41 Complications of Airway Management

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Ultimate goal of airway management is oxygenation of the patient and not placement of an endotracheal tube

—Benumof

Abbreviations

ANTS	Anesthetic non-technical skills
ARDS	Acute respiratory distress syndrome
ASA-PS	American Society of Anesthesiologists-Physical Status
CPAP	Continuous positive airway pressure
DAS	Difficult airway society
ED	Emergency department
EMG	Electromyogram
ETT	Endotracheal tube
HFNC	High flow nasal oxygen
ICU	Intensive care unit
LMAP	Laryngeal mask airway protector
NAP4/5	4th/5th National Audit Project
NIV	Non-invasive ventilation
OR	Operating room
POST	Post operative sore throat
RSI	Rapid sequence intubation
SAD	Supraglottic airway device
SLMA	Laryngeal mask airway supreme
SpO_2	Oxygen saturation
THRIVE	Transnasal Humidified Rapid Ventilatory Exchange

Key Messages

1. Complications during airway management can vary from mild trauma to hypoxia and death. The priority should be oxygenation and not endotracheal intubation.
2. Manipulation of airway can lead to multiple systemic manifestations, which can range from mild tachycardia to cardiac arrest.
3. Awareness of the need to restrict the number of attempts to secure the airway and calling for additional help will prevent many of the airway complications.
4. Non-operating room locations airway management are associated with high risk of airway complications.
5. Reduction in airway complications requires continuous, multi-pronged quality improvement measures.

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1 Introduction

Basic goals of airway management are related to oxygenation, ventilation, and airway protection [1]. Any complication arising because of airway management can have deleterious local or systemic effects, which must be addressed at the earliest to prevent further deterioration.

Airway related causes are responsible for 8% of anesthetic deaths as reported by American Society of Anesthesiologists (ASA) with hypoxia and aspiration being the leading causes [2, 3]. Airway related complications could occur in any location of the hospital, e.g., operation room (OR), intensive care unit (ICU), or emergency department (ED). Higher incidence is reported in female patients, elective surgeries, and outpatient procedures [4]. Patients with difficult airway have higher risk of complications, but the overall percentage of difficult airway cases being relatively small, higher incidence of complications are reported among patients with an easy airway [3].

In the Fourth National Audit Project (NAP4), total cases reported from the OR, ICU, and ED were 184 and major complications included death, brain damage, need for emergency surgical airway, unanticipated ICU admission or prolongation of ICU stay (Table 41.1) [5].

Following this report, NAP4 audit facilitated several changes in the practice of airway management, such as inclusion of capnography at all stages of securing the airway and training of nursing and junior staff in airway management [6]. Cardiac arrest following emergency endotracheal intubation in non-OR setting was found to be 1.7–23% by Marin [7]. The risk factors identified were pre-intubation hypoxemia, hypotension, shock index, body mass index (BMI), age, and number of intubation attempts. Morbid obesity was associated with a higher incidence of difficult mask ventilation than difficult intubation [8]. Study of obese patients showed increased rates of severe hypoxemia (39%), cardiovascular collapse (22%), cardiac arrest (11%), and death (4%) when they were intubated in ICU, compared to those who were intubated in the operation theater [9].

Airway complications were recorded in 4.2% in emergent non-operative intubations with 2.8% aspiration, 1.3% esophageal intubation, 0.2% dental injury, and 0.1% pneumothorax [10]. As a complication of increased number of intubation attempts Jaber reported death in 0.8% of patients in the ICU [11]. Mort observed significantly higher airway related complications and cardiac arrests with the increase in number of laryngoscopic attempts [12]. Modern technological advancements including novel oxygenation methods, second-generation supraglottic airway devices (SAD), and use of advanced gadgets like videolaryngoscopes have significantly reduced airway related complications [13].

The factors responsible for various complications are summarized in Fig. 41.1. However, each complication can be caused by a single factor or multiple factors. Human factors in the form of inadequate knowledge and skill, lack of communication, and negligence are given importance in recent times and methods to prevent such factors are emphasized through various training modules. Excessive stress of the airway operator must be taken into consideration to minimize the complications. Patient factors responsible for airway complications can be both anatomical and physiological. Adequate preoperative evaluation, planning, preparation, and proper management can reduce the incidence of complications. Surgical factors include head and neck surgeries and most often when the airway is shared, e.g., oral, or laryngeal surger-

Table 41.1 Major complications reported in the NAP4 audit

	Anesthesia related	ICU	ED
Total cases reported	133	36	15
Death	16	18	4
Brain damage	3	4	1
Emergency surgical airway	58	12	10
Unanticipated/prolonged ICU stay	100	12	10

ies, the complications must be anticipated. Drugs, which can cause hyper reactivity of the airway, e.g., atracurium, in susceptible individuals can give rise to complications. The anticipated airway complications must be explained to the patient and patient bystanders and informed consent must be obtained to go ahead with the procedure.

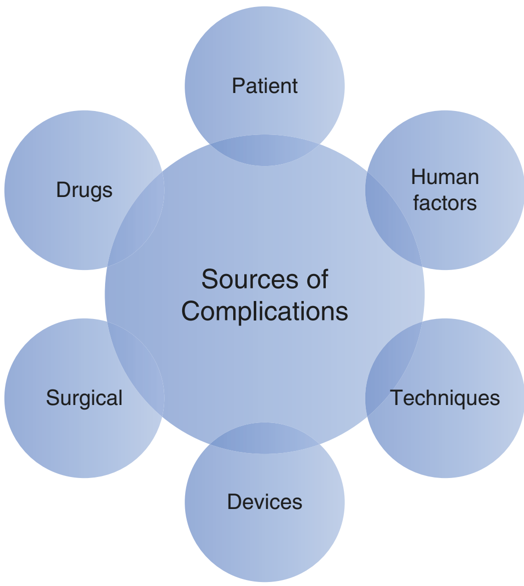


Fig. 41.1 Factors responsible for complications during airway management

2 Hypoxia

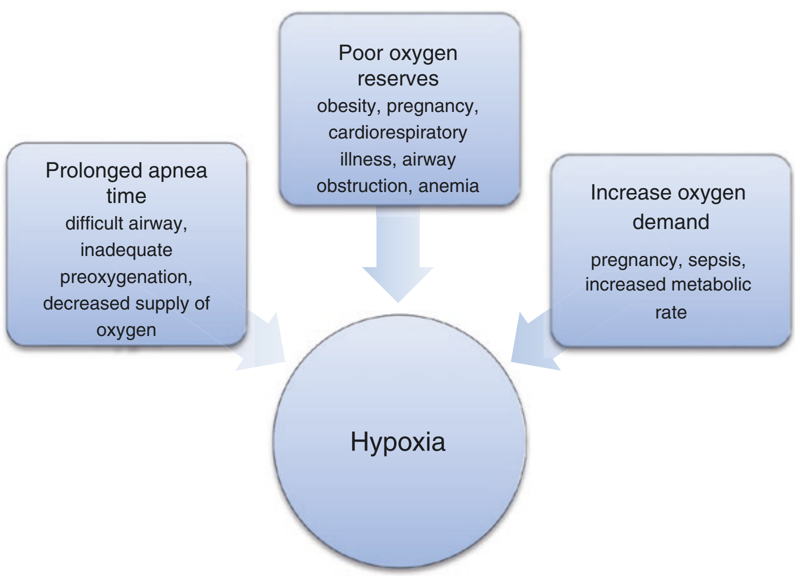
Hypoxia is a major complication of airway management and a leading cause of morbidity and mortality. Failed and difficult tracheal intubations are the main causes of hypoxia during airway management. However, hypoxia can also occur during extubation and all necessary precautions should be taken, especially in high-risk cases. Hypoxia during airway management and maintenance is rare in OR (1:180,000), compared to ICU (50–60 times higher) or ED (30 times higher) [5]. Hypoxia is the most common complication observed during airway management in the ICU and is most often associated with cardiac arrest.

