Review Article

Coping with airway emergencies: Get, Set, Go!

Address for correspondence:
Dr. Nishkarsh Gupta,
437, Pocket A, Sarita Vihar,
New Delhi - 110 076, India.
E-mail: drnishkarsh@rediffmail.com

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Raveendra US, Anju Gupta[1], Swagata Biswas[2], Nishkarsh Gupta[2]
Department of Anesthesia, Jerudong Park Medical Centre, Brunei, Darussalam, Departments of [1]Anesthesiology, Pain Medicine and Critical Care and [2]Onco-Anesthesiology and Palliative Care, AIIMS, Delhi, India

ABSTRACT

Airway emergencies are among the life-threatening events that are encountered in the operating room, emergency department or intensive care unit. They are important causes of preventable morbidity and mortality where time is the essence. It can be extremely challenging to rapidly assess the airway for early diagnosis and perform appropriate interventions simultaneously. Outcome depends on the implementation of an optimal strategy to establish a patent airway. Equally important is the overall stabilisation of the patient and management of the primary clinical condition as appropriate. Key components of management include early recognition of threatened airway, appropriate and timely airway intervention, and maintaining oxygenation. In this review, we describe aetiology, evaluation and management of airway emergencies.

Key words: Airway management, early diagnosis, emergencies, emergency department, intubation, oxygen

INTRODUCTION

Airway emergencies (AE) differ from emergency airway management, occur rarely and include sudden, life-threatening events, which disrupt the continuity of natural or artificial airway.[1] If not managed timely, they affect oxygen supply and gas exchange leading to significant morbidity and mortality. These emergencies can be encountered during pre-hospital care, patient transfer or in the in-hospital locations. Inside the hospital, majority of AE are usually encountered in intensive care unit (ICU), perioperative setting or emergency department (ED). Situation is further complicated by restricted access to the airway, comorbidity and unstable haemodynamic status.[1,2] Some of the individual emergencies (e.g., trauma, foreign body aspiration, etc.) have been discussed in various contexts in the literature, but comprehensive articles on managing AE are lacking. In this review article, we aim to discuss early diagnosis, correction of the reversible causes and approach to emergency airway management.

SEARCH STRATEGIES

We did a literature search using key words e.g., 'airway' and 'emergencies' and 'oxygenation' and 'intubation' and 'management' entered in common databases for example, PubMed, Medline, Embase for last 10 years and a total of 659 articles were found. These were further screened and a total of 150 relevant articles were shortlisted. These articles and their references were searched extensively for the present review.

Aetiology

AE can be described as emergencies arising out of an obstructed airway, traumatised airway or failed airway or a combination of any of these. [Table 1] The common factors are actual or potential failure of gas exchange and/or oxygenation and risk of pulmonary aspiration. Early recognition, use of appropriate equipment, drugs and strategy for maintaining oxygenation form the cornerstones of management.[1]

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Management

- **Recognition:** Emergencies do not always arise *de novo* and are a culmination of a series of changes over minutes or hours. Further, human factors such as improper assessment, fixation errors, fatigue, stress, inadequate communication, etc., contribute to the evolution of an airway emergency.[1] While actual AE are difficult to miss, evolving AE (potential emergencies) often go undetected. Anticipation, high degree of suspicion, clinical observation and monitoring for impending obstruction (red flags) can help in early diagnosis. [Table 2]
- **Preparation:** A dedicated trained difficult airway response team or DART (multidisciplinary team of anaesthesiologists and ENT surgeons) should be available round the clock for prompt action in case of an airway emergency.[4] All the emergency intubations are difficult, and a difficult airway cart should be ready[3]
- **Patient positioning**: During airway emergency, it may not be always possible to place the patient in supine or lateral position, rendering airway management difficult. In such circumstances, the aim should be to provide ventilation, using the immediately available, appropriate equipment. Supraglottic airway devices (SAD) could be lifesaving as rescue ventilation devices. If it is not feasible or fails, direct surgical access should be considered without any delay[1,4]
- **Plan for oxygenation:** In AE, we must adopt all the measures to maintain oxygenation like preoxygenation with 100%, nasal high flow oxygen, application of positive end expiratory pressure (PEEP), maintaining haemodynamic stability and appropriate ventilatory settings.[5,6] Additional methods like supraglottic jet ventilation, special tracheal tube and transtracheal jet ventilation have also been tried to improve oxygenation.[7-10] [Table 3]

