1. Airway Management

Tracheal intubation is one of the most commonly performed procedures in the ICU. In the ICU, unlike in the operating room with controlled conditions, a significant proportion of these procedures can be associated with life-threatening complications. This chapter gives a stepwise approach to airway management in the ICU, along with a detailed description of the preparation, assessment, procedure, precautions, main- tenance, and complications associated with tracheal intubation.

Step 1: Be prepared for advanced airway management before arrival

- History from the treating team will give you some idea of the equipment and expertise needed for airway management (e.g., mental state, respiratory and hemodynamic status, time of last feeding, comorbidities that might complicate airway management, and contraindications to succinylcholine/other drugs).
- Check oxygen source, properly working suction, airway tray/cart, monitors, drugs, and personal protection equipment are ready.

Step 2: Initial assessment, preoxygenation, and ventilation

Remember, failure to intubate will not harm a patient but failure to oxygenate/ ventilate will. Ensure adequate oxygenation at all times.

- Critically ill patients may have oxygen transport limitation and time-consuming airway management. During apnea, the time for oxyhemoglobin desaturation below 85% is much faster in these patients. Thus, maximal preoxygenation (at least 3 min) is recommended to buy adequate time to tolerate apnea during intubation.
- Instead of a simple facemask, give high-flow oxygen (12–15 L per min) using the mask and AMBU bag with a reservoir bag. This way you will be ready to ventilate if required and can give higher oxygen concentration (provide 100% oxygen).
- Check breathing, with the airway open (head-tilt/chin-lift/jaw-thrust maneuver), look for adequate chest expansion and rate of breathing, listen for audible breath sound (also auscultate chest), and feel for airflow.
- If the patient is not breathing adequately with airway open, perform bag-mask ventilation with a reservoir bag attached. Ensure adequate chest rise. Hold the mask with both hands if ventilation is difficult.
- Bag-mask ventilation may be difficult in the following cases: obesity, presence of a beard, facial deformity/dressing, massive/heavy jaw, large tongue, edentu- lousness, any airway pathology, poor neck extension, history of snoring, and obstructive sleep apnea.
- Clear upper airway obstruction if present:
    - Snoring, gurgling sound, paradoxical movement of the chest wall (inward movement during inspiration) and abdomen and inadequate/absent chest rise during ventilation may suggest upper airway obstruction.
    - Perform an oral or nasal (with soft malleable catheter) suctioning for no more than 10 s at a time and resume oxygenation soon after.
    - Use an oropharyngeal or nasopharyngeal airway if obstruction is not cleared by suctioning. The airway should have a length equivalent to distance from the tip of the nose/angle of the mouth to the tragus. Nasopharyngeal airway diameter should be less than the patient's nostril. It should be avoided if the patient has risk of nasal trauma/bleeding or cerebrospinal fluid rhinorrhea.
- Currently it is recommended to preoxygenate using noninvasive positive pressure ventilation in case of acute respiratory failure whenever possible. Use pressure support ventilation with FiO_2 of 1.0, inspiratory pressure support from 5 to 15 cmH_2O, to obtain an expiratory tidal volume between 6 and 8 mL/kg and positive end-expiratory pressure of 5 cmH_2O.

- Attach the cardiac monitor, noninvasive blood pressure, and pulse oximeter and secure the intravenous line. These setups should not hamper/delay ventilation and oxygenation.

Step 3: Assess the need for tracheal intubation

- Look for clinical signs of acute respiratory failure: anxiousness, sweating, rest- lessness, cyanosis, shortness of breath, rapid breathing and air hunger, use of accessory muscles of ventilation, paradoxical abdominal breathing, exhaustion, confused state or drowsiness.
- Arterial blood gas analysis may help measure disease severity. However, it should not replace clinical evaluation or delay need for airway intervention.
- Common indication of endotracheal intubation are as follows:
    - Facilitation of invasive mechanical ventilation (inadequate oxygenation/ ventilation, shock, cardiac arrest, avoidance of hypercarbia, controlled hyperven- tilation, need for neuromuscular paralysis, postoperative elective ventilation)
    - Protection of the respiratory tract from aspiration of gastric contents
    - Tracheobronchial toilet
    - Relief of upper airway obstruction