2.1 Risk Factors

Hypoxia can be the result of single factor or combination of factors as shown in Fig. 41.2.

Predictors of high risk of hypoxia include anatomical or physiological difficult airway, risk of aspiration, pregnancy, obesity, increased oxygen consumption, and specific requirements of airway management such as double lumen tube insertion. In the event of “cannot intubate cannot oxygenate” (CICO) situation, early decision to

Fig. 41.2 Risk factors for hypoxia during airway management



perform emergency front of neck access (eFONA) will reduce the complications of hypoxia and subsequent arrest. Hypoxia after endotracheal intubation may be the result of hypoventilation, worsening cardiac shunting, inadequate inspired fraction of oxygen (FiO_2), endobronchial intubation, aspiration, tube dislodgement or pulmonary edema. In elderly patients, lung volumes are reduced, causing ventilation–perfusion mismatch, reduced pulmonary reserve, and poor oxygen uptake in the lung [14].

Postoperative hypoxia may be the result of inadequate minute ventilation, hypo or hyperventilation, airway obstruction due to laryngeal edema, laryngospasm, postobstructive pulmonary edema, residual neuromuscular blockade, shivering, inhibition of hypoxic pulmonary vasoconstriction, mucociliary dysfunction and a possible decrease in cardiac output. Patients with hyperactive airways and smokers may be prone for spasm of the respiratory tract. Upper airway obstruction may occur in cases of laryngospasm, laryngeal edema, hemorrhage, trauma, and vocal cord paralysis/dysfunction [15].

In pregnancy, desaturation during apnea develops more rapidly because of the limited oxygen reserve and increased oxygen demand. Hence, preoxygenation with increased oxygen flows up to 10 L/min can delay the time for desaturation [16].

Most of the studies have proved that basal oxygen saturation at the time of induction, provider expertise, and acute respiratory failure as the indication for intubation were found to be the major risk factors for hypoxemia during airway management in ICU; a higher oxygen saturation (SpO_2) during induction was associated with better oxygenation [17, 18]. Other risk factors associated with hypoxia during airway management in the ICU include difficult airway, obesity, pregnancy, uncooperative patients, and mechanical obstruction to preoxygenation or endotracheal intubation. Severe hypoxemia was observed in 26% and 1.6% sustained cardiac arrest during intubation attempts in ICU. These results are due to a combination of intrapulmonary shunt, low cardiac output, anemia, hypermetabolic state, and apnea or hypoventilation in ICU patients [11].

2.2 Management and Prevention of Hypoxia

Avoidance of hypoxemia while securing the airway is the goal and is a frequently used endpoint as well [19]. History and examination of the patient for any predictors of difficult airway, systemic examination for conditions like respiratory and cardiac illness that could compromise the oxygenation, help in safe airway management by way of better planning, selection of appropriate equipment and smooth execution of techniques could reduce the incidence of hypoxia. In an emergency, where time for assessment is limited due to actual or potential deterioration requiring immediate endotracheal intubation, a quick judgment and decision of the operator by observation could reduce the risk of hypoxia.

Technical mishaps that are preventable like failure to switch on the oxygen supply should be overcome by following a systematic checklist prior to airway management procedure and constant vigilance. The ABCD approach adopted in the airway algorithms should be changed to "OABCD" where oxygenation is given prime importance to prevent hypoxia and the associated complications [13].

Various preoxygenation techniques used to prevent drop in oxygen saturation are through mask ventilation, apneic oxygenation techniques, and non-invasive ventilation (NIV) using continuous positive airway pressure (CPAP). High flow nasal cannula (HFNC), which can deliver up to 60 L/min of oxygen added with NIV, prolonged desaturation time during airway management of critically ill patients as demonstrated by Jaber et al. [20]. However, preoxygenation for a prolonged period, i.e. more than 4 min was associated with increased incidence of desaturation in ICU [21]. Apneic oxygenation techniques using nasal cannula [22] and Transnasal Humidified Rapid-Insufflation Ventilation Exchange (THRIVE) [23] has been proven to be very effective in preventing desaturation during emergency intubations. Humidification and warming of inspired oxygen help to prevent the side effects of headache, dryness, and nasal irritation, risk of bleeding is high with conventional cold and dry oxygen supplementation. A nasal cannula that is easily available can be placed under the facemask with oxygen on flow during mask ventilation but is contraindicated in skull base fractures [24]. Peroxygenation is the process of administration of oxygen from the time of anesthetic induction till the airway is secured by either a SAD or endotracheal tube (ETT). This is recommended in all patients undergoing general anesthesia and particularly in the presence of difficult airway, obesity, critical illness, sepsis, and pregnancy. This simple and universally adaptable technique of prolonging safe apnea time include the use of a nasal cannula at a flow of >15 L/min or buccal oxygenation [13].

During intubation, optimizing the patient position to semi-sitting or reverse Trendelenburg in spine trauma patients improves oxygenation [25–27]. Similarly, head up position is beneficial in obese patients and parturients. High dose rocuronium (1.2 mg/kg) provides longer and safer apnea time than succinylcholine due to the absence of fasciculation induced oxygen consumption. Presence of a senior experienced anesthesiologist or a consultant experienced in surgical airway techniques in cases of anticipated difficult airway along with appropriate equipment can decrease the incidence of hypoxemia. Knowledge and the willingness of the operator to follow the airway management guidelines in the critical setting can prevent hypoxia to a great extent. Awake fiberoptic intubation may be the preferred choice of securing the airway in morbid/super morbid obese patients (BMI >50 kg/m^2) especially when associated other factors contribute for worsening of hypoxia [28].

In ICU clearing of the lower airways by preinduction physiotherapy, recruitment maneuver by increasing the inspiratory pressure for 30–40 s, delayed sequence induction [29] using low dose ketamine (1–2 mg/kg in 0.5 mg/kg divided doses) for facilitating preoxygenation followed by regular induction and muscle relaxant are additional strategies to prevent hypoxia during intubation. During contemplation of securing the airway in critically ill hypoxemic patients, further hypoxic contributions by other factors like low cardiac output should be taken care of [30]. Pre-intubation optimization of hemodynamic status and cardiac function also help in reducing the risk of hypoxia in such patients.

3 Aspiration

Mendelson, in 1946, described the concept of aspiration pneumonitis in pregnant women under anesthesia [31]. In the NAP4 report, pulmonary aspiration of regurgitated gastric contents was reported to be 17% and 5% as the primary and secondary adverse event, respectively, and accounted for 50% of anesthesia related deaths and in the ICU incidence was found to be 5–15% [32].

50% or less of aspiration occurs during anesthetic induction and intubation. However, aspiration can also occur before induction due to excessive sedation, during maintenance or during extubation [33]. Aspiration was the contributory factor in many of the adverse events that occurred during emergence and recovery in the NAP4 audit. It also proved that aspiration often occurred as a result of poor judgment, failure to recognize the risk of aspiration and modify anesthesia technique as per the situation [34]. Use of first generation supraglottic airway devices (SAD) in obese and high risk for aspiration patients was the main cause for inadequate ventilation and aspiration. Aspiration of solid substances can cause physical obstruction whereas acidic gastric fluid aspiration causes pneumonitis like features; increase risk of mortality and morbidity is seen with increase in volume and acidity of aspirated material [34, 35].

3.1 Risk Factors

Risk of aspiration was higher in patients posted for emergency surgeries and in patients with higher American Society of Anesthesiologists-physical status classification (ASA-PS) [36]. Each risk factor may individually increase the risk of aspiration or there could be combination of multiple risk factors as shown in Fig. 41.3.

