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AIRWAY MANAGEMENT – A REVIEW OF CURRENT METHODS, GUIDELINES AND EQUIPMENT

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ABSTRACT

Maintaining airway patency is an essential issue in many fields of medicine. The modern approach to CPR, which focuses on maintaining airway, breathing, and circulation was finally established by Peter Safar in his book *ABC of Resuscitation* (1950). At present, along with the development of evidence-based medicine, techniques which are proven to be clinically effective are regularly published in a convenient form – as bundles and guidelines. Regarding airway management, ERC and DAS guidelines are the most reliable and useful sources of knowledge and practical clinical advice. Among the medical staff, there is emphasis put on the mastery of ABC techniques. Airway management is the first step in the resuscitation algorithm. It consists of a variety of procedures ranging from simple and non-invasive to more complex, requiring professional training and experience. Currently, the most clinically effective and life-saving actions are incorporated into whole procedures and bundles, such as ERC or DAS guidelines, which are evenly checked, evaluated and, eventually, modified. This method of regular revision allows us to keep all medical professionals at the same level of competence.

The aim of the study was to describe basic and advanced techniques, methods, and devices which are currently used to provide it. Currently applicable guidelines regarding CPR and airway management were reviewed and summarized.

KEYWORDS: airway, LMA, LT tube, Guedel, intubation

List of abbreviations: BLS – basic life support; CPR – cardiopulmonary resuscitation; DAS – Difficult Airway Society; ERC – European Resuscitation Council; GEB – gum-elastic bougie; LMA – laryngeal mask; SAD – supraglottic airway device.

Maintaining airway patency is an essential issue in many fields of medicine. It plays a crucial function especially in emergency medicine, anesthesia, intensive care, and first aid. Airway management devices and techniques are also inseparably related to cardiopulmonary resuscitation (representing the "A" in ABC) or Difficult Airway Society guidelines. The importance of assuring correct gas exchange and oxygenation is indisputable, having been clearly stated centuries ago. Back in the 16th century it was discovered that air must reach the lungs to give an unconscious victim any chance for survival. Thus, first attempts for preserving gas exchange utilized bellows (like those used by blacksmiths) to transfer an air into a patient's airway. That method was ultimately withdrawn by the 18th century due to the significant disadvantages and difficulties surrounding it. Further developments were made in 18th century, when the Dutch Humane Society was founded. The aim of this group was to rescue people drowning in the waterways. Each saved life brought

a monetary reward for rescuers, which stimulated a wealth of ingenuity among the lifesavers. Some techniques used then may seem a little bit strange, such as suspending the victim upside down or rolling him on a barrel. At the same time, endotracheal cannulae were used for the first time. The modern approach to CPR, which focuses on maintaining airway, breathing, and circulation was finally established by Peter Safar in his book *ABC of Resuscitation* (1950). Along with the progress of technology and medicine, more sophisticated and effective ways to provide adequate oxygen delivery and carbon dioxide elimination were developed and subsequently established [1–3].

The airway is generally divided anatomically into upper (consisting of the oral/nasal cavity, pharynx and larynx) and lower segments, which include the tracheobronchial tree and lungs. Obstructions may occur at any level of the respiratory tract, resulting in impairment of gas conduction and its exchange. Possible causes of an airway obstruction include:

1. Infection – laryngotracheitis, bacterial tracheitis, peritonsillar abscess, retropharyngeal abscess, epiglottitis
2. Aspiration of a foreign body.
3. Unconsciousness – regardless of its origin. Glasgow Coma Score of 8 or less predicts loss of airway patency and is an indication for endotracheal intubation. The obstruction is caused by the base of the tongue sagging against the posterior pharyngeal wall.
4. Facial or laryngo-tracheal trauma.
5. Anaphylaxis, excessive laryngeal stimulation.
6. Paralysis of the vocal cords (e.g. iatrogenic).
7. Pulmonary edema, bronchospasm, bronchial secretions, aspiration on gastric contents – affecting lower airway.
8. Tumors – due to either occluding the lumen or exerting external pressure.

Airway management may be divided into two general categories: basic (or non-instrumental) and advanced (includes also instrumental techniques).