Step 4: Assessment for difficult intubation

- Several methods are available; however, they are often impractical to use and also difficult to assess in the ICU unlike in the operating room, especially during emergency airway management.
- Generally accepted, independent predictors of difficult airway in controlled setting which can be quickly and easily assessed are as follows:
    - Length of upper incisor—relatively long
    - Interincisor distance—less than two fingers (3 cm)
    - Overbite—maxillary incisors override mandibular incisors
    - Temporomandibular joint translation—cannot place mandibular incisors anterior to maxillary incisors
    - Mandibular space compliance—small, stiff, indurated, or occupied by mass
    - Thyromental distance—less than three fingers (6 cm)
    - Mallampati class—III and IV (Table 1.1 and Fig. 1.1)
    - Neck—short, thick
    - Limited neck mobility—cannot touch chin to chest or cannot extend neck
- Despite outward appearances, a history of difficult intubation may be the most reliable predictor of future difficult intubation.
- Call for help in advance if difficulty in oxygenation, ventilation or intubation is anticipated.

Step 5: Checklist before intubation

Providing adequate ventilation is a priority over intubation. Hence, do not attempt intubation until everything is ready. Before intubation, check the following:

- Fasting status
- Oxygen source and working suction
- Monitoring present (cardiac monitor, noninvasive blood pressure, pulse oxime- ter). Intra-arterial pressure monitoring is preferable and may be considered prior to nonemergency intubations especially in patients with shock.
- The intravenous line is secured. Fluid loading is recommended (isotonic saline 500 mL or colloid 250 mL) in absence of cardiogenic pulmonary edema. Be prepared to treat hypotension.
- All airway equipment are at hand (Table 1.2) and checked.
    - Working laryngoscopes (two blades—one standard blade and one long blade): Check light.
    - Endotracheal tubes (ETTs): Keep appropriate size tube ready (at least two). Check cuff for leaks and apply jelly on the cuff. The ETT with subglottic suction should preferably be used for all patients in whom prolonged intuba- tion is anticipated.
- All the appropriate drugs are drawn up and ready (Table 1.3).

- Personal protection is adequate (gloves, mask, and eye protection) and expert help is available in case of anticipated difficult airway.
- If the patient is to be ventilated, set up the ventilator and prepare drugs for long-term sedation.