Risk of aspiration is highest in extremes of age. Ollson and colleagues reported an increased incidence of aspiration in patients with difficult airway [37]. Among parturients; maternal obesity, polyhydramnios, and multiple pregnancies contribute to increased risk of aspiration. Patient factors responsible for aspiration are as shown in Fig. 41.4. Emergency procedures, laparoscopic surgery, bariatric surgery, and upper abdominal surgery are among the surgical risk factors [38]. First generation SAD and uncuffed tubes are the devices more commonly associated with aspiration. However, cuffed endotracheal tubes and tracheostomy tubes provide no absolute protection against micro aspiration. Lighter planes of anesthesia, multiple intubation attempts, prolonged positive pressure mask ventilation, and incorrect placement of airway are other anesthesia related factors contributing to aspiration [37]. Anesthetic drugs contributing to aspiration by reducing the lower esophageal sphincter tone are propofol, volatile anesthetic agents, β agonists, opioids, atropine, thiopental, and glycopyrrolate [39]. Obtunded laryngeal reflexes, residual neuromuscular blockade, and centrally depressed cough reflex in the postoperative period are also risk factors for postoperative aspiration. Topical anesthesia, including airway blocks, applied to the larynx to suppress intubation response will further compromise the cough reflex leading to aspiration. Anesthesia provider expertise in terms of knowledge and experience to handle the airway and prevent aspiration were also implicated in the study done by Nafiu [40].

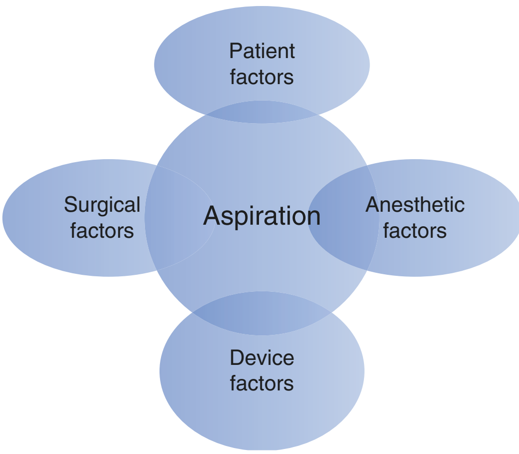


Fig. 41.3 Risk factors for aspiration

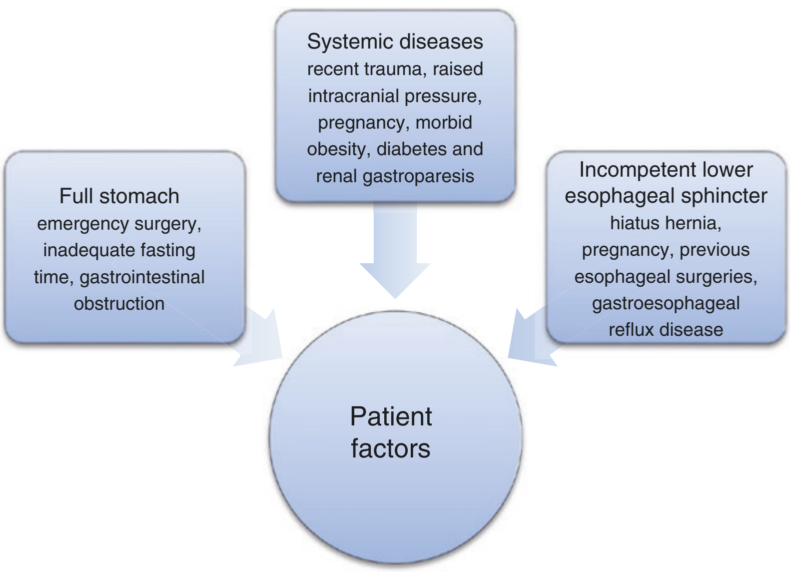


Fig. 41.4 Patient factors responsible for aspiration

3.2 Methods to Prevent Pulmonary Aspiration

Presence of an experienced anesthesiologist for high-risk cases is critical for prevention of aspiration [41]. Also of importance is adhering to fasting guidelines, pharmacological prophylaxis, specialized induction techniques, and use of cuffed ETT. In patients with difficult airway and increased risk of aspiration awake tracheal intubation with adequate psychological preparation, use of intravenous (IV) antisialogogues to dry up secretions, judicious use of IV sedation, and application of topical anesthesia on the upper airway is beneficial. Preoperative ultrasonography to determine the gastric volume and contents may prove advantageous to detect high-risk patients for aspiration [42]. Preinduction gastric emptying by aspirating through the nasogastric tube is helpful to reduce the aspiration risk.

- Fasting guidelines as per ASA guidelines [43] updated in 2017
  - Clear liquids—2 h
  - Breast milk—4 h
  - Solid food, infant formula, and non-human milk—6 h
  - Fried and fatty food—8 h

3.2.1 Aspiration Prophylaxis

ASA does not recommend the routine use of drugs for aspiration prophylaxis but is useful in patients with high risk for aspiration, such as full stomach, symptomatic gastro-intestinal reflux disease, hiatal hernia, presence of nasogastric tube, morbid obesity, diabetic gastroparesis, and pregnancy [44]. Prophylaxis aims to decrease the gastric volume and increase the gastric fluid pH.

Aspiration prophylaxis agents are used alone or in combination. Commonly used drugs are nonparticulate antacids-30 mL of 3% sodium citrate and promotility drugs-metoclopramide, H_2 receptor antagonist-ranitidine. These drugs can be given individually or in combination.

3.2.2 Rapid Sequence Induction (RSI) and Intubation

RSI was first described in 1970 for patients who are prone for aspiration [45]. The objective is to cause mechanical obstruction for regurgitation and to rapidly place a cuffed ETT.

After preoxygenation, cricoid pressure (described by Sellick as Sellick's maneuver in 1971) of 10 Newtons is applied and following the administration of IV induction agent it is increased to 30 Newtons [46]. A rapid bolus dose of succinylcholine 1.5 mg/kg is given IV and without positive pressure ventilation, intubation is attempted with a cuffed endotracheal tube. When succinylcholine is contraindicated and with the introduction of sugammadex, non-depolarizing muscle relaxants like rocuronium 1–2 mg/kg or vecuronium 0.3 mg/kg can be used. The pressure is released only after the cuff of the ETT is inflated and then positive pressure ventilation is initiated.

Modification of RSI (mRSI)

Changes in mRSI include gentle mask ventilation with inspiratory pressure of <20 cm of H_2O in addition to cricoid pressure in patients who are at risk for hypoxia.

Controversies

Some studies suggest that cricoid pressure decreases the lower esophageal tone, thus increasing the risk of aspiration [47]. Lateral displacement of the esophagus is demonstrated on magnetic resonance imaging studies rather than compression of the esophagus. Difficulties in mask ventilation, visualizing the cords or endotracheal intubation are other complications, thereby prolonging intubation time and increasing the risk of hypoxemia and aspiration. Current status is to use mRSI when indicated, and to reduce or release the cricoid pressure if there is interference in insertion of airway device or ventilation or both.

3.3 Management of Pulmonary Aspiration During Airway Manipulation

High degree of suspicion, immediate recognition, and quick and appropriate response are the essentials of managing aspiration while securing the airway or during extubation. If regurgitation or pulmonary aspiration is suspected or diagnosed, a thorough suction of the oral cavity and pharynx is done immediately. Trendelenburg position with patient in lateral position, or head turned to one side will prevent further aspiration. When severe aspiration is suspected early intubation and ventilator support is the only option. Flexible bronchoscopy is an important adjunct for orotracheal and endotracheal suctioning; rigid bronchoscope may be beneficial in aspiration of solid particles.

