Technique of holding the face mask. (A) One-hand technique; (B) Two-hand technique.

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- Gas leak leading to environmental pollution and gas wastage (due to higher fresh gas flows)
- It does not protect airway against aspiration.
- This can lead to gastric inflation with positive pressure ventilation.
- It is difficult to use in situations where airway access to anesthesiologist can be difficult (MRI).
- More intraoperative airway manipulations are needed to maintain the airway.
- It can cause injuries to the eye, skin, and nerves.

ARTIFICIAL AIRWAYS

The maintenance of an open airway is important for gas exchange. In unconscious and anesthetized patients, loss of muscle tone leads to upper airway obstruction at the level of the tongue, soft palate, and epiglottis as these structures fall against one another or against the posterior pharyngeal wall. Artificial airways are adjuncts used to open the natural airway and maintain its patency, when maneuvers such as head tilt, chin lift, and jaw thrust have failed to open the natural airway. These can be inserted through the mouth (oropharyngeal airways) or through the nose (nasopharyngeal airways).

Oropharyngeal Airways

These are inserted through the mouth and maintain airway patency by pushing the tongue and the epiglottis away from the posterior pharyngeal wall.

Description

They can be made of plastic or elastomeric material. The parts of the oropharyngeal airway include the flange, the proximal buccal end, the bite portion, the curved portion, the air channel, and the distal pharyngeal end **(Fig. 5)**. The flange at the buccal end prevents the airway from slipping deeper into the mouth and helps in fixation. The bite portion is the rigid part that lies between the teeth and is the straight portion of the airway. It prevents the patient from closing the lumen of the airway by biting. The curved portion of the airway lies between the tongue and the palate. The pharyngeal end of a correctly placed airway should lie at the posterior part of the tongue above the epiglottis. The air channel extends from the buccal to the pharyngeal end.

Specific airways include the Guedel airway, the Berman airway, the Patil Syracuse airway, the Ovassapian fiberoptic intubating airway, the Williams airway intubator, the Berman intubating airway, etc.

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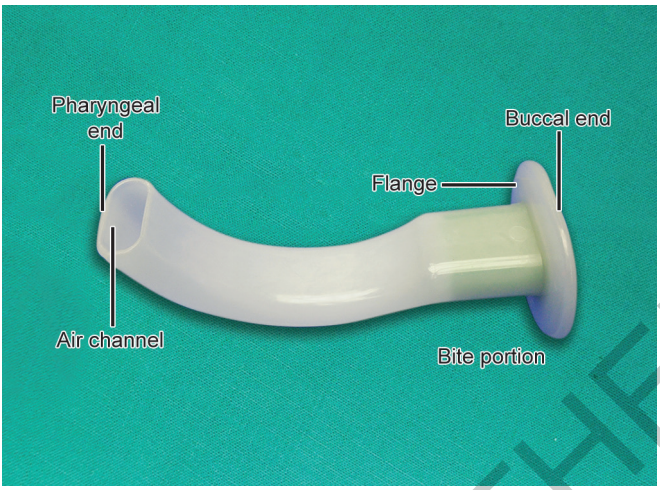

Fig. 5: Parts of the Guedel oropharyngeal airway.



Fig. 6: Sizes of Guedel oropharyngeal airway.

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Sizes

Airways come in different lengths and diameters for patients of different sizes, and they are color- and number-coded according to standards **(Fig. 6)**. The correct size of the Guedel's airway is chosen by placing the unstraightened airway between the lips and the tragus of the patient. If it is not inserted deep enough, it can cause the tongue to fold back and worsen airway obstruction. If the airway is inserted too deep, it may push the epiglottis and worsen airway obstruction or irritate the laryngeal inlet leading to laryngospasm.

Technique of Insertion

After extending the head and opening the mouth, the airway is inserted with its concave surface facing toward the upper lip and hard palate and advanced till the bite portion reaches the incisors, at which point it is rotated 180° so that the concave surface now faces the tongue. Jaw thrust can be used to overcome any resistance during insertion. Alternately, it can also be inserted with the concave side facing the tongue, using a tongue depressor and then advanced.

Complications

- Airway obstruction by the airway if an inappropriate-sized airway is used.
- Trauma to the teeth and oropharyngeal structures
- Edema, ulceration, and necrosis of the tongue with prolonged use
- Coughing and laryngospasm, if it is inserted in a light plane of anesthesia

Nasopharyngeal Airways

These are used for relief of airway obstruction at the level of the nares, nasopharynx, tongue, and soft palate.

Description

They are soft and made of rubber, plastic, or polyurethane. They have a curved body (like a short tracheal tube) and a fixed or adjustable flange at the proximal end to prevent loss of device into the nose. The tip is beveled and atraumatic.

Size

They are available in different sizes **(Fig. 7)** from 2 to 9 mm, described by the ID in millimeter. The correct length of the airway is estimated by measuring the distance from the tip of the nose to the tragus of the ear. The correct size is determined by the size of the nostrils.