Step 6: Proceed with tracheal intubation

- *Proper positioning* (refer to Fig. 1.2)
    - Remove the head board and position the patient's head at the edge of the bed resting on a pillow of at least 10 cm thickness, with the forehead at the level of operators xiphisternum.
    - Flex the patient's neck and extend the head (sniffing position). This aligns the oral, pharyngeal, and laryngeal axes making pathway from lips to glottis nearly in a straight line.
    - In patients with suspected cervical spine injury, maintain the head in neutral position and give manual in-line cervical stabilization. Use the cervical collar at all times during airway manipulations.
- *Drug therapy (preintubation)*: The choice of agents (Table 1.3) will depend on the hemodynamic status of the patient and the anticipated nature of difficulty in intubation.
    - Patients may be given intravenous fentanyl, morphine, or midazolam. Physicians with appropriate experience may choose to use anesthetic induction agents such as ketamine, thiopentone sodium, propofol, or etomidate. These drugs should be given slowly to effect with or without muscle relaxants. Intravenous ketamine, unless contraindicated, is the preferred induction agent, especially in hemodynamically unstable patients.
    - Etomidate is cardiostable, but there are concerns of adrenal insufficiency following even a single dose.
    - Propofol can cause profound hypotension and myocardial depression and should be used with extreme caution.
    - Rapidly acting muscle relaxants such as succinylcholine/rocuronium may be used for rapid sequence intubation. Succinylcholine is used only in absence of hyperkalemia, severe acidosis, acute or chronic neuromuscular disease, exten- sive burn, and cervical trauma.
    - Longer-acting muscle relaxants (e.g., atracurium and vecuronium) should be given only after confirming that ventilation is possible.
    - Note that in sick, fatigued patients, very small drug doses may be sufficient. Inject drugs very slowly and until effect (do not give calculated/standard induction doses).
- *Rapid sequence intubation (RSI)*: As most ICU patients are at a risk of aspiration, this sequence should preferably be performed during all intubations.
    - After giving adequate preoxygenation and proper position, cricoid pressure is given just before the beginning of induction. As soon as the patient is asleep, increase the pressure.
    - Use only rapidly acting muscle relaxants (suxamethonium or rocuronium) while maintaining cricoid pressure.
    - Only if saturation is not maintained, give gentle positive pressure ventilation (modified RSI).
    - Perform laryngoscopy and intubation. Hold the laryngoscope handle in the left hand. Open the mouth of the patient with the thumb and the index finger of the right hand. Insert the laryngoscope blade gently into the mouth from the right-side angle of the mouth and move it to the left side taking the tongue along with the blade as it is inserted further inside the mouth. When the epi- glottis is visualized, insert the curved blade into the vallecula and pull the laryngoscope forward and upward to expose the glottis (Fig. 1.3). Now, insert the ETT using the right hand between the vocal cords under direct vision.
    - For nasal intubation, use prior nasal mucosal vasoconstrictors and lubrication; Magill's forceps may be used to guide the tube into the trachea.
    - Optimal external laryngeal manipulation (OELM) with the right hand or by an assistant by quickly pressing in both cephalad and posterior direction over the thyroid, cricoids or hyoid cartilage may be used to further optimize laryn- goscopic view.

    - Use of stylet in ETT, bougie (a thin long plastic/rubber cylinder with a bent tip that is passed through the partially visible glottic opening and then the ETT is guided over it), or other airway adjunct can aid oral intubation.
    - After intubation, inflate the ETT cuff just enough (usually 4–6 mL) to avoid pharyngeal leak during ventilation.
    - Release cricoid pressure only after intubation, cuff inflation, and confirmation of tube placement.
- *Confirm tracheal tube placement* (clinically by auscultation over the stomach and lungs (5-point auscultation): The gold standard to confirm correct tube place- ment is by using end-tidal CO_2 with a portable capnograph (wait to see five to six waveforms before confirmation). Disposable calorimetric CO_2 detectors devices may be used instead. If in doubt, confirm by direct visualization of the tube between cords. If still in doubt, take it out and continue bag-mask ventilation.
- *Proper tube positioning* (ideally 2.5–4 cm above carina): Confirm bilaterally equal chest expansion and air entry in the lungs by auscultation. Using depth of tube insertion (i.e tube fixation at 20 cm. mark for females and 22 cm. mark for males at the incisor level) is most superior method to determine proper tube posi- tion in adults. When all above 3 methods are combined, the sensitivity is 100% and the specificity is 95%. Make a note of the exact distance of the ETT at the lips/nose on the case notes and ICU chart. This position should be noted daily during every nursing shift.
- *Tube fixation*: Secure the ETT with two tube tapes and preferably also a tube tie or use a commercial ETT fixator. Insert an oro/nasogastric tube under direct vision.
- Anticipate and treat hypotension with vasopressors and colloids.

Step 7: Steps after tracheal intubation

- Initiate mechanical ventilation if required.
- Give analgesia and sedation as required.
- Obtain chest radiograph to confirm tube position, bilateral lung expansion, and oro/nasogastric tube position.
- Do not start feeding until position of oro/nasogastric tube is confirmed on chest radiograph.
- Check the ETT cuff pressure using the cuff pressure machine and maintain it below 20 mmHg at all times.