For milder forms of aspiration in awake patients who do not improve with oxygen supplementation, continuous positive airway pressure (CPAP) up to 12–14 mmHg can be administered. In obtunded patients, mechanical ventilation with positive end expiratory pressure (PEEP) is the preferred choice.

Despite these measures if hypoxemia persists with bilateral lung infiltrates, management is similar to that of acute respiratory distress syndrome (ARDS). Studies have proven that corticosteroids have no role in the treatment of aspiration [48].

4 Prolonged ICU Stay

Patients requiring emergency endotracheal intubation were found to have prolongation of ICU stay as compared to the other population in ICU. Coexisting medical disorder that is responsible for the requirement of securing the airway [sepsis, obstructive sleep apnea (OSA)], complications of these disorders and the surgeries undergone by the patient are the major factors concerned with the duration of ICU stay [49]. Complications such as hypoxia, aspiration, and trauma to the airway that occur during airway management are few important causes that prolong ICU stay. Aspiration can lead to dangerous pneumonias and trauma can cause mediastinitis that can be resistant to treatment and require prolonged ventilation. Complications during FONA can lead to infections and various fistulae, which need systematic nursing in the ICU or ventilatory support. Difficult airway patients requiring multiple attempts and techniques, precipitation of hypotension, arrhythmias, and cardiac arrest during induction and intubation can significantly contribute to the prolongation of ICU stay.

5 Death

Hypoxia is the common cause of airway related deaths. Although the death rate due to anesthesia complications has significantly decreased over the past few decades (3.6/10,000 pre 1970 to 0.3/10,000 after 1990), the exact proportion of these deaths related to airway is unknown [50]. Mortality rates as high as 46% has been reported in emergent intubations [51].

However, in a study by Irita et al., cardiac arrest was reported in 100/million anesthetics and airway complications and aspiration accounted for 11% of the events [52]. Cardiac arrest during airway management could be the result of difficulty in securing the airway resulting in hypoxia or due to underlying comorbid causes precipitating the catastrophic event. Accidental unrecognized complications leading to mortality during airway management include esophageal intubation, ETT kinking, obstruction by mucus, blood, secretions, gastric content aspiration, cuff herniation, and errors in oxygen supply. Most of these fatal complications are likely to occur in a novice trainee who lack the knowledge and skill of providing patient care during crisis [53]. Development of novel training programs, preprocedural checklist, and care bundle for preprocedural evaluation and post-event debriefing will improve outcomes [54].

6 Trauma to the Airway

Endotracheal intubation associated with airway injury has acute and chronic sequelae. It could vary from mild soft tissue injury to laryngotracheal stenosis or tracheoesophageal fistulae [55]. Incidence of airway injuries during airway management is 0.5–7% [10]. Anatomical and pathological obstruction to airway increases susceptibility to injury, worsening already existing difficult airway situation. Bleeding from the injured site and ensuing edema further compromises the airway leading to total loss of airway, emergency surgical airway or severe hypoxia. Soft tissue hematoma, lacerations, arytenoid dislocations, vocal cord paralysis, hoarseness or loss of voice are the consequences of airway injuries that can occur during airway management.

Risk factors for injury to the airway include difficult airway, emergency airway management, skill and experience of the operator, cuff pressure and volume, number of attempts, absence of an experienced anesthesiologist, location of emergency airway management (patients in the ward have higher incidence than in the ICU) [51], comorbidities like hypertension, liver or kidney disease, gastroesophageal reflux disease, and diabetes mellitus (due to poor tissue perfusion, necrosis, and ulceration) [56].

6.1 Soft Tissue Injury

Epistaxis due to soft tissue injury of the nose can occur during nasopharyngeal airway insertions or nasotracheal intubations, which can be self-limiting or life-threatening. Large hematomas can cause devascularization injury of the cartilages [55]. Forceful insertion of the nasotracheal tube can cause accidental avulsion of the turbinates and posterior pharyngeal wall lacerations. Pressure necrosis of the alar tissue and sinusitis due to obstruction of the sinus opening can result from prolonged nasotracheal intubation. Preventive measures include proper use of lubricants, nasal decongestants, and warming of the nasotracheal tube before insertion. Management of mild injury like abrasion is conservational, with observation for excessive bleeding. Otolaryngologist consultation is advisable for more serious injuries [57].

Injury to the lips, buccal mucosa, tongue, floor of the mouth and palate are commonly seen during laryngoscopy, oral intubation, oral airway, and supraglottic airway insertion. Hematoma, if present should be observed, as it can be a major cause for airway obstruction.

Direct trauma on the larynx and vocal cords may cause sore throat, dysphagia, hoarseness of voice, vocal cord fatigue and granulomas, erythema, ulceration and rarely aspiration. Perforation of the larynx, trachea, and esophagus is a major complication and risk of death is 15–20%. Oropharyngeal perforations can lead to a rare complication of mediastinitis as well as subcutaneous emphysema [58]. Early diagnosis and immediate surgical consultation is advised.

6.2 Dental Injury

Risk of fracture, dislocation, or avulsion of one or more teeth is higher in patients with poor quality dentition, artificial dentures or difficult airway. Injury can occur during intubation or removal of endotracheal tube, and insertion or removal of oral airways or SAD. Hence, they should never be withdrawn forcefully when the patient bites on these airway devices during extubation [59]. Upper anterior incisors are most susceptible to damage [60]. The lose fragment or the teeth, if fractured or avulsed, should be immediately removed and patient should be counseled after the procedure. Tan stressed the need for dental referral or documentation of a referral in patients who have sustained dental injury as a result of airway management [61]. Preoperative risk consent for dental injuries should be obtained and adequate management of diseased teeth should be done.

6.3 Injury to the Eye

Incidence of ocular injury after general anesthesia is <0.1% and the risk factors include lateral and prone position, prolonged surgery, and head and neck surgeries [59]. Corneal abrasions are caused by direct trauma by face masks and manual compression by the hand, inadvertent chemical exposure from chemically sterilized airway equipment like face masks or regurgitated gastric material. Prevention includes padding and taping of both eyes, application of eye ointment and bio-occlusive dressing. Povidone iodine 10% solution is safe to the eye and hence recommended for skin preparation on the face. Immediate saline irrigation is vital after chemical exposure. Local antibiotics, lubricants, and patching of the eye will prevent further damage after corneal abrasions [59].

7 Postoperative Sore Throat

Postoperative sore throat (POST) is a common complication with an incidence of 14.4–90% following endotracheal intubation during general anesthesia, which can lead to dissatisfaction, discomfort, and delayed return to normal activity [62]. Major cause of POST is trauma to the airway mucosa during airway management, which in turn depends on the ease of laryngoscopy, endotracheal intubation, patient characteristics like obesity and skill of the operator. Tracheal tube cuff pressure, mucosal inflammation, and dehydration are other causes of POST.

Risk factors for the development of POST as identified by Minamiguchi [63] includes: (1) age <65 years, (2) surgeries of head and neck, pharynx, and spine (3) use of laryngeal mask airways, (4) postoperative intravenous patient-controlled analgesia, and (5) large size endotracheal tube. Other factors contributing to the development of POST are female gender, smoking habits, and prolonged duration of surgery [64]. Aqil et al. concluded that Glidescope was associated with lesser cases of POST as compared with Macintosh laryngoscope [65]. Prolonged duration of laryngoscopy, and time to intubation also increased the incidence of POST. Difficult airway increases the risk of POST due to repeated attempts and constant movement of the laryngoscope and the endotracheal tube or SAD in the airway.