  Patients like those with a huge thyroid swelling with signs of airway obstruction may present with progressive airway obstruction with worsening hypoxia. These patients may be relieved of hypoxemia with a mixture of helium and oxygen (heliox)[11] while one prepares for definitive airway access
- **Plan for definitive airway management:** The airway management plan involves quick assessment of the airway, patient, and situation to formulate a working (primary) and standby (back up) plans for management.
  a. **Assessment:** Airway assessment in emergency radically differs from conventional preoperative assessment. Assessment should be quick, complete and goal directed. Often, despite a normal physical appearance, the patient could have a compromised airway. Adequacy of breathing, signs of obstruction and hidden airway injuries should be looked for in non-intubated patients. In intubated patients, adequacy of ventilation and monitoring of capnogram help in diagnosis of AE. In addition, airway pressure, expired tidal volume, compliance, trends

Table 1: Aetiology of Airway emergencies

Medical conditions: Croup, supraglottitis, epiglottitis, angioedema, etc.
Mechanical obstruction: Tumour, polyps, foreign body, aspiration of blood or vomitus, tracheomalacia, Ludwig's angina, obstructive sleep apnoea.
Trauma: Airway trauma like maxillofacial, laryngotracheal, chest injury, inhalational injury.
Iatrogenic: complications of invasive airway procedures e.g., percutaneous tracheostomy, perioperative loss of airway, airway fire etc.
"Complete Ventilation Failure"[3] situation after failure of repeated attempts of intubation.

Table 2: Red flag signs for early recognition of airway obstruction: a look, listen and feel strategy

Look	Listen	Feel
Rapid, shallow breathing.	Normal speech (rules out the obstruction).	Subcutaneous emphysema.
Tracheal tug sign.	Stridor.	Chest wall crepitus.
Nasal flaring.	Noisy breathing	Tachycardia.
Retraction of neck muscles.	Gurgling sound.	Capillary refill time >3 sec
Rib retraction.	Hoarseness.	Paradoxical pulse.
Paradoxical pattern of breathing (rocking chest motion)	Complete absent of breath sound.	
Cyanosis		
SpO_2 <90% or a progressive fall in SpO_2		
Ineffective respiratory effort/air hunger		
Agitation		
Lethargy		

Table 3: Techniques of oxygen administration in AE[4,6-9]

Technique	Recommendations	Indication(s)	Remarks
Preoxygenation	10 L/min tight fitting mask with a Bain's circuit.	Potential airway emergency	Target is to achieve an end-tidal oxygen >90% and end-tidal nitrogen <4%. Enhances effectiveness of subsequent techniques.
Nasal cannula/prongs	5-15 L/min flow	During preparation for airway management and during airway procedure	THRIVE High flow nasal cannula (HFNC). Needs an upper airway to be patent. Prolonged duration of safe apnoea.
Face mask/ Non-rebreathing mask	4-8 L/min flow	During preparation for airway management	Especially for those with poor oxygen reserve. A tight seal around the mask is mandatory but may be difficult for trauma patients.
Nasal jet ventilation	Through modified nasal airway with a port for jet ventilation	Prior to and during airway procedures.	Purpose made (Wei nasal jet) equipment. Barotrauma risk is minimal
Supraglottic jet ventilation	Different techniques like tubeless field techniques	During foreign body removal, bronchoscopy, or surgical airway access	Helps to maintain oxygenation with minimal risk of barotrauma
Mask ventilation and supraglottic airway devices	Attempt to maintain oxygenation during surgical airway establishment	Even with sub optimal placement, it can help in oxygenation	Can be combined with nasal oxygenation
Transtracheal jet ventilation[12]	Through a custom made set or available devices like Manujet III (VBM, GERMANY)	Temporary lifesaving oxygenation technique	Can lead to barotrauma, auto positive end expiratory pressure (PEEP), hemodynamic collapse. Try to keep upper airway patent
Oxygen through intubation fiberscope[13]	Administered through the working channel	During fibreoptic guided techniques	

in saturation and blood gas analysis should be checked if time permits. A chest X-ray or bedside airway ultrasound often help clinch the diagnosis. A '**HEAVEN**' criterion has been used as a tool for prediction of difficult airway for emergency airway management in un intubated patients.[12] It consists of **h**ypoxemia, **e**xtremes of sizes, **a**natomical challenge, **v**omit/secretions in the pharynx or hypopharynx, **e**xsanguination and restricted **n**eck mobility

b. Plan/options for airway access: Only endotracheal intubation and tracheostomy are the definitive airway devices. Alternate reasonably safe rescue options include SAD and cricothyrotomy.

