18 Mask Ventilation: A Neglected Art

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Key Messages

1. Mask ventilation is a basic airway technique which all healthcare workers should be familiar with. Anesthesiologists should perfect the techniques.
2. Effective mask ventilation is crucial before and during attempts of advanced airway techniques, and as a rescue technique when the oxygenation is threatened due to repeated attempts of intubation.
3. Masks are available in different sizes, shapes, and made up of different materials. Transparent ones are preferred. Pediatric masks have minimal dead space. There are special purpose masks like endoscopy masks.
4. Optimal mask ventilation demands proper patient positioning, technique of mask holding, use of drugs and adjuvants like airways.
5. Difficult mask ventilation might be because of inadequate seal or increased airway resistance due to any cause or due to decrease in distal compliance. General principles of overcoming difficulty of mask ventilation and addressing each cause on specific case by case basis requires understanding of the mechanism of difficult mask ventilation.

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1 Introduction

Mask ventilation is a basic skill in airway management. Maintenance of adequate oxygenation in apneic patient is of prime importance and failure to ventilate can lead to adverse events. While there have been significant advances in our ability to manage difficult intubation, fundamentals of mask ventilation remain the same. Even though supraglottic airway devices bridge the gap between the mask and endotracheal tube, importance of mask ventilation cannot be overemphasized. It has role both as a life-saving and elective oxygenation technique.

2 Indications, Contraindications, Advantages, and Disadvantages [1–3]

Indications for performing mask ventilation or assisted ventilation to maintain airway patency and oxygenation are (a) apnea of any cause, (b) respiratory failure, (c) cardiac arrest, before a definitive airway is available, (d) ventilation in an anesthetized patient before placing definitive airway device or in between attempts to intubation

R. S. Ubaradka et al. (eds.), *The Airway Manual*, https://doi.org/10.1007/978-981-19-4747-6_18

or during establishment of a surgical airway, and (e) conducting very short surgical procedures under general anesthesia without endotracheal intubation.

Advantages of mask ventilation include (a) restoring or maintaining oxygenation as a sole technique or part of other techniques, (b) increasing safe apnea time during airway procedures, (c) protecting patient from hypoxia till skill and equipment for more advanced techniques of airway management arrive, (d) relatively easy to learn and the simplicity of the device, and (e) economy, ease of sterilization/disinfection, portability, and universal applicability.

However, mask ventilation, being a skill, needs training and is not easy in all patients. Presence of difficult mask ventilation requires various maneuvers and adjuvants like airways. Improper or inadequate mask ventilation can lead to gastric insufflation and increased risk of aspiration of gastric contents. There is no absolute contraindication for mask ventilation. However, it may be impossible in gross distortion of anatomy of face due to disease, trauma or burns and in the presence of broncho cutaneous fistula. It is ideally to be avoided or the technique modified with the use of low inflation pressure and application of Sellick's maneuver in a full stomach patient or during rapid sequence induction and intubation during anesthesia.

3 Equipment for Mask Ventilation [1, 2]

Equipment includes proper size and shaped face mask, oxygen source (anesthesia machine, oxygen flowmeter) a breathing system or circuit with a reservoir bag or a self-inflating manual resuscitator and airway adjuncts such as an oropharyngeal and nasopharyngeal airway. In edentulous patients, a soft dressing pad may be required to fill the hollow cheeks to provide effective mask seal.

Face masks are discussed in more details here while others have been described elsewhere in this book.

3.1 Face Mask: Description and Components

Facemask is a device used as an interface between a patient's upper airway and the breathing system. These are designed to fit faces of different sizes and they come in various designs, shapes, materials, and sizes.

It consists of a **body** that is somewhat truncated, pyramidal or triangular in shape which is broad on one end that is uniformly curved to sit on the chin and mandible of the patient and a uniformly narrower or tapering end that sits on the nasal bridge of the patient. The body of the mask rests on the **seal** which is either an air-filled **cuff/pad/cushion** or the body itself is extended as a non-inflatable **flange/rim/flap**. The proximal end has a **22-mm** inlet **connector/orifice/collar** which can fit an angle piece extending from a breathing circuit or a manual resuscitator. Few older designs have clamps or rings with hooks around the connector for harnesses or face straps to be attached (Fig. 18.1).