Insertion Technique

The lubricated nasopharyngeal airway is inserted through the external nares with the bevel facing the septum and advanced over the floor of the mouth till the tip lies in the oropharynx below the base of the tongue and above the epiglottis. The proximal end can be connected to a breathing circuit using a 15-mm tracheal tube connector for oxygenation, CPAP, and to maintain anesthesia during fiberoptic intubation. They are better tolerated than oropharyngeal airways.

Their use is contraindicated in fractures of the skull base, coagulopathy, and sepsis or deformity of the nose.

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Fig. 7: Different sizes of nasopharyngeal airways.

Complications

- Bleeding from the nose
- Stimulation of laryngeal reflexes if inserted too deep.

LARYNGOSCOPES

These are devices that are used to visualize the larynx to facilitate endotracheal intubation, and they can be rigid or flexible.

History

The first direct laryngoscopy was performed by Alfred Kristein in 1895 using an esophagoscope that he had modified for this purpose and it was called the autoscope. In 1913, Chevalier Jackson popularized the use of direct laryngoscopy further. But, the use of the laryngoscope for visualization of the vocal cords for intubation was popularized by Sir Robert Reynolds Macintosh and Sir Ivan Magill in the 1940s.

Parts of a Rigid Laryngoscope

The parts of the rigid laryngoscope include the handle and the blade **(Fig. 8)**, which can be detachable or attached as a single piece. When the blade and handle are detachable, there is usually a hook on connection between them. This is the part that is held in the user's hand and it has a rough surface to provide a good grip. It houses the power source in the form of disposable or rechargeable batteries. Handles are either made of surgical stainless steel or hardened aluminum (in the newer laryngoscopes), which makes the handle lighter.

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Fig. 8: Macintosh curved blade laryngoscope with blades of four sizes (1, 2, 3, and 4) and handle.

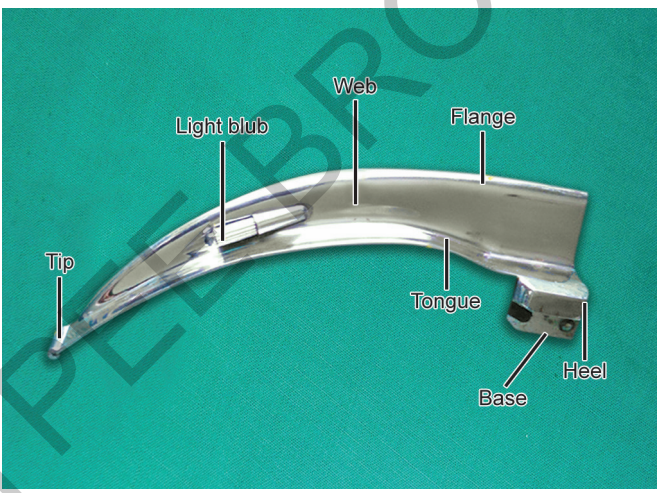

Fig. 9: Parts of the Macintosh curved blade.

Blade

This is the portion of the laryngoscope that is inserted into the patient's mouth during direct laryngoscopy. It consists of the base, heel, tongue, flange, web, tip, and the light source **(Fig. 9)**. The base is the part of the blade that comes in contact with the handle through a hinge connection. It has a slot to accommodate the hinge pin of the handle. The end of the base is the heel. The tongue is that part of the blade that is used to deflect the patient's tongue and other oropharyngeal structures. It can be curved or straight, based on which the laryngoscope is classified as a curved- or straight-blade

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laryngoscope. The distal end of the blade is the tip that is in contact with the vallecula or epiglottis and is made blunt to avoid trauma. The flange is the portion of the blade that projects from the side of the tongue. The web is the part of the blade between the tongue and the flange that has the electrical connections and the bulb.

The angle between the handle and the blade is usually 90°, but it can be made more obtuse or acute, by using an adapter between the blade and the handle.

Light Source

The light source is either an incandescent bulb located in the blade with the power source located in the handle or the bulb in the handle with the light transmitted to the blade through a fiberoptic bundle **(Figs. 10A and B)**.

When the bulb is located in the blade, it is usually at one-third distance from the tip of the blade and is of the screw on type. The electrical connection is completed when there is metallic contact between the handle and the blade, which happens when the blade is opened for use. The socket for the bulb can get soiled by fluids during laryngoscopy causing the light to fail.

The advantage of the fiberoptic bundle **(Figs. 11A and B)** is that there is no risk of the bulb getting detached and lost during laryngoscopy and there is also a decreased incidence of burns. Cleaning and sterilization are easier. These laryngoscopes are marked by a green dot in the heel for identification, as per the ISO standards **(Figs. 12A and B)**.

Newer laryngoscopes use light-emitting diodes (LEDs) in the handle instead of halogen bulbs, which provide white and brighter light. The LED light source is also energy efficient providing longer-lasting power.



Figs. 10A and B: (A) Blade with a bulb of the screw type in a socket with light source in the handle; (B) Blade with fiberoptic light guide with light source in the handle.