Prevention of POST by non-pharmacological methods includes the use of SAD, smaller size tube, minimizing intracuff pressures, and gentle oropharyngeal suctioning. Pharmacological methods include use of lidocaine, ketamine, and steroids. Magnesium in the form of gargle, lozenges, and nebulizers also proved to be equally effective in preventing POST [66].

8 Laryngospasm

It is a protective reflex (to prevent aspiration) characterized by sustained closure of vocal cords, resulting in either complete or partial loss of airway, stimulus can be direct laryngeal or distant visceral, most often under lighter planes of anesthesia [67]. Sequelae of laryngospasm include hypoxia, bradycardia, obstructive pulmonary edema, pulmonary aspiration, arrhythmias, and death. The various risk factors that can lead to the development of laryngospasm during airway management are shown in Fig. 41.5

Extubation in patients who have risk factors for laryngospasm should be attempted either in deeper planes or fully awake state. The "no touch" technique, which includes pharyngeal suction and lateral position in deeper plane of anesthesia followed by extubation in fully awake state, has shown to reduce the incidence of laryngospasm [68]. Partial obstruction presents as inspiratory stridor and complete obstruction as absence of breath sounds with flat capnography. Treatment includes maintenance of oxygenation, removing irritants or any components causing airway stimulation, deepening the plane of anesthesia and if not resolved administration of pharmacological agents.

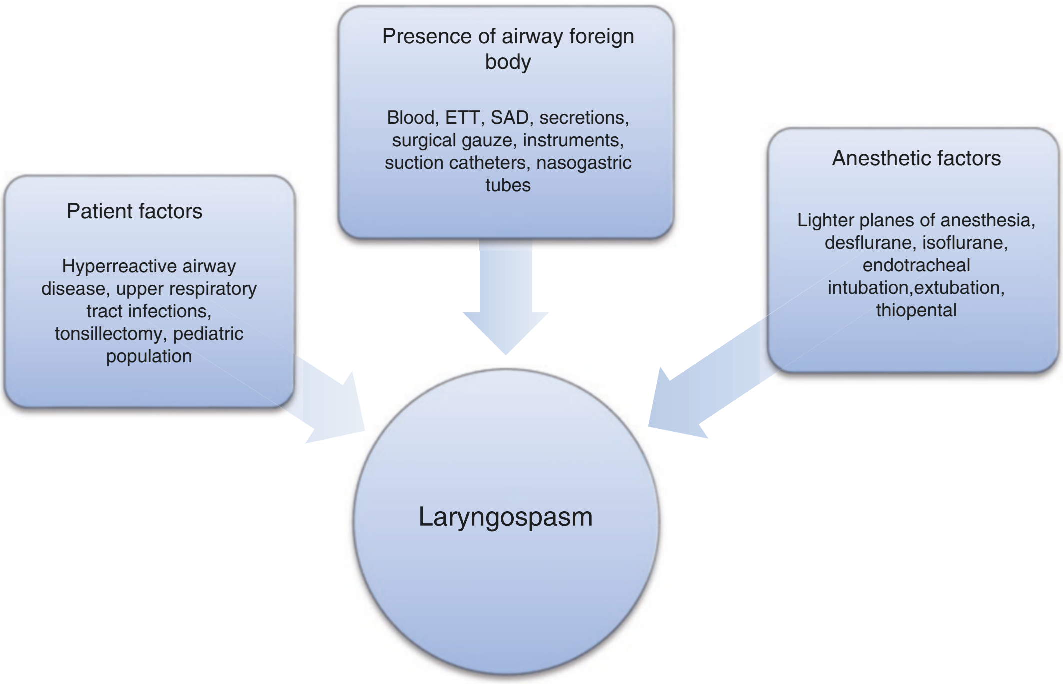


Fig. 41.5 Risk factors for the development of laryngospasm during airway management

Pharmacological methods to prevent laryngospasm

1. Magnesium-15 mg/kg i.v. [69]
2. Lidocaine-1.5–2 mg/kg i.v.
3. Lidocaine spray-4 mg/kg

Treatment of laryngospasm:

Most often, manual jaw thrust will relieve the spasm; otherwise consider deepening the plane of anesthesia and paralysis.

CPAP with 100% oxygen

Pharmacological treatment of laryngospasm [67]:

1. Propofol-0.5 mg/kg increments.
2. Succinylcholine-0.1–2 mg/kg i.v. if IV access is unavailable intralingual injection-3–4 mg/kg.

Anecdotal treatment options:

1. Larson's maneuver-bilateral firm pressure between the angle of the mandible and mastoid process.
2. Gentle chest compressions [70].
3. Superior laryngeal nerve block.
4. Nitroglycerin or doxapram infusion.

9 Bronchospasm

Bronchospasm is a reversible reflex constriction of the smooth muscles lining the bronchioles, triggered by mechanical or pharmacological stimulus under anesthesia. Precipitating factors for bronchospasm include hyper reactive airway disease, upper respiratory tract infection, and smoking. Anesthetic drugs include desflurane, cholinesterase inhibitors, histamine releasing atracurium, morphine and thiopental, nonsteroidal anti-inflammatory drugs, and nonselective β blockers [71]. Airway manipulations, which increase the risk of bronchospasm, are endotracheal intubation (9%) and LMA insertion (0.13%), incidence being nil with mask ventilation [72, 73]. Fiberoptic intubation can be a precipitating factor for bronchospasm if the subglottic airway is not anesthetized sufficiently. Induction of general anesthesia, airway manipulation, and emergence from anesthesia are the crucial stages for precipitating an attack of bronchospasm. Tracheal intubation and carinal stimulation cause transient reflex bronchoconstriction, higher incidence being associated with lighter planes of anesthesia. Preoperative administration of steroids and bronchodilators are helpful in preventing bronchospasm in susceptible individuals. Pretreatment with nebulized β agonist like salbutamol and ipratropium, intratracheal or nebulized lidocaine, IV propofol induction, and oral or inhaled steroids may also be helpful. Treatment of intraoperative bronchospasm includes inhalation of epinephrine or a β_2 agonist (albuterol or terbutaline) or by deepening the level of a volatile anesthetic. Ketamine and magnesium sulfate can also be used in severe cases.

10 Laryngeal Edema

This is the most common cause of postextubation airway obstruction, often seen in pediatric age group. Risk factors for postextubation laryngeal edema are female gender, prolonged duration of intubation, and the size of the tube [74]. Laryngeal edema can occur due to direct trauma to the retro arytenoid space, in the subglottic level due to tight fitting ETT, overinflated cuffs, traumatic intubation, and bucking or coughing over the ETT [75]. Laryngeal edema manifests as stridor within 30–60 min following extubation, sometimes as late as 6 h. The presence of respiratory distress and postextubation stridor reflects the narrowing of the airway lumen by more than 50% [76]. Use of cuff leak test, ultrasonography, and videolaryngoscopy prior to extubation to check for the presence or possibility of laryngeal edema is essential in susceptible individuals. Management consists of humidified oxygen, IV corticosteroids-dexamethasone 5 mg, methylprednisolone 20–40 mg, and nebulized epinephrine-1 mg in 5 mL [77], head up position and if there is persistent hypoxia, reintubation with a smaller size ETT. Nebulized corticosteroids have been found to be equally effective to IV administration [78]. In patients without difficult airway, but prone for laryngeal edema, ETT can be replaced with SAD before reversal (Bailey’s maneuver) under anesthesia towards the end of surgery. In the modified Bailey’s maneuver, the Laryngeal Mask Airway Protector (LMAP) is left in situ throughout the procedure for smooth extubation postoperatively [79]. In patients with difficult airway, prophylactic epinephrine nebulization can be given by placing another ETT in the oral cavity with the bevel of the tube near the glottic opening [80].