Masks are made up of either silicone, black rubber (e.g., Connell mask) or transparent plastic. Transparent designs provide advantage over black rubber as the former allows visualization of vomitus, secretions, blood, etc. Exhaled moisture can also be noted through a

Fig. 18.1 Transparent facemasks with hooks

transparent mask that indicates proper mask ventilation.

3.2 Special Masks

Pediatric masks: Pediatric designs require smaller dead space. These can either be round like Ambu-design or the **Rendel-Baker-Soucek** (RBS) design which has a triangular body without any cuff. RBS mask is availible in sizes of 00, 0, 1 and 2 and can be used up to 10 years of age. The sizes 1 and 2 have dead spaces of 4 and 8 mL, respectively. The RBS design can be made of either plastic or rubber. It can also attach pacifiers (Figs. 18.2 and 18.3).

Ambu transparent masks are made of hard plastic that rests on a cushioned seal. There is a thumb rest on the body of the mask (Fig. 18.4). Endomask/Endoscopic masks are designed to allow mask ventilation while an upper GI endoscope is being used. There is a port or a diaphragm in the mask that allows passage of an endoscope creating a seal (Fig. 18.5). Patil Syracuse Mask is an example of endoscopic mask. Endoscopic masks allow use of flexible endoscope guided intubation to be performed uninterrupted while maintaining mask ventilation, by using a swivel connector. Lastly, certain masks come with scented flavor which helps camouflaging the irritant smell of inhalational anesthetics. These masks thus increase patient acceptance particularly in pediatric population.

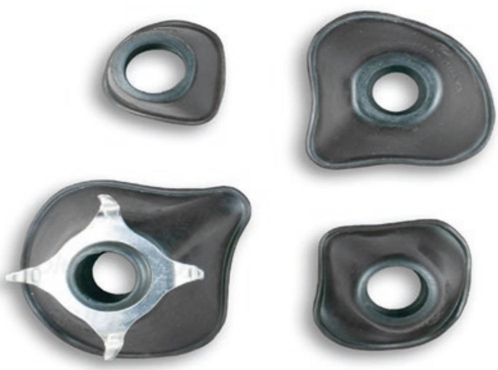

Fig. 18.2 Black rubber RBS mask designs

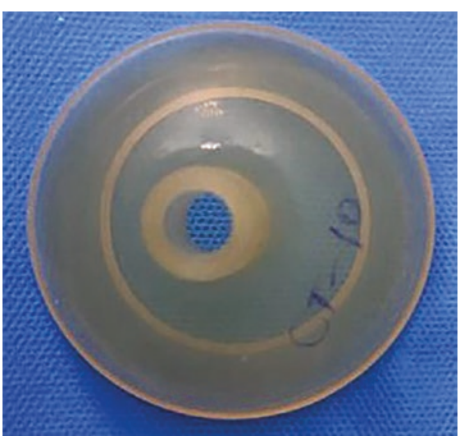

Fig. 18.3 Round bodied transparent pediatric mask

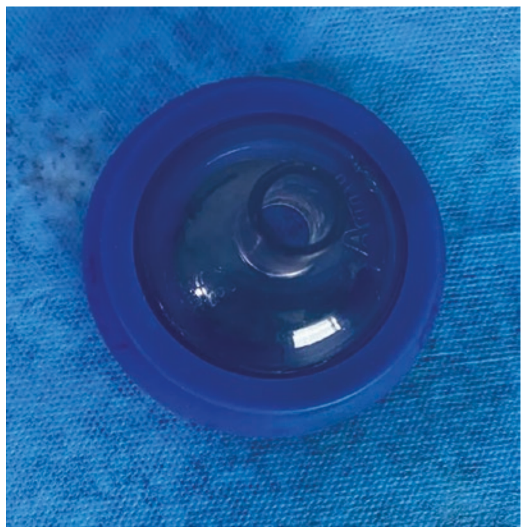

Fig. 18.4 Ambu transparent mask

Fig. 18.5 Endoscopy mask with sealed port for endoscope

4 Techniques of Mask Ventilation [1–4]

4.1 Relevant Anatomy

Upper airway is composed primarily of soft tissue, bordered proximally by the bones and cartilage of the nose and hard palate and distally by the rigid trachea. Unsupported soft tissue that includes soft palate, and pharynx and are prone to collapse, especially when the upper airway dilator muscles such as the genioglossus, levator palati, geniohyoid, etc. are depressed due to loss of consciousness or pharmacologic paralysis. For successful mask ventilation, the generated positive pressure must overcome the critical closing pressure of the collapsed pharynx or the upper airway for the air to reach the lower airways and the lungs. Since a gas (air or oxygen) follows the path of least resistance, positioning the patient and holding the mask are both of immense importance to create a well aligned unobstructed anatomical path of least resistance and prevent any air leak.