Basic techniques are non-invasive, simple, and relatively easy to perform. There is no need to use any equipment to carry them out. Basic procedures consist of:

1. head tilt–chin lift – one of the quintessential man oeuvres from BLS guidelines, used to obtain airway patency and assess a patient's breathing. It is also widely used in anesthesiology, intensive care, and emergency medicine, usually to increase the efficiency of bag-valve-mask ventilation. May be followed by a finger sweep or jaw thrust to further improve its effectiveness. One hand is placed on a patient's forehead, the other hand is put just below the chin. Then, the forehead is pushed backwards while the chin is lifted upwards.
2. Esmarch maneuver (jaw thrust) – typically used to restore airway patency in patients with cervical spinal cord injury or as a supplement to head tilt-chin lift. The mouth is gently opened and chin displaced downwards using your thumbs, while the mandible's angle is moved forward using the other fingers. In a case of cervical spine injury, the MILS (manual in-line stabilization) is performed by an assistant. However, in life-threatening situations, obtaining airway patency is more important than potential neurological detriment (Fig. 1).

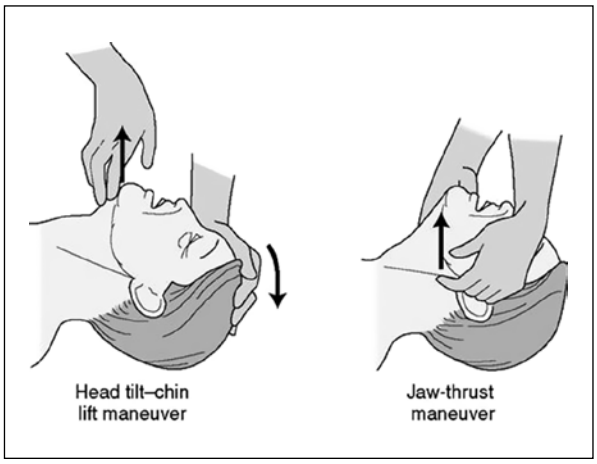

Fig. 1. Basic (non-instrumental) techniques airway management

3. Sniffing position, ear-to-sternal notch, ramped head – these are the types of head positioning performed mostly in the operating theatres to facilitate view during laryngoscopy. They also improve airway patency and respiratory mechanics, making bag-valve mask ventilation easier [4].
4. Finger sweep – removing a visible foreign body from the airway. A blind finger sweep is not recommended.
5. Back blows and abdominal thrusts – carried out in cases of foreign body airway obstruction (FBAO), and included in BLS guidelines. Should be performed in victims with severe FBAO. First, the patient leans forward (while supported with the rescuer's hand). Then the rescuer stands to the side and gives up to five firm blows between the shoulder blades. If ineffective, abdominal thrusts are performed – the rescuer stands behind the patient with their hands clenched together between victim's navel and ribcage. The rescuer delivers a sharp inward and upward pull (up to five times). If still ineffective, back blows should be performed again. It is very important to recognize choking and its severity, because techniques described may be harmful in mild choking. If the victim's condition is worsening, CPR should be started.
6. Recovery position – performed in spontaneously breathing persons. The tongue and jaw fall forward under gravity, thus improving the airway patency and offering a degree of protection against aspiration of stomach contents (Fig. 2).

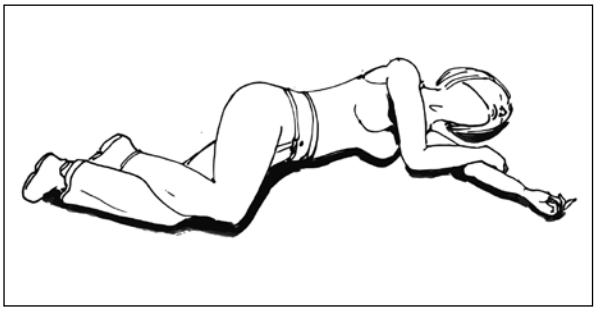

Fig. 2. Recovery position (source: wikipedia.com, author: Rama)

Advanced airway management includes the use of more sophisticated equipment. The most important and popular instruments are:

1. Naso–pharyngeal tubes (NP) – widely used in emergency medicine (Fig. 3). These devices maintain patency between the tongue and posterior pharyngeal wall. They are softer and much less irritating than the oropharyngeal tube, and are thus suitable for conscious and unconscious patients. They have proven utility in anesthesia, e.g. during gastroscopy. Very helpful in cases of trismus or clenched jaws. Size is adjusted according to the diameter of the patient's fifth finger (usually 6mm for females and 7mm for males), although height provides more accurate matching. The NP tube should be inserted (with lubrication) into the nostril, pushed carefully downwards, parallel to hard palate to minimize trauma to nasopharynx. Presence of a base skull fracture puts the patient at risk of intracranial tube insertion. NP tube placement is contraindicated in patients on anticoagulation agents or in epistaxis [5,6].