- SADs are useful for emergency ventilation, and as an intubation aid, particularly in failed intubation, accidental extubation and post extubation airway emergency. However, SAD may not be useful in cases with infraglottic pathology and airway bleeding. Second generation SAD (LMA Proseal and I-gel) should be preferred to prevent gastric insufflation. In their absence, the most familiar device should be used.
- Endotracheal intubation can be facilitated by videolaryngoscope, bougie, Bonfil's retromolar scope, etc., depending on the indication, availability and preferences of the anaesthesiologist. Intubation fiberscope, when used, will also aid in diagnosis of the condition while simultaneously guiding intubation. Last, intubation can be performed through a SAD under the guidance of intubation fiberscope[3,13]
- Infraglottic airway techniques include trans-tracheal jet ventilation, cricothyrotomy and tracheostomy. Decision to execute any of these techniques should be taken quickly and early considering experience and feasibility in the given circumstance. All India Difficult Airway Association (AIDAA) recommends a simple effective scalpel bougie technique for emergency airway access.[3] Supraglottic jet ventilation is also possible with modified Wie nasal jet or other similar devices and can be lifesaving.[8] Attempts to ventilate can continue through a SAD or facemask during the preparation and execution of infraglottic invasive techniques.
- Rigid bronchoscope can be an especially useful device if the airway obstruction is distal to the glottis.[14]

- Cardiopulmonary bypass(CPB) and Extracorporeal membrane oxygenation(ECMO) are lifesaving if available when no other airway technique is successful in maintaining oxygenation, but it needs a prior planning.[15]

Management of specific AE

Acute airway obstruction

Obstruction of the airway is one of the common underlying/contributory factors for an airway emergency. The 4th National Audit Project (NAP4), reported 50 obstructed airway cases while investigating anaesthesia-related major airway complications.[16]

- The site of obstruction influences the efficacy and suitability of any airway technique. The classic symptoms and signs of obstruction at the various sites vary and include stridor at a nasopharyngeal level, gurgling at an oropharyngeal level, inspiratory stridor at a supraglottic level, inspiratory or biphasic stridor at a glottic or subglottic level, and expiratory wheeze at tracheobronchial level[17]
- Obstruction can be caused by several factors. [Table 1] Complete (or near complete) obstruction, intrathoracic location (especially mediastinal mass), combined with bleeding, known difficult airway and distorted airway after previous surgery are few factors that may increase the risk of contributing to airway emergency

  In patients already intubated, unrecognised obstruction of endotracheal tube is a serious complication and can lead to irreversible hypoxic damage.

Management

- Oxygenation should be restored or maintained by various appropriate methods described above. In patients with obstruction, helium oxygen mixture creates more laminar flow as it decreases the airway resistance (helium has lower density) and can pass through the narrow orifices due to partial obstruction[11,18]
- Assessment for details of obstruction within the limits permitted by the patient's condition should be done. Depending on the urgency, X-ray chest, airway ultrasound, indirect laryngoscopy, computed tomography (CT) and magnetic resonance imaging(MRI) chest, and awake fibreoptic bronchoscopy could be useful. Virtual imaging of the airway is a recent advance in the technology of evaluating the airway.[19-21]
- Meticulous preparation includes arranging equipment, drugs and personnel, within the limitation of time. NAP4 recommends the following as prerequisites for safe management of acute airway obstruction (AAO).[16]
  a. Fully equipped environment with full surgical, anaesthesia and nursing support preferably an operation theatre
  b. As a safer alternative, awake tracheostomy should always be considered with low threshold.
- Certain manoeuvres such as change in position, insertion of airway, lifting of large goitre, etc., may help in partially improving the patency. Optimal mask ventilation or use of SAD can temporarily restore oxygenation or prevent hypoxia
- Inappropriate use of sedation, paralysis or airway blocks should be avoided as they may convert a partial obstruction to complete
- Need for/feasibility of surgical airway/ infraglottic techniques, rigid bronchoscopy/ CPB/ECMO should be considered early in management[14,15]
- In lower airway obstruction, if a difficult facemask ventilation or intubation is predicted, awake fibreoptic intubation should be planned. Rigid bronchoscopy and tracheostomy should be kept as a backup plan for all the cases.