4.2 Seal First Versus Maneuver First

The early bag-valve-mask techniques followed the sequence of "*airway maneuver first, seal second*." A two-handed hyperextension of the head allowed the implementation and assessment of the of the airway maneuver before it was converted into a one-handed grip for the seal [5]. This sequence was later replaced by the basic one-hand technique (i.e., "*seal first*" [the "C"], "*airway maneuver second*" [the "E"]) that generated a seal ("snuggly apply the mask") followed by an undetermined airway maneuver ("pull the mandible into the mask"). The early narratives describing the one-hand face mask ventilation weather in emergency medicine, resuscitation, and anesthesia remained imprecise, and without any specific endpoints. This new positive pressure ventilation technique required a perfect seal and an effective airway maneuver which was largely addressed by tightening the ineffective E-C grip and the suboptimal or ineffective airway maneuver was ignored. Two-handed ventilation achieved both an effective seal and airway maneuver together and consistently proved to be better than one handed technique [6].

Usually, bag mask ventilation requires only one person. But in case of difficult mask ventilation two-person bag mask ventilation may be necessary where one person holds the mask making a tight seal and the other one provides ventilation. Rarely the second person can also help in providing chin lift while ventilating with other hand.

4.3 Positioning

Proper positioning is an important prerequisite. Most preferred is sniffing position (lower-cervical flexion and upper-cervical extension) which optimizes conditions for airflow. In obese patients, a head up, supine position is recommended (head elevated laryngoscopy position). Patient is positioned in such a way that an imaginary line passing from the tragus of the patient to the sternal notch is parallel to the table level. Sometimes, mask ventilation may have to be performed in lateral position when the patient cannot lie supine, for example, in a child coming for surgery for lumbar or cervical meningomyelocele.

4.4 Grips

The operator stands on the head end of the patient. A properly held mask allows no or minimal leak while causing minimal fatigue of the operator. The thumb and index finger of the hand are placed on the body of the facemask on either side of the connector. The middle finger is placed on the chin, the ring finger on the mandibular ridge and little finger on the angle of mandible. This is known as the classical **C and E grip** (Fig. 18.6) where the thumb and index finger form the C and the other three fingers form the E. While the C grip helps in maintaining a firm pressure over the nose and chin preventing any

Fig. 18.6 The classical C-E grip

Fig. 18.7 The double C-E grip/claw grip

leakage, the E grip helps in tilting the head backwards, lifting the chin, and pulling the jaw forward (jaw thrust). The latter maneuvers lift the tongue, opens the airway, and aligns it. Positioning maneuvers can reduce upper airway obstruction (Fig. 18.6). The sniffing position and chin lift stent open pharyngeal soft tissue by increasing longitudinal tension. Jaw thrust displaces the mandible increasing the retrolingual and retropalatal spaces. There is a variant of the C-E grip called the **O-E grip** (Fig. 18.6) where the thumb and index finger are kept closer to each other around the connector making almost a circle. This supposedly produces better seal by exerting more downward pressure.

Another one-hand non-E-C technique which has been described is the **chin lift grip** technique [7]. The "chin lift grip" is applied by placing the web space between the thumb and index finger just around the connector with the rest of the fingers placed below the chin. This generates a power grip that controls the whole mask and provides effective seal. The torque that maintained head extension was applied along the sagittal plane with this grip while in the "E-C technique" the torque was off the sagittal plane. The sequence applied in this technique is the "airway maneuver first, seal second." This technique is said to provide effective and easier seal for novice airway managers as with its use ventilatory parameters could be maintained over a prolonged period.

During a difficult mask ventilation often a two-handed mask grip and jaw thrust is required. Thumbs are placed on either side of the body of the mask. The index and other fingers are placed under bilateral mandibular rami. The head is dorsiflexed at the atlanto occipital joint and jaw is lifted anteriorly with a forward thrust on the angle of mandible. This is also called **double C and E grip** (or a two-handed **claw grip**) and the maneuver is known as Esmarch-Heiberg maneuver (Fig. 18.7).