11 Vocal Cord Paralysis

The incidence of vocal cord paralysis following endotracheal intubation is less than 0.1% resulting in airway obstruction, hoarseness of voice, aspiration or postoperative morbidity or mortality [81]. Incidence is increased in patients with age, diabetes mellitus and hypertension due to associated peripheral neuropathy, and atherosclerotic changes of the microvasculature of the laryngeal nerves, respectively [82]. Diagnostic confusion between the cause of vocal cord dysfunction by surgical factors, e.g. thyroidectomy and postintubation factors can arise. Iatrogenic injury to the recurrent laryngeal nerve was associated with carotid endarterectomy, anterior approach to cervical spine surgery, and thyroid surgeries [83]. Lim et al. observed increased incidence of vocal cord paralysis following upper limb surgery including clavicle, performed in sitting posture. Hyperextension of neck to obtain a better surgical view must have led to migration of the endotracheal cuff causing compressive injury to the recurrent laryngeal nerve [84]. Arytenoid dislocation or subluxation (complete loss of contact or partial loss of contact respectively between the arytenoid and cricoid cartilage) is another mechanical cause of vocal cord immobility caused by direct trauma to the arytenoid cartilage. Anterior dislocation occurs during forceful intubation and posterior dislocation is seen during extubation [55].

The factors responsible for vocal cord paralysis after endotracheal intubation are: (1) mechanical compression of the cords in between the endotracheal tube and the lamina of the thyroid cartilage, (2) inappropriate size of the ETT, (3) inflation of the cuff at the level of the cords, (4) direct compression by the endotracheal cuff and resulting neuropraxia of the recurrent laryngeal nerve, (5) prolonged duration of endotracheal intubation [85], (6) use of double lumen tubes [86], (7) ethylene oxide sterilization of ETT causing chemical burns [87], (8) overextension of the neck causing stretch of the vagus, (9) insertion of the nasogastric tube can occasionally damage the left recurrent laryngeal nerve (more common in reflux esophagitis patients) [88].

11.1 Prevention

1. Ideal placement of the cuff should be 15 mm below the vocal cords [4].
2. Regular use of high-volume low pressure cuffed endotracheal tubes and frequent monitoring of intracuff pressure, especially with the use of nitrous oxide intraoperatively is required to prevent compression of the nerve [89].
3. Use of smaller size endotracheal tube (<7.5 mm) for prolonged surgeries has been suggested by Santos [90] and use of lidocaine 4% for cuff inflation is helpful in reducing mucosal injury and hoarseness.
4. Ethylene oxide sterilized reused tubes should be aerated 10 days after sterilization and before use [91].
5. Avoidance of excessive change in position of the neck, e.g., overextension. If required continuous sedation to prevent any movement is essential.

11.2 Management

Early recognition and supportive therapy are the priority in managing patients with vocal cords dysfunction. Consent issue (19%) was the major problem associated in the closed-claim analysis done by Shaw and Pierce [92]. Hence, pre-intubation consent is very vital. Laryngeal electromyogram (EMG) is required to evaluate the function of the nerve and to review the progress of therapy. Respiratory distress caused by vocal cord palsy should be immediately managed by respiratory support in the form of endotracheal intubation, mechanical ventilation, and careful weaning and follow-up. Early intervention speech therapy significantly improves voice quality, voice stability, and efficiency. Glottic insufficiency resulting from paramedian or lateral position of the paralyzed vocal fold may benefit from medialization techniques (vocal fold injection, laryngeal framework surgery, arytenoid adduction procedures) of the immobile vocal folds [55]. Endoscopic reduction of the suspected arytenoid dislocation will improve vocal fold mobility and voice performance. Psychological therapy and support is required for the unpredictable recovery of the patient.

12 Aphonia

Vyshnavi et al. reported the loss of voice or aphonia in three cases following endotracheal intubation [93] in surgeries not involving any neck dissection; no history of arthropathy and intubation was always accomplished in the first attempt. All patients recovered within 30–60 days. However, mild distortion of the vocal cords was observed on indirect laryngoscopy. Meticulously following safety checklist in each step of airway management is essential to prevent the occurrence of aphonia [94]. Reassurance, guided speech therapy, and voice exercise is required to hasten recovery in patients with aphonia following airway management.

13 Laryngotracheal Stenosis

Laryngotracheal stenosis is a long-term sequel of endotracheal intubation. The presence of comorbid conditions such as diabetes, gastro esophageal reflux, and immunosuppression has shown to increase the incidence of stenosis [95]. Inflammatory changes are seen as early as 2–5 days after endotracheal intubation and the main mechanism is localized tissue ischemia followed by ulceration, fibrosis, and scar formation [56]. Most common sites for stenosis are the posterior glottis, subglottis, proximal trachea, and interarytenoid regions wherever the ETT is in contact with the tissues. Exertional dyspnea, inspiratory stridor progressing to respiratory failure will worsen gradually over time and needs immediate intervention. Inability to pass the tube across the stenotic part as well as multiple forceful attempts can lead to edema of the mucosa further compromising the airway. Planned surgical tracheostomy is the preferred choice and evaluation of the stenotic area is possible with continued oxygenation. Jet ventilation is another mode of oxygenation, provided proper expiration is ensured.

Management includes use of laser or cold instrumentation for scar excision, serial dilatations using rigid bronchoscope, balloon dilatation, and laser resection of scar tissue. Mitomycin C, an antineoplastic agent, has been helpful in preventing restenosis. Placement of T tube stent, laryngotracheal reconstruction, tracheal resection, and anastomosis are some of the definitive surgical treatments when serial endoscopic therapies have failed, and the stenotic lesion is more than 2 cm in length [55].

14 Other Rare Complications of the Larynx and Trachea

14.1 Tracheomalacia

Tracheomalacia is caused by pressure necrosis and destruction of the tracheal cartilages by the endotracheal or tracheostomy cuffs followed by loss of cartilaginous support and collapse of the tracheal wall. Symptoms vary from mild dyspnea to severe respiratory failure [96]. Management includes tracheostomy to bypass that part of the collapsed trachea, intraluminal stenting, and external stabilization with stenting and surgical resection with end-to-end anastomosis [97].

14.2 Tracheoinnominate Artery Fistula

Erosion of the anterior tracheal wall by the tip or cuff of the tube can create a fistula between the trachea and the innominate artery leading to massive hemoptysis, which can be fatal. On diagnosis of this major complication, immediate hyperinflation of the tracheostomy or endotracheal cuff distal to the bleeding site in order to apply compression on the vessel may reduce the bleeding. A finger inserted into the tracheal lumen and compression of the anterior tracheal wall and the bleeding vessel against the sternum till definitive ligation of the vessel may be effective in reducing blood loss, although the survival chances are very remote [98].

14.3 Tracheoesophageal Fistula

The pathophysiology for developing a tracheoesophageal fistula is prolonged tissue ischemia caused by cuff inflation followed by ulceration and necrosis, forming a fistula between the posterior wall of trachea and the esophagus. Critically ill patients with diabetes, infection, and the presence of nasogastric tube are more prone to develop this complication. Recurrent aspiration pneumonia, cough while feeding, gastric distension or suctioning of food particles from the ETT should raise a high degree of suspicion and the management is either stenting across the fistula or surgical repair [99].