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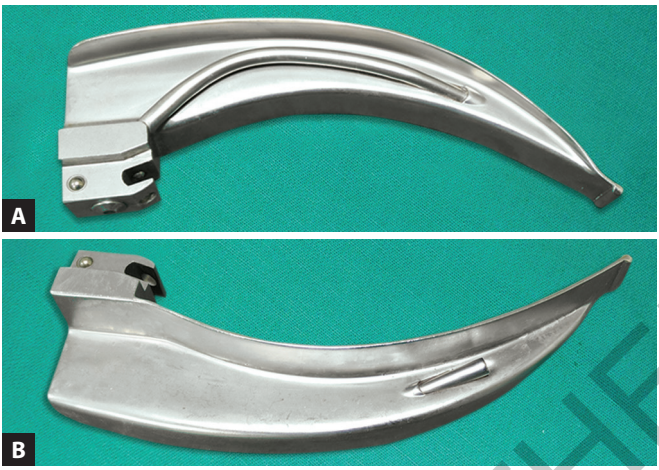
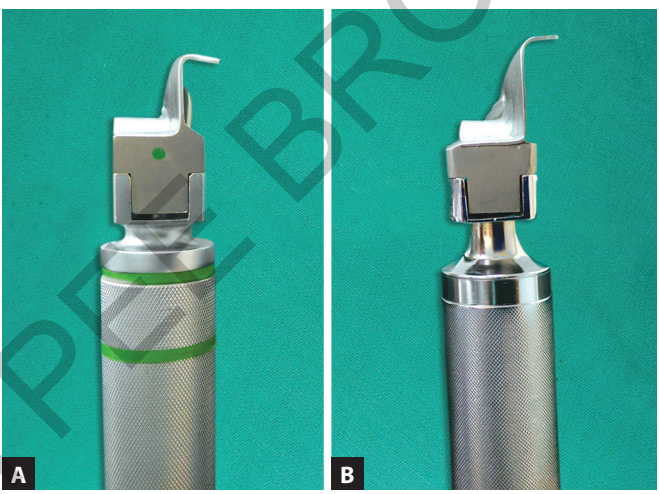


Figs. 11A and B: Fiberoptic guide as light source in Macintosh curved-blade laryngoscope. (A) Light guide is seen emerging from the base of the blade and extending along the web; (B) Light guide is seen emerging on the tongue of the blade.



Figs. 12A and B: Fiberoptic laryngoscope identification. (A) Fiberoptic laryngoscope having green circular bands in the handle and a green dot in the heel of the blade; (B) Conventional laryngoscope without a fiberoptic light source with no green mark on the handle or blade.

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Sizes of Laryngoscopes

Laryngoscopes are sized according to the blade size. They come in eight sizes as per the ISO standard from 000 for the small premature infant to size 5 for the extra-large adult **(Table 1)**. The blades and handles from different manufacturers are interchangeable and there are two ISO standards, the green system (ISO 7376/3) and the red system (ISO 7376/1) that allow this,

TABLE 1: Different sizes of laryngoscope blades with the age for intended use.

Size of the laryngoscope blade	*Age for intended use*
000	Small premature neonate
00	Premature neonate
0	Neonate
1	Small child
2	Child
3	Adult
4	Large adult
5	Extra-large adult

the difference between the two being the position of the light source and the dimensions of the hinges.

Types of Blades

There are different types of blades. Some of the commonly used ones include:

Macintosh

This is the standard curved-blade laryngoscope that is most commonly used. The tongue, flange, and the web form a reverse "Z" on cross-section. A curved blade is more suitable for adults and also for children with macroglossia.

Miller

This is a straight-blade laryngoscope that is commonly used in children **(Figs. 13A and B)**. The tongue of the blade is straight except for a gentle upward curve near the tip. In cross-section, the tongue, flange, and the web form a flattened "C" **(Fig. 14)**.

McCoy

This is a modified Macintosh blade in which the tip can be flexed by pressing a lever attached to the handle. The flexible tip allows further elevation of the vallecula and the epiglottis, thus improving the laryngoscopic view **(Fig. 15)**. However, movements are limited to the last 25 mm from the tip.

Polio

This is a modification of the Macintosh blade where the angle between the handle and the blade is more obtuse (135° instead of the usual 90°). It is useful in situations like large breasts, barrel chest, and restricted neck mobility.

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Principles of
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Salient Features

- The chapter on "Equipment" covers important topics that are part of the MD (Anesthesia) syllabus and frequently asked examination questions
- The book contains a novel classification and/or functional analysis with respect to flowmeters, vaporizers, anesthesia breathing systems, and anesthesia ventilators
- The chapter on monitoring includes capnography and elaborated on the state-of-the-art cardiac output monitors
- The "Airway" chapter has been updated to include few new additions and updates in airway management including adjuncts
- Other highlights include chapters of simulation, equipment for regional anesthesia, central neuraxial blocks, etc.

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