There is another two-handed mask grip called the **V-E grip** (or a two-handed **vice grip**) where the thumbs and thenar eminences are placed over each side of the mask while the second through fifth digits pull the jaw upward.

Two-handed mask holding techniques require an additional operator for providing ventilation. If a ventilator is available (like inside operation theaters), a single operator can maintain a two-handed mask grip while the ventilator might be put on a controlled mode, that delivers the ventilation.

Care must be taken to prevent compression of eyes and other facial structures while mask ventilating. A properly placed face mask fits the bridge of the nose superiorly, the nasolabial folds laterally, and the mental crease inferiorly. The top of a well-seated mask should be slightly inferior to the bridge of the nose to avoid leak into the eyes. Eyes can be covered with soft pads or gauge pieces in an anaesthetized patient to prevent trauma while mask ventilation is being done.

It is important to keep the generated peak airway pressures to less than 20 cmH_2O during mask ventilation to prevent gastric insufflation.

4.5 Ventilation Technique

An adult mask with oxygen supplied at 5–15 L/min and a full reservoir bag can provide up to 1.5 L of oxygen delivered per breath. Mask ventilation should be done with caution and only until chest rise is appreciated to reduce the risk of gastric insufflation, possibly causing vomiting and barotrauma from overdistention. The rate and tidal volume are generated manually and must be matched with the inherent compliance and weight of the patient. If the patient has spontaneous efforts, it is imperative to synchronize the positive pressure with the patient's own efforts. This requires years of practice.

Adequacy of mask ventilation is assessed/indicated by chest rise and fall with each breath, auscultating bilateral air entry in chest, uniform deflation, and reinflation of the reservoir bag with each breath, square wave pattern on end-tidal carbon dioxide monitor (it may not be really square shape when being manually ventilated) and maintenance/improvement/restoration of oxygen saturation.

5 Difficult Mask Ventilation

"The American Society of Anesthesiologists (ASA) Task Force defines difficult mask ventilation as when it is not possible for the unassisted anesthesiologist to maintain oxygen saturation more than 90% using 100% oxygen and positive pressure mask ventilation in a patient whose oxygen saturation was more than 90% before anesthetic intervention; and/or it is not possible for the unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure and mask ventilation" [1, 8]. The incidence of difficult mask ventilation is 1.4% (range 0.9–7.8%) of patients undergoing general anesthesia and 4–11% of patients in the emergency room. The actual incidence in the out of hospital setting is unknown [4].

5.1 Risk Factors of Difficult BMV

Risk factors of difficult BMV include: snoring, obstructive sleep apnea, retrognathia, micrognathia, macroglossia, edentulous state, short thick neck, Mallampati grade 3 and 4, inexperience of the provider, body mass index (BMI) > 26 kg/m^2. BMI itself is not a very useful predictor, but it is a marker of potential oxygenation issues (due to reduced functional residual capacity in the obese) and increased aspiration risk [9]. Obstetric patients also have a higher incidence of difficult mask ventilation.

Hans et al. proposed classification of difficult of mask ventilation into four grades [4]. They are Grade 0: mask ventilation not attempted, Grade 1: ventilation by mask, Grade 2: Ventilation by mask and airway adjunct, Grade 3: Inadequate and unstable mask ventilation even with airway adjuncts requiring more than one providers, and Grade 4: Impossible mask ventilation.

Kheterpal et al. [10] adapted this score in their study and elaborated it to make it more objective. They defined grade 3 as difficult mask ventilation when mask ventilation was inadequate to maintain oxygenation, an unstable mask ventilation, or when mask ventilation requires two practitioners. Grade 4 mask ventilation was defined as impossible mask ventilation distinguished by absence of end-tidal carbon dioxide measurement and lack of any noticeable chest wall movement during attempts at positive pressure ventilation despite the use of airway adjuncts and additional personnel.