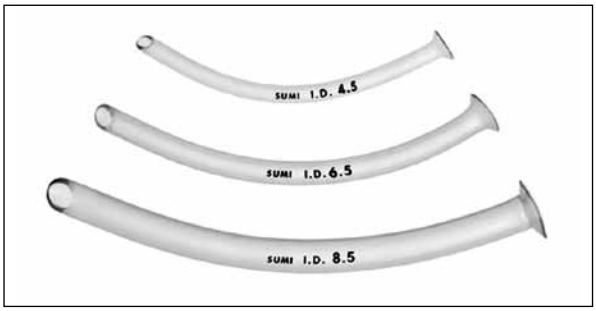

Fig. 3. Nasopharyngeal airway (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

2. Oro–pharyngeal tubes – these are Guedel (hollow) (Fig. 4) or Berman devices. Used in unconscious, unresponsive patients as they are more irritating and may stimulate a gag reflex. Size is adjusted by measuring (or comparing) the corner of mouth-earlobe or incisor-mandibular angle distance. Proper placement requires inserting the tube upside down and twisting it by 180 degrees to avoid pushing the tongue backwards. Easy and fast insertion makes it especially practical and gives rise to its use in operating theatres, emergency departments, and war zones [7].

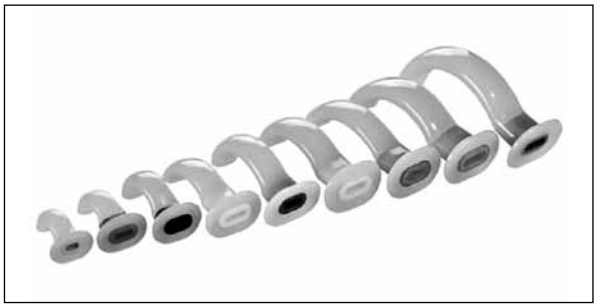

Fig. 4. Guedel airway (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

3. Laryngeal mask – consists of a head with circumferential cuff, a tube, a pilot balloon, and proximal 15mm connector. May be single-use or reusable. Patient may breathe spontaneously or ventilation may be controlled (peak pressure up to 25-30cm H20). Applications include maintaining the airway in difficult intubations, emergency airway management in failed intubation, ensuring airway patency in unconscious patients, inhalational anesthesia, and CPR. Size is adjusted according to patient weight (1 – patients under 5kg, 5 – over 80kg; may slightly differ between manufacturers). It is important to note that the LMA does not protect from aspiration of gastric contents. Before insertion, the cuff should be lubricated and/or slightly inflated, then it is slid through the larynx. An LMA's aperture should face a laryngeal inlet or may be placed posteriorly and twisted towards the larynx once behind the tongue. Then, the cuff is inflated up to 60cmH2O. It is considered the fastest way to achieve airway patency. Currently, 2nd generation SAD (such as i-gel or Proseal) are recommended, especially for unexpectedly difficult intubations [8–14].
4. Tracheal tubes – used widely during endotracheal intubation. There is a huge diversity between types and sizes of ET tubes (reinforced, noncuffed, preformed, pediatric, double lumen). Standard, single-use tubes are made of PVC and have an inflatable cuff with a pilot balloon near the proximal end. Its distal end has a hole (called Murphy's eye) and a left facing bevel. The proximal end is equipped with a connector that allows quick linkage to ventilator tubing or a self-inflating bag.

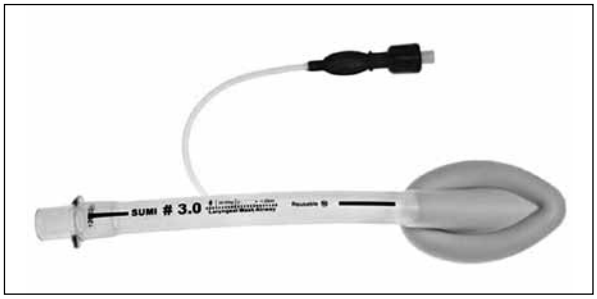

Fig. 5. Multi-use LMA (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

Tubes are usually marked with manufacturer's name, size (ID – internal diameter) and distance from the tip in centimeters. Modern ones have also a radiopaque line incorporated for easy visualization on x-ray (Fig. 6, 7).