Step 8: Management of a difficult airway

- *Anticipated difficult airway*
    - Ensure that expert airway help is available before attempting tracheal intubation.
    - If ventilation is not possible, avoid the use of muscle relaxants.
    - An awake fiber optic intubation with the flexible fiberscope is the gold stan- dard for an anticipated difficult airway and can be used for both oral and nasal intubations. It should be considered as the first option rather than the last resort in such a situation.
    - Video Laryngoscopes may be used if available and will give an optimum view, making intubation easier, especially in a difficult airway setting.
- *Unanticipated difficult airway* (Fig. 1.4)

Step 9: Watch for and treat immediate complications of endotracheal intubation

- Esophageal intubation/endobronchial intubations/accidental ETT disconnec- tions—atelectasis formation/collapse in the unventilated lung and hyperinflation and barotrauma with development of pneumothorax of the intubated lung (in endobronchial intubations) can cause profound hypoxemia manifesting as bradycardia and even progressing to cardiac arrest
- Hypertension, tachycardia, raised intracranial pressure, and myocardial ischemia due to stimulation from laryngoscopy and intubation
- Hypotension due to loss of sympathetic tone from drugs for intubation or dynamic hyperinflation due to hyperventilation or relative dehydration

- Aspiration of gastric contents
- Airway trauma, bleeding
- Negative pressure pulmonary edema after sudden relief of severe airway obstruction
- Cardiac arrest

Step 10: Follow a protocol for airway maintenance

- Proper maintenance of the airway will reduce the incidence of accidental extuba- tions, disconnections, tube blockage, and nosocomial pneumonia.
- Keep the head elevated at 30–45°.
- All ETT and tracheostomy tubes (TT) should be checked for position at incisor teeth/alae nasi, adequate fixation, patency, tracheal cuff pressure (<20 mmHg), and pharyngeal leak during each shift and should be documented.
- In case of oral ETTs, secure firmly at the angle of the mouth and change position preferably every 24 h to avoid sores/ulcers.
- Oral ETTs (without subglottic suction) should be cut 2–3 cm from the angle of the mouth.
- The universal connector should be pushed right down to its shoulder to avoid accidental disconnections.
- Confirm correct positioning of ETTs above the carina on the X-ray and document in the case notes.
- All ventilated patients should receive humidification (with HME (Heat and Moisture Exchanger) filter or using a heated humidifier circuit).
- ETT/TT suction should be done only when required and preferably using a closed suction system.
- Sedate patients well when they need to remain intubated. Do not allow them to get restless.
- Start weaning the patient off sedation, only in the daytime when ICU staff is in adequate strength.
- Do not leave the patient unattended when sedation has been turned off and the patient is just about waking up. Reassure patients as they wake up from sedation.
- Apply boxer gloves/bandages to those patients who appear agitated. Refrain from tying patient's limbs.
- Report any airway accident as a "critical incident."

Step 11: Extubation of the airway (refer to Chap. 7)

- Perform a good oral and endotracheal suction prior to extubation.
- Keep all equipment ready for reintubation/noninvasive ventilation if required.
- Do a cuff-leak test (especially after prolonged intubations)—deflate the ETT cuff and check for air leak around the cuff. If absent, suspect laryngeal edema. Consider the use of steroids and plan extubation at a later date over a tube exchanger.
- Intravenous methylprednisolone started 12 h before a planned extubation has been shown to substantially reduce the incidence of postextubation laryngeal edema and reintubation in patients intubated for more than 36 h and having absent cuff leak.
- In a patient with a difficult airway, ensure that expert airway help is available prior to extubation and extubate preferably over a tube exchanger. Oxygenate the patient through the exchanger and remove it only when you are sure that the airway is not compromised/obstructed. If in doubt, pass the ETT back inside over the tube exchanger and secure in place.

Step 12: Continue to watch for and treat complications of tracheal intubation (days to months after extubtion)

- Sore throat
- Airway edema
- Airway infections/pneumonia
- Laryngeal damage/granuloma
- Tracheal stenosis, tracheomalacia, trachea-esophageal fistula

Questions

Q1. How does one prepare for advanced airway management, even before the patient has arrived?

Q2. How do you do the initial assessment of the patient before oxygenation or ventilation?