The Japanese Society of Anesthesiology proposed the use of three distinct capnography waveforms as a consistent diagnostic tool for evaluating the efficacy of bag mask ventilation during anesthesia: (a) waveform with plateau (expected tidal volume range > 5 mL/kg), (b) waveform with only rapid upswing without plateau (2–5 mL/kg), and (c) lack of any noticeable waveform, meaning apnea or dead space ventila-

Table 18.1 Mask ventilation scale based on end-tidal carbon dioxide

Grade A	Plateau present
Grade B	No plateau, with end-tidal carbon dioxide ($ETCO_2$) greater than 10 mmHg
Grade C	No plateau with $ETCO_2$ less than 10 mmHg
Grade D	No $ETCO_2$

Table 18.2 Anatomical face mask sizes according to age [1]

Age	Mask size
Premature infant	0.00
Newborn to 1 year	0.1
1–4 years	1.2
4–10 years	2
10–14 years, small adults	3
Adults	4
Large adults	5

tion [11]. Recently, Lim and Nielsen have proposed a mask ventilation scale (Table 18.1) based on the best capnography waveform attained with an optimal first attempt wherein the first two reflect effective and adequate ventilation while the last two indicate an inadequate and absent ventilation [12].

There are mnemonics like BONES (beard, obesity or BMI more than 26 kg/m^2, no teeth, elderly or age more than 55 years, snorer) and MOANS (mask seal problems, obesity, advanced age, no teeth, snorer) to predict difficult mask ventilation. While these mnemonics provide a rapid and simple basis of anticipating mask ventilation during assessment of airways of the patients, understanding the etiology of difficult mask ventilation is essential to make the appropriate diagnosis and subsequent management in the emergency [8]. For ease of understanding, clinical predictors for difficult face mask ventilation can be classified into three categories: (a) predictors that expect poor face mask seal (e.g., lack of teeth, presence of beard), (b) increased soft tissue collapsibility (e.g., male sex, age greater than 55 years, increased body mass index, history of snoring/obstructive sleep apnea, Mallampati Class III or IV, airway masses and tumors), or (c) inability to perform an adequate airway maneuver (e.g., acute or chronic cervical spine pathology, history of neck radiation, limited mandibular protrusion) [13, 14].

5.2 Mechanisms of Difficulty in Mask Ventilation

Difficult mask ventilation is caused by one or more of the following mechanisms [4]: low-resistance alternative path due to leak or inadequate seal, increase in airflow resistance along the path to the lungs, decrease in compliance of the lungs and/or chest wall leading to increased distal pressure, and lastly loss of ventilation to the atmosphere as in the case of bronchopleural or broncho cutaneous fistula.

Inadequate seal at the mask-patient interface Improper mask size and shape, facial hair, edentulism, loss of facial fat in old age, retrognathia and other maxillomandibular abnormalities, presence of a nasogastric tube all can lead to inadequate mask seal and leak. In general, increasing the fresh gas flows from the source and two-handed mask grip (described earlier) can help in such situations. An appropriate size and shape of face mask is of prime importance. The smallest face mask suitable should be used to reduce dead space. A rough estimate of appropriate sizes of facemask is provided in Table 18.2. If an inadequate face mask seal persists despite optimization strategies, alternative mask-patient interfaces like a nasal mask or a toddler-sized mask can help. It is held with the lower border resting above the patient's upper lip can provide adequate seal if the mouth of the patient is occluded manually or with gauze piece.

Facial hairs can be trimmed, but if undesired by patients can be covered with gauze pieces or occlusive dressings like Tegaderm (St. Paul's, Minnesota). Edentulism leads to loss of buccinator muscle mass and bone atrophy which creates a gap between mask and cheeks. Placing gauze pieces to seal the gap or even placing intraoral gauzes to recreate fullness of the cheek can help.

In such cases care must be taken to prevent aspiration of these foreign bodies (gauge pieces). Placing the inferior aspect of the mask inside the lower lip on the lower alveolar ridge can also help. Artificial dentures, if left in place, can provide better anatomical foundation for proper mask fit as compared to mask fit after removing these dentures. But care must be taken not to injure them and iatrogenically cause a foreign body aspiration.

In maxillomandibular abnormalities, seal cannot be achieved often despite best efforts and use of airway adjuncts are often indicated. Early use of a supraglottic device instead of heroic mask ventilation effort for oxygenating or ventilating the patient before intubation can be life-saving.