5. Tracheostomy tubes – similar to tracheal tubes, curved, with or without cuff, made of plastic or metal – types vary in certain features for different purposes (Fig. 8).
6. Combitube – this is a double lumen, double cuffed device which may be inserted blindly. Once in place, it is crucial to ascertain which lumen delivers proper lung ventilation. The Combitube is currently being replaced by laryngeal tubes, which have less complicated construction and are simpler in use.
7. Laryngeal tube – designed to be easily, blindly inserted into esophagus. It has only one lumen and two cuffs with only one pilot balloon (Fig. 9). These cuffs occlude the esophagus and pharynx, thus allowing ventilation while offering some protection against aspiration of gastric contents (Fig. 10). Used mostly in emergency settings and CPR [15].
8. Laryngoscopes – essential equipment needed to perform laryngoscopy and endotracheal intubation. Consists of a handle and a blade (Fig. 11). The latter vary in size and type (i.e. Macintosh, Miller, Magill, McCoy, Soper).
9. Bougie introducer (GEB) – flexible, can be bent into desired shape. It is inserted into the trachea, then the endotracheal tube is fed over it. After

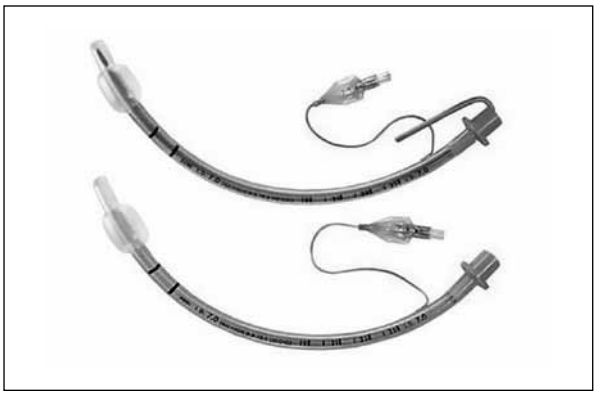

Fig. 6. Reinforced ET tubes incorporated for easy visualisation on x-ray (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

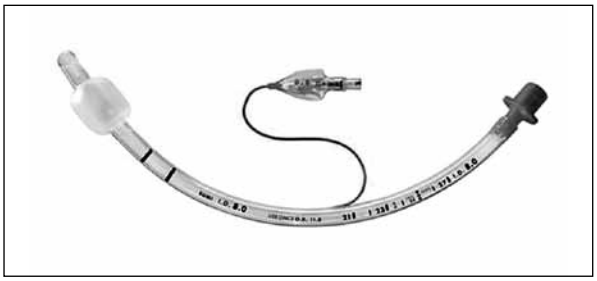

Fig. 7. Cuffed ET tube (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

Fig. 8. Tracheostomy tubes (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

Fig. 9. Cuffed LT tube (source: under courtesy of VBM Medizintechnik GmbH www.vbm-medical.de)

Fig. 10. LT tube positioning (source: under courtesy of VBM Medizintechnik GmbH www.vbm-medical.de)

Fig. 11. Laryngoscope

that, the introducer is removed. The GEB is an indispensable device for difficult tracheal intubations. It is also necessary (Fig. 12) for immediate front-of-neck access (Fig. 13) [12].

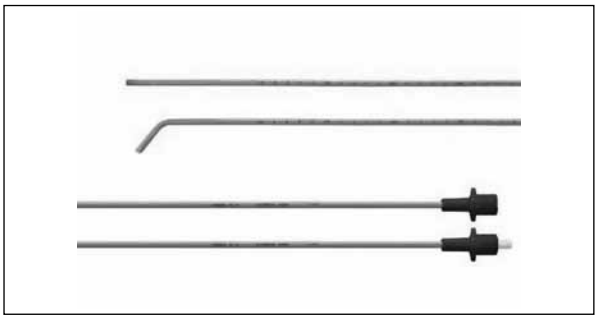

Fig. 12. GEB with ventilation lumen (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

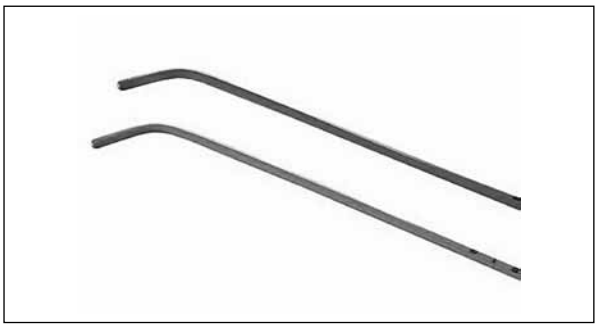

Fig. 13. Bougie introducer (source: under courtesy of Sumi Ltd. www.sumi.com.pl)

10. Tracheal catheter with ventilation lumen – similar to bougie introducer, allows oxygenation.
11. Suction equipment – indispensable instruments in ICUs, operating rooms, and emergency teams (usually as mobile devices).
12. Magill forceps – facilitates removing foreign bodies from an upper airway. Used in naso-tracheal intubation. Helpful when performing throat packing.
13. Stylets – flexible devices used usually as an adjunct to reinforced ET tubes (these are usually not rigid enough to insert into trachea)
14. Optical devices – i.e. fiberoscopes, videolaryngoscopes, optical stylets – these instruments are used especially when anticipating difficulties with a patient's airway.