Trauma involving airway

Trauma to the airway is an important cause of airway emergencies.[22] When it is not overt and when other obvious injuries are not present, the potential airway problems may not be identified by the initial care giver. Nature of injury, crepitus and subcutaneous emphysema, swelling, haematoma, hoarseness of voice etc., are some of the findings which should alert to the possibility of airway injury.

Management of traumatised airways is complicated by associated injury (head injury, abdominal trauma, hypovolaemic shock, cervical spine instability), distorted anatomy, bleeding from airway, full stomach, obesity, pregnancy, extremes of age and comorbid conditions.

- A quick airway assessment should be done as a part of a primary survey in trauma and their cervical spine protected using a cervical collar or manual in line stabilisation

- Awake oral intubation (avoid nasal intubation due to possible base of skull injury) using fibreoptic or intubating SAD like Intubating laryngeal mask airway is preferred. However, coughing and bucking during awake intubation may increase haematoma
- If awake intubation is not possible than modified rapid sequence induction **(**RSI) is preferred
- In extensive airway trauma, a definitive surgical airway distal to the site of injury is an ideal choice
- A new concept in trauma or emergency airway management is Delayed Sequence Intubation.[23] In this, an agitated patient who does not allow preoxygenation is sedated in a controlled fashion with titrated doses of ketamine and preoxygenated before intubation sequence is initiated.

Soiled airway

An airway soiled with blood, vomitus or secretions is often encountered in the emergency department and makes intubation conditions more difficult. Success rate of intubation in a soiled airway has been found similar with conventional and videolaryngoscope.[24,25]

The following principles are the key points while managing a soiled airway:

- Patients should `be positioned in a reverse Trendelenburg position to allow drainage of vomitus or blood. Two large bore suction catheters should be available and additional measures for example, nasal packing for epistaxis should be taken for control of bleeding.
- Positive pressure ventilation should be avoided or minimised.
- Visibility is often better with direct laryngoscope than videolaryngoscopes.[26] Epiglottis is identified as a landmark and can be easily lifted to facilitate bougie guided intubation.
- An alternative approach recently described by James DuCanto is suction-assisted laryngoscope airway decontamination (SALAD) technique.[27] It involves insertion of Yankauer rigid catheter through the right angle of mouth to suction out all the secretions, insertion of a videolaryngoscope while continuing suction through the catheter, reinsertion of catheter through the left angle of mouth to continue suctioning followed by insertion of the endotracheal tube through the trachea.[28]

Airway Fire

- Despite present-day inhaled anaesthetics being non-inflammable, advances in cautery and electrical circuitry, airway fires are still not completely preventable. Fire can develop in presence of three components (fire triad) that is an oxidiser (oxygen and nitrous oxide), an ignition source (electrocautery, lasers) and fuel (alcohol-containing solutions, gowns etc).[29] High-risk surgeries include laser surgery, adenotonsillectomy and airway surgery. Use of laser resistant tubes, covering the tube with aluminium foil, restricting FiO_2 to lowest possible level, use of a cuffed tube (prevents leak) and use of saline for inflating the cuff are preventive steps as far as airway fire is concerned.[29] In case of airway fire, the surgeons should be informed to stop surgery. Remove the endotracheal tube, replace it with a new one and consider surgical airway if needed. The field should be irrigated with saline and cautery disconnected.[29]

Intraoperative loss of airway

Loss of airway (spontaneous or accidental extubation) during surgery is a nightmare. If the surgery is related to head and neck region (oral cavity, neurosurgery or maxillofacial surgery, etc) then the consequences can be more disastrous.[30,31] It is diagnosed by a sudden loss of capnogram, absence of chest expansion, zero expired tidal volume and sudden decrease in oxygen saturation (takes some time). Less severe intraoperative airway problems which could eventually lead to airway emergency are obstruction of the endotracheal tube due to physical damage during surgery, partial airway obstruction during airway surgery in an unprotected airway or a displaced SAD in a patient with known difficult airway. [Table 4]

Post extubation loss of airway

Another dangerous airway emergency is loss of airway immediately following extubation. Common causes include laryngospasm,[32] oedema of airway including tongue[26] and bleeding. The contributory factors include inadequate recovery/reversal, obesity, known difficult airway, surgery in or around the airway, prone or sitting position, presence of external fixator or devices obstructing mask ventilation, etc., [Table 5]