Increased airway resistance This is most caused by upper airway or supraglottic abnormalities like adenotonsillar hypertrophy, intraoral mass, neck or cheek mass compressing on the airway, redundant soft tissue in OSA patients and obese patients, and dynamic pharyngeal tube closure (due to light anesthesia, laryngospasm, opioid induced vocal cord closure), etc. Lower airway pathologies like foreign bodies, mucous plug and secretions, tracheal stenosis, tracheomalacia, airway or mediastinal mass, and bronchospasm can also increase airway resistance and each of these pathologies have specific management.

Positioning maneuvers as described before are best to overcome increased upper airway resistance. Frequently an exaggerated head tilt is utilized in these circumstances. The use of airway adjuncts often help but must be placed cautiously in case of intraoral mass like tonsils and tumors which can bleed due to inadvertent injury. Selecting a properly sized nasopharyngeal airway or oral airway is also important as an extra-large artificial airway can posteriorly displace the epiglottis or enter the esophagus while a smaller airway may not relieve the obstruction or even increase it by posteriorly displacing the tongue. Nasal mask ventilation as opposed to combined oral and nasal mask ventilation, as described before, can anteriorly displace the tongue, and provide better ventilation in these scenarios.

Reverse Trendelenburg position can pull down the diaphragm and trachea and keep the collapsible pharynx stented. It also helps in decreasing the overall resistance to ventilation. Upper airway collapse can also be overcome by using continuous positive airway pressure (CPAP) of 5–10 cmH_2O which stents open the patency of the airway and is widely used while mask ventilating obese and OSA patients. In case of dynamic pharyngeal tube closure deepening the anesthetic plane and inducing pharmacological paralysis can improve the mask ventilation. The age-old practice of assessing adequacy of mask ventilation before using muscle relaxant is rather questioned in such circumstances and delaying its administration may introduce unnecessary risk. Currently, the administration of muscle relaxant in cases of suspected difficult or impossible mask ventilation remains controversial as the fear that the patient may not regain spontaneous respiration before life threatening hypoxemia ensues remains. With only rocuronium can be a rational choice of muscle relaxant in such situations that too only if its reversal agent sugammadex is available since the latter can reverse effects of rocuronium within minutes.

Management of infraglottic causes of increased airflow resistance is etiology specific. Airway secretions can be suctioned, foreign bodies can be removed with flexible or rigid bronchoscopy or, in the setting of complete airway obstruction, may need to be pushed distally into a smaller branch of the airway. Bronchospasm is treated with beta-agonists such as salbutamol, increased concentrations of volatile anesthetics, or increased PEEP. Tracheomalacia, tracheal stenosis, and airway or mediastinal tumors are traditionally managed by maintaining spontaneous ventilation and appropriate positioning, although CPAP may also help by increasing luminal pressure and lung volume. In the case of a fixed obstruction, like a thyroid mass increasing the driving pressure and lengthening inspiratory time assist in ventilating past the obstructions. These patients are often able to breathe with only minimal difficulty before induction of anesthesia, but as lung volume is reduced, partial occlusion of the lower airway becomes complete obstruction. Preoperative examination should identify the position in which the patient is able to breathe most easily. The patient should be placed in this rescue position if impossible ventilation develops after induction. Manual elevation of the mass if possible, should be tried early in such scenarios. In some cases, a rigid bronchoscope may be required to bypass the obstructed segment.

Decreased distal compliance Decreased compliance of the lungs and chest wall causes difficult mask ventilation by increasing distal pressure, which decreases the driving pressure gradient. This may be caused by inadequate depth of anesthesia or inadequate paralysis, obesity, restrictive lung disease (kyphoscoliosis, acute respiratory distress syndrome, intra-abdominal hypertension due to ascites, and tension pneumothorax). Appropriate anesthetic depth or paralysis should be ensured. Provision of higher inflation pressures may be needed to ventilate appropriately but care must be taken to prevent gastric insufflation or leak at the mask-patient interface. Large ascites must be drained preoperatively. Identification of a developing tension pneumothorax during mask ventilation requires a high index of suspicion and must be treated with emergency needle decompression because large positive pressure may worsen the condition.