15 Systemic Manifestations of Airway Management

Cardiovascular manifestations during airway manipulation occur due to the mechanical and chemical stimulation of the various receptors located along the respiratory tract. These receptors are unequally distributed in the respiratory tract, present in large numbers in the larynx and proximal tracheobronchial tree, thus they vary in their response to each stimulus [100]. Under lighter planes of anesthesia, hypertension, tachycardia, and arrhythmias caused by airway stimulation can be fatal in patients with poor cardiovascular reserve. Hence, a delicate balance between the oxygen demand and supply by maintaining hemodynamic stability is essential [101]. Various methods used to block the hemodynamic response during airway management are (a) block the afferent pathway-topical application or local infiltration of anesthetic drugs to block the superior laryngeal nerve or local anesthetic spray before intubation, (b) central blockage of sensory inputs by using opioids, (c) block the efferent pathway and effector site-by using β blockers, calcium channel blockers, and lidocaine [102].

Common drugs used for attenuation of cardiovascular response during laryngoscopy and intubation are:

1. Dexmedetomidine-0.75 μg/kg intravenous, over 10–20 min [103].
2. Clonidine-2 μg/kg over 10 min or 200 μg orally before 90 min prior to surgery [104, 105].
3. Intravenous fentanyl 1 μg/kg, sufentanil 0.1 μg/kg, alfentanil 10 μg/kg, and remifentanil 1 μg/kg [106].
4. Esmolol 1 mg/kg bolus dose 3 min prior to intubation or 1.5 mg/kg as infusion [107].
5. Labetalol 0.25 mg/kg, IV over 1 min.
6. Calcium channel blockers-nicardipine 30 μg/kg or verapamil-100 μg/kg IV 3 min prior to intubation.
7. Intravenous lidocaine 1.5 mg/kg over 10 min followed by continuous infusion at 1.5 mg/kg/h [108].

Optimization of the systemic parameters prior to anesthesia and meticulous anesthetic management with the use of appropriate drugs and devices along with a skilled operator to reduce the hemodynamic alterations can prevent the complications. The use of videolaryngoscopes attenuated the postintubation hemodynamic alterations when compared with Macintosh laryngoscope, the lesser degree of lifting force and cervical spine movement required to view the glottis was attributed to this response [101, 109].

16 Complications with the Use of Videolaryngoscopes

The incidence of injury to the soft palate, retro molar trigone, larynx, tongue, and teeth are increased with the use of videolaryngoscopes, the oropharynx being more prone due to the stretch of the tonsillar pillars by the scope, and trauma due to blind tube advancement [110]. The rigid stylet of the Glidescope can cause more injury to the soft tissues of the oral cavity than the regular ETT stylets [111]. Mild trauma may heal with conservative management whereas severe form of injury may require primary closure and hemostasis. Prevention includes midline insertion of the tube under direct vision and maintaining the tip of the tube parallel and close to the blade of the scope till it is viewed in the monitor. Successful airway management using the videolaryngoscope necessitates experience in its usage, as Cormack–Lehane grade-1 does not guarantee successful endotracheal intubation [112].

17 Complications Associated with the Use of Fiberoptic Endoscopes

Fiberoptic intubation is considered as part of a complete airway management strategy [113]. However, the use of fiberoptic scope can lead to potential airway complications which include injury to the soft tissues of the airway and bleeding, laryngospasm, bronchospasm, postoperative sore throat, hoarseness of voice, erythema, and hematoma of the vocal cords.

Hypoxia can occur due to mechanical obstruction by the scope or apnea caused by over sedation. Insufflation of high-pressure oxygen through the suction channel can cause barotrauma, submucosal tear (in extreme cases tracheal perforation), and seepage of air into the tissue planes resulting in subcutaneous emphysema of the head and neck, pneumomediastinum, pneumothorax. High flow nasal oxygen can be used to prevent complications of oxygen insufflation.

Aspiration of blood, saliva, and gastric rupture due to oxygen insufflation are also reported [113–115].

Hypertension and tachycardia were associated with fiberoptic intubation, but more often during prolonged duration of securing the airway and with inadequate topicalization and sedation [116]. Better sedation techniques, adequate topicalization, preprocedural counseling, proper technique, and handling of the equipment can reduce the systemic manifestations [117]. Complications due to drugs can occur due to overzealous use of sedatives and local anesthetics. The fourth national audit project identified over sedation as a significant problem area leading to failed fiberoptic intubation. It recommends awake intubation as a first choice when patient factors make fiberoptic intubation as a preferred option. The maximum dose of topical lidocaine for airway block is 8.2 mg/kg as recommended by the British Thoracic Guidelines and systemic effects of local anesthetic toxicity are manifested at maximum blood levels of >5 mcg/mL [118]. Hence, care should be delivered during administration of airway anesthetic drugs.

With the recent videolaryngoscopes being easily available and user friendly, recent journal editorial stated that awake fiberoptic intubation is becoming obsolete and may no longer be the gold standard for managing the difficult airway [119]. Proper selection of the patient and the right indication for fiberoptic intubation will reduce the complications of airway management to a great extent.

18 Complications with the Use of SAD

In the NAP4 report, 33 complications were reported with the use of SAD, which included aspiration, airway trauma, loss of airway on insertion, failed insertion, displacement after insertion, and extubation related problems [5]. The risk factors identified for the complications were obesity, associated comorbidities, traumatic insertion, and inappropriate size of the device, inexperienced operator, and inadequate depth of anesthesia.

Pulmonary aspiration of gastric contents is a major complication associated with the use of SAD. It is prevented by the use of appropriate size, careful positioning of the SAD, adopting novel techniques of confirming the position of the SAD by passing a gastric tube and the standard fiberoptic confirmation.

The separate gastric channel present in the second-generation SAD allows for early recognition of regurgitation of gastric contents. The I-gel has a narrow esophageal seal, which prevents dysphagia in the postoperative period. LMA Supreme (SLMA) was found to be a safer device to prevent regurgitation and other related complications [120]. The authors of NAP4 recommended that "if tracheal intubation is not indicated and there is a small concern regarding regurgitation, then second-generation supraglottic airway device is a more logical choice than the first-generation device" [121].

Soft tissue injuries of the lips, teeth, pharyngeal mucosa, tongue, uvula, and epiglottis are reported with the use of SAD, which is caused by forceful placement or indirectly by compression or laceration [55]. Vascular compression by the inflated cuff can lead to tongue ischemia [122]. Nerve injuries associated with the use of SAD are bilateral recurrent laryngeal nerve, hypoglossal and lingual nerve, mainly due to direct compression by the cuff of the SAD. The cuff pressure exerts pressure on the nerve, because of which there can be neuropraxic injury resulting in vocal cord paralysis, hemi-lingual paralysis, or lingual anesthesia [123]. Manual over inflation of the cuff or diffusion of nitrous oxide can gradually increase the cuff pressure. Regular monitoring of the cuff pressure, especially during the use of nitrous oxide is recommended. Avoid extreme position changes of the head and neck during the surgery [124].

Malposition of the SAD and consequently hypoventilation can result from a small or large size SAD, hypo or hyperinflation of the cuff, too deep or superficial insertion of the device. The epiglottis can get folded in the bowl of the SAD increasing the airway resistance [125]. Use of videolaryngoscope or fiberoptic bronchoscope to confirm the alignment of the SAD tube and the tracheal opening is beneficial.

19 Role of Human Factors in Airway Complications

Human factors were found to be responsible for 40% of airway related complications claimed in NAP4 [5] ranging from organizational failure to individual errors, incidence being higher in ICU than during anesthesia. Flin et al. demonstrated that deficiencies in non-technical skills increase the chance of errors and the likelihood of occurrence of complications [126]. Errors of omission exceeded errors of commission. This includes failure to recognize the magnitude of the problem, make appropriate observations, or act in a timely manner. The importance of when and how to “call for help” during airway management cannot be overemphasized. In the Parmesan cheese model of Moloney, each time a small cheese shaving sliced from the whole block, which is akin to the deficiencies and substandard practice incorporated into the routine patient care, has a major contribution in poor patient outcome [127]. In the 5th National Audit project (NAP5) two-thirds of accidental awareness reports during general anesthesia occurred during induction and emergence and 73% were considered avoidable with miscommunication being the major contributing factor [128]. Observational team errors may be classified into task execution, procedural, communication, decision, and intentional non-compliance [129].