Q3. How do you assess a ICU patient's need for tracheal intubation?

Q4. What are the checks one needs to perform before intubation?

Q5. How do you position the patient's head for tracheal intubation?

2. Noninvasive Positive-Pressure Ventilation

Noninvasive positive-pressure ventilation (NIPPV) augments spontaneous ventila- tion using the tight-fitting nasal or oronasal mask without endotracheal intubation. This can be used in a large number of conditions if there is no contraindication. The application of NIPPV should not delay clinically indicated endotracheal intubation.

Step 1: Initial resuscitation

- The patient should be resuscitated as mentioned in Chap. 78.
- The first step after resuscitation would be to quickly examine the patient in detail.
- Look for hemodynamic instability, sensorium, and oxygenation by pulse oximetry.
- If SpO_2 is low, give oxygen—not more than 1–2 L/min. Titrate oxygen to minimum flow to keep SpO_2 at 87–92%.
- Check arterial blood gas (ABG) and initiate other investigations as mentioned below:
    - Hemogram, blood urea, serum creatinine, and serum electrolytes
    - Blood and sputum culture if infection is suspected
    - Chest skiagram
    - Electrocardiogram (ECG) and Echocardiogram (Echo)
- Disease-specific treatment such as bronchodilators (salbutamol and ipratropium nebulization), antibiotics, corticosteroids should be started.

Step 2: Assess the need of NIPPV

- In addition to the rest of the treatment, NIPPV should be applied simultaneously to a patient in acute respiratory failure (ARF), based on the clinical criteria (Table 3.1), provided there is no contraindication.
- There are no absolute contraindications for the use of NIPPV. Some contraindi- cations have, however, been suggested (Table 3.2).
- NIPPV is indicated in patients with appropriate diagnosis and proven evidence of effectiveness of NIPPV if any two of the clinical criteria are fulfilled (Table 3.1).

Step 3: Application of NIPPV

Protocol for application of NIPPV: For successful NIPPV, it is important to fine-tune the patient, interface, and ventilator.

- Patient interface—nasal or oronasal mask.
- Mode of ventilation:
    - Bilevel positive airway pressure—spontaneous or spontaneous/timed mode in portable pressure ventilators or NIPPV option on conventional ventilators.
    - Pressure support/pressure control/volume control—conventional ventilators.
- Explain the therapy and its benefit to the patient in detail. Also, discuss the possibility of intubation.
- Choose the correct size interface. The oronasal mask is preferred in ARF.
- Set the NIPPV portable pressure ventilator in spontaneous or spontaneous/timed mode.
- Start with very low settings, low inspiratory positive airway pressure (IPAP) of 6–8 cm H_2O with 2–4 cm H_2O of expiratory positive airway pressure (EPAP). The difference between IPAP and EPAP should be at least 4 cm H_2O at all times.
- To start with administer oxygen at 2 L/min.

- Hold the mask with the hand over the face. Do not fix it.
- Increase EPAP by 1–2 cm increments until the patient's inspiratory efforts are able to trigger the ventilator.
- If the patient is making inspiratory effort and the ventilator does not respond, it indicates that the patient has not generated enough respiratory effort to counter auto-PEEP and trigger the ventilator (in COPD patients). Increase EPAP further until this happens. Most of the patients require EPAP of about 4–6 cm H_2O. Patients who are obese or have obstructive sleep apnea require higher EPAP to trigger the ventilator.
- When the patient's effort is triggering the ventilator, leave EPAP at that level.
- Now, start increasing IPAP in increments of 1–2 cm up to a maximum pressure, which the patient can tolerate without discomfort and there is no major mouth or air leak.
- In some NIPPV machines, inspiratory time (T_i) can be adjusted. Setting the T_i at 1 s is a reasonable approach.
- Now, secure interface with head straps. Avoid excessive tightness. If the patient has a nasogastric tube, put a seal connector in the dome of the mask to minimize air leakage.
- After titrating the pressure, increase oxygen to bring oxygen saturation to around 90%.
- As the settings may be different in wakefulness and sleep, readjust them accordingly.