In the past, irrespective of the cause, in situations where mask ventilation failed, efforts were made for achieving rapid sequence intubation to secure the airway and oxygenate the patient before dangerous hypoxemia ensued. With the advent of laryngeal mask airways and other supraglottic devices these unanticipated intubations in haste can be avoided and ventilation or oxygenation can be maintained with these supraglottic devices whenever mask ventilation fails. However, any difficult mask ventilation should keep the provider cautious of possible catastrophe and appropriate help must be obtained without delay. All difficult airway algorithms are designed accordingly, and institutions must develop their practices according to these guidelines.

The causes of difficult mask ventilation that have been discussed above have been summarized in Table 18.3 and methods to overcome them have been summarized in Table 18.4.

Table 18.3 Causes of difficult mask ventilation

Inadequate seal	Increased airway resistance	Decreased distal compliance
Improper mask size or shape	*Upper airway*	Restrictive lung diseases (Fibrosis, ARDS, pulmonary consolidation, Kyphoscoliosis, etc.)
Edentulism	Adenotonsillar hypertrophy	Tense ascites
Facial hair or beard	Obesity or redundant soft tissues like in OSA patients	Pneumothorax
Maxillomandibular deformities	Oropharyngeal mass	Inadequate anesthetic depth
Nasogastric tube	Neck mass or hematoma	Obesity
	Laryngospasm	Intra-abdominal hypertension
	Inadequate depth of anesthesia	
	Lower airway	
	Secretions	
	Foreign body	
	Anterior neck mass	
	Tracheal stenosis	
	Tracheomalacia	
	Bronchospasm	
	Excess cricoid pressure	

Table 18.4 Methods to overcome difficulty of mask ventilation

Inadequate seal	Increased airway resistance	Decreased distal compliance
Increase gas flows	*Upper airway*	Ensure adequate anesthetic depth and muscle paralysis
Select proper sized and shaped mask, use alternate size or design	Position the patient properly	Use higher driving pressures
Try two-handed mask seal/ alternative grip	Reverse Trendelenburg position	Reverse Trendelenburg position
Keep artificial dentures in situ, pack cheeks with gauze piece, pull cheek anteriorly	Use airway adjuncts	Drain ascites, treat pneumothorax emergently
Shave facial hair, occlude beard	Use CPAP, higher driving pressure	
Remove nasogastric tube	Deepen anesthetic plane, use relaxants	
	Lower airway	
	Suction airway, remove foreign body or push distally into smaller airway, treat bronchospasm, lift a neck mass, etc.	

5.3 Ventilation in Broncho Cutaneous and Bronchopleural Fistula

In patients with a broncho cutaneous or bronchopleural fistula, positive pressure ventilation leads to air leakage and potential hypoxemia. In the former condition, sealing the cutaneous opening of fistula and using lowest possible airway pressures during ventilation is the recommended technique. Omori et al. described a case of right upper lobar broncho cutaneous fistula scheduled for esophageal reconstruction [15]. They covered the broncho cutaneous fistula with gauze and film prior to anesthesia induction to prevent air leakage. Subsequently mask ventilation was performed with a limited peak airway pressure of 10 cmH_2O. A left-sided double lumen endobronchial tube (DLT) was inserted into the right mainstem bronchus, thereby occluding only the right upper lobe bronchus, and two-lung ventilation could be easily performed without air leakage through the fistula.

In patients with bronchopleural fistula, ventilation of an open airway is an important concern and prompt lung isolation is vital to minimize the risk of ventilating the pleural cavity. It is paramount to avoid positive pressure ventilation if feasible until the lung with air leakage has been isolated by avoiding muscle relaxant and maintaining spontaneous ventilation while securing the airway [16]. Standard relaxant technique has been used clinically while maintaining lower mean airway pressures (below the critical opening pressure of the fistula) during bag mask ventilation [17, 18]. It should be ensured that the chest tube is working prior to intubation to avoid possibility of tension pneumothorax.

6 Complications of Mask Ventilation

They include gastric insufflation, injury to eye and other facial structures, pressure injury to facial skin and acute transient sialadenopathy due to compression of salivary ducts during prolonged periods of mask ventilation [9, 10]. Impossible mask ventilation has an incidence of 0.15% as found in a large series by Kheterpal et al. [10]. In 25% of these cases, patients were also difficult to intubate. Tuncali et al. [19] reported a case of bilateral mandibular nerve injury following a short period of bag mask ventilation, which they proposed was likely the result of use of a semi-silicone facemask with an over-inflated cushion. The authors concluded that an over-inflated sealing cushion of a facemask may lead to difficult mask ventilation which in turn may lead to mandibular nerve injury. They suggested that when airway maintenance requires application of high degree of pressure on mandible, an alternative airway management technique such as laryngeal mask airway should be considered [19]. The mechanism of acute sialadenitis has been suggested to be increased airway pressure (during ventilation with a facial mask) combined with muscle relaxation which may cause air to enter the parotid gland orifice and obstruction of the excretory ducts [20].