Managing an airway in highly contagious respiratory illness

Over the last two decades, there have been several outbreaks of aerosol born infectious diseases, for

example the severe acute respiratory syndrome (2003), Middle East respiratory syndrome coronavirus (2012) and most recently, the novel coronavirus disease (COVID-19) in 2020. Emergency intubation is often needed for these patients in ICU or ED.[27,33] In addition, different kinds of AE (obstructed, traumatized, or failed airway) may develop in these patients. The resulting situation would be much more challenging due to multiple factors like severe respiratory disease with imminent hypoxaemia, lack of adequate experienced manpower, non-availability of appropriate equipment, poor communication and exhaustion due to personal protective equipment (PPE). In addition, failed extubation has been reported in COVID patients on ventilatory support due to a variety of reasons that is, upper tracheal and subglottic edema, epiglottic or subglottic ulcers.[27] The principle of management of such cases is to maximise preparation to ensure that the first attempt of intubation becomes successful, while minimising the aerosol exposure to the health care workers. The recommended steps to be followed while handling these patients are summarised in Table 6.[27,33]

Table 4: Management of intraoperative loss of airway[12,35,36]

Cut off anaesthetics, start 100% oxygen using face mask, call for help, inform surgeon
Consider the feasibility of turning patients to supine while getting ready the airway equipment.
Consider performing the remaining surgery under SAD if feasible.
Use appropriate drugs to increase depth or to paralyse depending on the situation.
If it is a difficult airway, then avoid multiple attempts. Call/inform ENT surgeon for tracheostomy while attempting intubation in such cases.

Table 5: Prevention of post-extubation loss of airway

Planned extubation considering risk factors
Optimise mask ventilation
100% oxygen before extubation
Extubate after complete recovery and reversal
Plan for extubation failure and re-intubation before actual extubation like extubation over airway exchange catheter or fiberscope or Baileys manoeuvre
Consider need for rescue technique like surgical airway early

Table 6: Airway management in patients with highly contagious disease like COVID 19

Optimise the patient's condition with adequate hydration and stabilise the haemodynamics.
Proper personal protective equipment (PPE) should be worn by all healthcare workers. The use of PPE (N95 face mask, goggles, face shield, gown, etc) may make communication with members and intubation further difficult.
Airway plan should be prepared beforehand, as appropriate. Fibreoptic intubation and nebulisation should be avoided, unless indicated.
Roles of team members should be delineated beforehand, and closed loop communication should be maintained.
Intubation should be performed by the most experienced physician of the team.
Ensure availability of difficult airway cart, videolaryngoscopes and suction catheters.
Consider using disposable equipment as far as possible.
An intubation box/plastic sheet should be used as barrier between operator and patient.
Preoxygenation for 5 min with 100% oxygen is recommended. A viral filter should be attached between the facemask and breathing circuit.
Perform RSI with cricoid pressure. Use of positive pressure should be avoided prior to securing it but if required, small volume ventilation should be performed.
Immediately inflate the cuff before checking for ventilation.

Role of ultrasound in management of airway emergency

Airway ultrasound has developed in a big way in the last decade. It can be of great help in managing the airway in an emergency. Some of the potential applications of ultrasound for managing AE include diagnosing airway pathology, presence and site of obstruction, measuring diameter of trachea, wall thickness of trachea, estimation of endotracheal tube size, identification of cricothyroid membrane **v**isualisation of epiglottis and vocal cords, **d**iagnosing oesophageal intubation and confirming ventilation using lung sliding sign.[34,35]

Limitations

We have tried to incorporate majority of the commonly encountered clinical conditions and practice essentials for safe management of AE but doing justice to such a vast topic within the prescribed word limits is quite challenging,

Future perspectives

Our aim of this review is to create awareness regarding management of AE to reduce these preventable morbidity and mortality. There is lack of consensus on best technique for oxygenation and airway instrumentation in emergency setting due to lack of randomised controlled trials. As an alternative, we suggest use of causal models with counterfactual concepts[36] (e.g., marginal concept models) that will robustly infer causal relationship between an intervention and patients' outcome from observation data. Establishing institutional guidelines and DART are additional safety measures that should be considered.

We also anticipate wider role of newer equipment like videolaryngoscopes, imaging modalities like 3D printing, virtual imaging and ultrasonography during assessment and management of AE in future.

CONCLUSION

AE have multiple etiological factors but have a common feature and consequence of risk of hypoxia and aspiration. AE can occur in prehospital settings, during transfer of patients and in the in-hospital settings. We should always be ready with the strategies for managing these patients with early diagnosis and appropriate interventions to prevent permanent morbidity or mortality. A systematic approach with immediate call for help could save the day for both clinician and the patient.

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Conflicts of interest

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