Advanced airway management techniques are always (to variable extent) invasive. Procedures include using a combination of basic man oeuvres as well as instruments (described above). Some of them are complex and carry a risk of potentially fatal complications. Training and experience are needed to master them. Generally, advanced airway management procedures may be divided into supra- and infraglottic. Supraglottic techniques include inserting a nasopharyngeal airway, oropharyngeal airway, or laryngeal mask. Disadvantages of SAD include risk of aspiration, air leakage, and inspiratory peak pressure limits of approximately 20-25cm H_2O. Infraglottic advanced airway management consists of:

1. Tracheal intubation – defined as placing a tube in the trachea (via oral or nasal cavity). This is considered the most reliable way to achieve airway patency, providing satisfactory protection against aspiration of gastric contents. The indications to intubation include anesthetic – abdominal-, cardiac-, neurosurgery, protection against soiling, restricted access to neck and head during anesthesia; and non-anesthetic – such as CPR, respiratory failure, airway obstruction, unconsciousness, need for aspiration of tracheobronchial contents. During CPR and in the emergency setting (unconscious victim) it is usually performed without pharmacological preparation, while in the operating theatre intubation is carried out under general anesthesia (awake intubation is reserved for patients with known difficult airway) and optimal conditions – sniffing position, preoxygenation, patient paralyzed, with all the equipment (described above) prepared for potential emergencies (inability to ventilate and/or oxygenate). Following successful laryngoscopy, a tube (usually size 7-8mm ID in adults) is inserted between the vocal cords. Then, the cuff is inflated to a pressure of 20-30cmH20 and chest auscultation is performed, focusing primarily on presence of symmetrical breath sounds. If present, the tube is fixed and taped in position. These techniques require training and experience because intubations that are traumatic, prolonged, or failed and go unrecognized may lead to serious complications, such as hypoxaemia, hypercapnia, damage to teeth, mucosa, or larynx, bleeding, laryngospasm, cardiac arrhythmias, and/or hypertensive response [9].
2. Cricothyroidotomy – this is considered the fastest and most reliable way to gain airway access in case of emergency. The aim is to achieve lung ventilation as quickly as possible. The proper technique includes approaching a patient from the left side, identifying laryngeal anatomy (by a handshake), then specifically identifying the membrane between cricoid and thyroid cartilage using the left index finger. Subsequently, the stab incision is made with the right hand, followed by a 90-degree rotation of the blade. Once the opening is made, the bougie is inserted into the trachea and scalpel removed. The 6.0mm tracheal tube is railroaded over the bougie into the trachea – after that, the introducer is removed, ventilation confirmed and position fixed. This technique is described as "stab-twist-bougie-tube", recommended for all CICO (can't intubate, can't oxygenate) situations [11].
3. Tracheostomy – surgical technique, performed as an open or percutaneous procedure. A horizontal incision is made below the cricothyroid car-

tilage, then a vertical incision through the 2nd, 3rd, and 4th tracheal ring. The tube is inserted via a slit or circular opening in the trachea. Widely performed in ICU and palliative medicine to relieve airway obstruction, protect the tracheobronchial tree against aspiration, maintain patency when laryngeal reflexes are obtunded (vocal cords paralysis, neurological disease), or allow prolonged mechanical ventilation. Allows for easier nursing and increases patient comfort. Depending on underlying disease and general condition, patient may eat and speak with a tracheostomy tube [9].

Today, ABC principles are of fundamental importance not only for people working in health professions, but also among the non-medical population. Even younger children are taught the basics of first aid and their importance. Quick and proper management in life-threatening situations may be priceless in saving someone's life. Currently, awareness and knowledge about resuscitation, life support, and life-saving techniques are widely propagated among societies. Ideally, everyone should be familiar with basic life-saving procedures. Among medical professionals, there is an emphasis put on the mastery of ABC techniques. Airway management is the first step in the resuscitation algorithm. It consists of a variety of procedures, from simple and non-invasive, to more complex, requiring professional training and experience. At present, along with the development of evidence-based medicine, techniques which are proven to be clinically effective are regularly published in a convenient form - as bundles and guidelines. Regarding airway management, ERC and DAS guidelines are the most reliable and useful source of knowledge and practical clinical advice.

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