There are many components of human factors that can prevent airway complications. Organizational preparedness such as adequate staffing, equipment, maintaining a structured protocol, training of personnel to develop good communication skills, team leadership, assertiveness to manage the airway and to prevent or minimize complications is very essential. The recent introduction of national and international airway management guidelines allows for a systematic approach to airway management both in anesthesia and in emergency settings outside the OR. Consideration given to human factors in the Difficult Airway Society (DAS) guidelines in the form of “stop and think” and “declaration of emergency” allows the team to rethink the strategies during crisis management and ensures that all members are on the same page to handle the situation [130].

Competency based assessment may be required to monitor the knowledge and skill of the individual. Availability of skilled doctors in times of airway crisis is crucial in preventing many of the complications [131]. Teaching and measuring “Anesthetic Non-technical skills” (ANTS), i.e. situation awareness, decision-making, and leadership skills are a major contributing factor for the successful management of airway [132]. Communication with the other members of the team including the surgeon, nursing staff, and the technicians is deemed to be very effective in managing emergency situations.

Elaine Bromiley Case

In 2007, Elaine Bromiley was scheduled for a routine sinus surgery, which ended in a catastrophe due to inability to secure the airway or maintain oxygenation. Repeated attempts to secure the airway despite the presence of three experienced doctors (two anesthesiologists and one ENT specialist) was not successful and she sustained severe hypoxic brain injury, following which life support was terminated 13 days later.

Human factors were considered to be the major factor responsible for this mishap and the key factors considered were (a) lack of communication, (b) lack of a clear plan, (c) non-assertiveness by the team members, and (d) lack of control and team leadership.

20 Prevention of Airway Complications

There are numerous ways by which complications can be reduced during airway management; most of which are caused by human errors. Few modifications can be made in routine practice to optimize our approach and techniques based on the resources available, ultimate priority being patient safety. Careful assessment, application of knowledge, skill, judgment, and planning capacity by the individual operator, following the time tested airway guidelines, good communication, teamwork, and institutional preparedness are the most important factors to be considered for securing the airway [3]. Inadequate airway management planning and errors in judgment were major contributors of airway complication as per the closed claims analysis done by Joffe [133]. Plan for failure of the original plan and proper communication of the planned procedure with the team members is essential for a successful outcome during airway management.

Uses of monitors like the end tidal carbon dioxide, oxygen saturation, and electrocardiogram (ECG) are essential for early detection of adverse events. Knowledge and use of the right kind of device such as SAD, videolaryngoscopes, and fiberoptic scopes in indicated or contraindicated patients will prevent many of the airway related complications. Interventions aimed at achieving first pass intubation success (use of videolaryngoscopes, bougies, and stylets) should be incorporated into those that maintain physiological stability (use of inotropes, fluid infusion) to prevent the multiple complications of airway management [134].

Repeated attempts of tracheal intubation should be avoided as the risk of airway obstruction increases significantly. Improvement of professional skills by simulation of airway complications and regular update of the existing knowledge can significantly decrease the incidence of airway complications. Emergent airway management by physicians was found to be successful in 88.1% of patients in a study by Yoon, which was attributable to the extensive airway training, and simulation programs provided to the operator [49].

Few of the complications that occurred because of airway manipulation are as shown in Fig. 41.6.

Minimizing complications is the goal of a successful airway management plan. It is the result of planning, preparation, and execution of knowledge and skill especially during crisis management. Regular updating of the existing knowledge and skill will prove to be beneficial for better patient outcome. Teamwork with good communication is the basis of providing complete care to enhance patient safety.

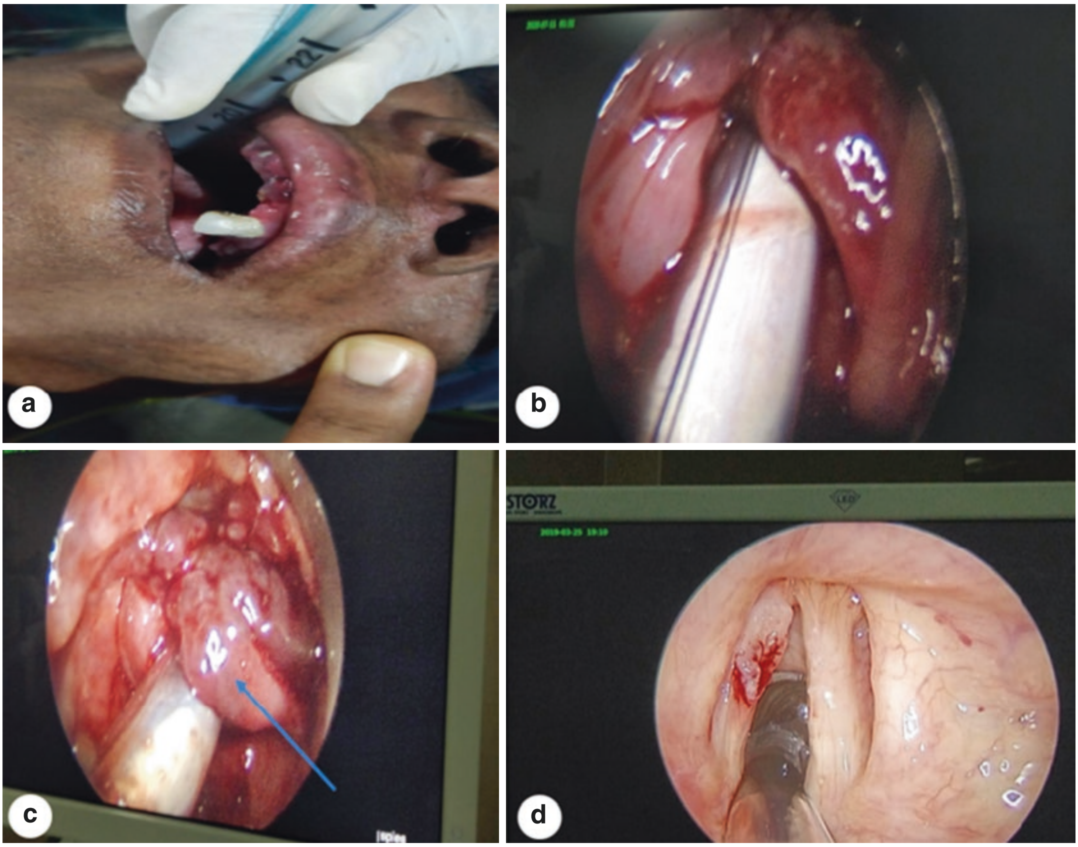


Fig. 41.6 Complications as a result of airway management. (**a**) Broken tooth, (**b**) laryngeal edema, (**c**) trauma to the laryngeal opening followed by laryngeal edema (**d**) trauma to the vocal cords

21 Conclusion

Any airway management technique may lead to innumerable life-threatening complications. Hence all prophylactic measures must be taken to minimize these complications, special precautions taken in anticipated difficult airway cases and non-emergency intubations. In case of unanticipated complications, swift management with available resource and personnel will prevent the deterioration of the situation. Use of appropriate equipment, monitors, and judicious use of the required drugs forms the corner stone of successful airway management. The skill and knowledge of the operator plays a major role in prevention of these complications. If a complication has occurred, early recognition, management, and follow-up of the consequences are essential to reduce the morbidity and mortality. This necessitates regular updating, exposure, and training of the operator and assistants to provide safe patient care with regard to airway management.

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