7 Use of Ultrasound

Ultrasound assessment is now a well-established method to predict difficult airway. Most of the studies aim at assessing the thickness of the soft tissues of the neck at different levels of the airway and have been mostly carried out to predict difficult laryngoscopy and intubation [21, 22]. Still, data suggests that increasing skin to hyoid bone thickness also called depth of skin to hyoid bone (DSHB) correlates with increasing difficulty of mask ventilation (Fig. 18.8) [22]. However, no specific cut off value has yet been established to differentiate between easy and difficult mask ventilation.

8 Conclusion

The art and science of mask ventilation can be summarized with a list of Do's and Don't.

The Do's are: Practice mask ventilation regularly on mannequins. Always assess difficulty of mask ventilation while evaluating airway of the patients. Consider addressing potentially reversible causes of difficult mask ventilation in the preoperative period itself. Always call for help. Keep different size and shape of facemasks, artificial airways/ adjuncts, supraglottic devices prepared whenever feasible. Offer a more experienced operator to intervene in case of difficulty or fatigue. Lastly, use airway adjuncts early whenever difficulty is faced.

Always remember not to (1) underestimate the possibility of potential catastrophe in case of difficult mask ventilation, (2) use improperly sized

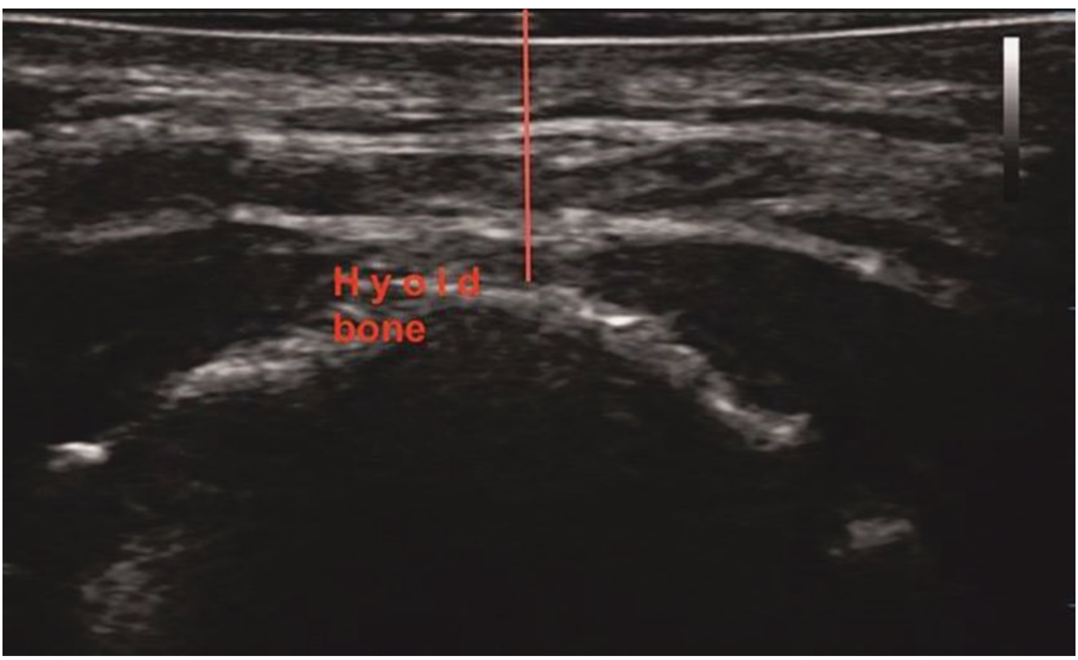

Fig. 18.8 Ultrasound of neck at the level of hyoid showing the vertical distance from skin (red line)

adjuncts in absence of proper size, and (3) wait for oxygen saturation to go down before using alternative methods.

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