When NIPPV is being initiated for ARF, close monitoring and the capability to
initiate endotracheal intubation and other resuscitation measures should be avail- able in the same setup. Start NIPPV preferably in the intensive care unit or in the emergency room in ARF.

Application of NIPPV using a critical care ventilator

- The first step is to select a ventilator, which is capable of fulfilling the needs of the patient.
- Explain the therapy to the patient.
- Choose the appropriate mode. Usually, pressure support or pressure control modes are preferred. Standard critical care ventilators using flow-by system (noninvasive mode option) allow the patient to breathe without expending effort to open valves. In selected patients, such as those suffering from neuromuscular diseases, volume assist or volume control mode may be used.
- Choose an appropriate interface.
- Silent ventilator alarms.
- Keep FiO_2 at 0.5.

Using pressure support/control approach

- Start with low settings such as inspiratory pressure support at 5–6 cm H_2O and PEEP at 4 cm H_2O.
- Initiate NIPPV while holding the mask in place and confirm optimum fit. If it is big or small or loose, change it.
- Hold the mask. Do not fix the headgear.
- Now, increase PEEP until inspiratory efforts are able to trigger the ventilator.
- If the patient is making inspiratory effort and the ventilator does not respond, it indicates that the patient has not generated enough respiratory effort to counter auto-PEEP and trigger the ventilator (in COPD patients). Increase PEEP further until this happens.
- Once the patient's inspiratory efforts trigger the ventilator, start increasing pres- sure support further, keeping the patient's comfort in mind. (Reduced respiratory rate, reduced use of respiratory accessory muscle, etc.) Ensure that there are no major leaks.
- When there is significant mouth leak, there may be asynchrony. In that case, pressure control will be the preferred mode of NIPPV and the T_i can be set to avoid asynchrony.
- Increase fraction of oxygen concentration to maintain oxygen saturation more than 90% at all times.
- Secure interface with the headgear. It should be tight, but not overtight. Small leaks are acceptable.
- A peak inspiratory pressure of more than 25 cm is rarely required in COPD, but higher pressures can be used when using NIPPV for other indications. PEEP is usually titrated between 5 and 10 cm H_2O to improve triggering and oxygenation.

Step 4: Patient must be monitored very closely

- The patient must be monitored very closely clinically (Table 3.4). All this must be documented every 15 min for the first hour in the clinical notes.
- The patient will show improvement in parameters if NIPPV is effective.
- ABG sample should be sent after 30 min to 1 h after the application of noninva- sive ventilation.
- In ventilator setting, look for air leaks, triggering and patient–ventilator interaction.

Step 5: Continuously look for complications and manage them

- Monitor carefully the worsening respiratory distress, sensorium, tachypnea, and deteriorating blood gases, and intervene early because delay in intubation is a very common major complication of NIPPV.
- Most complications are minor that can be managed very easily, and so every attempt should be made to continue NIPPV.
- It is extremely important for the air seal to be tight. Ulceration and pressure necrosis related to local skin effects commonly occur at the bridge of the nose. Protective synthetic coverings may help prevent skin breakdown and ulceration on the bridge of the nose.
- Eye irritation and pain or congestion of the nasal sinuses may occur. Put some decongestant nasal drops.
- Distension of the stomach due to aerophagia and aspiration can occur secondary to vomiting. A nasogastric tube can be used to relieve the distension while still allowing the mask to seal.
- Adverse hemodynamic effects from NIPPV are unusual, although preload reduction and hypotension may occur. Give intravenous fluids.

Step 6: Discontinuation of NIPPV

It is very important to know when to discontinue NIPPV and intubate and ventilate the patient.

- NIPPV failure
    - Worsening mental status
    - Deterioration of pH and $PaCO_2$ after 1–3 h of therapy
    - Refractory hypoxemia—when even a brief discontinuation of NIPPV leads to significant fall in oxygen saturation
- Intolerance to NIPPV
- Hemodynamic instability.
- Inability to clear secretions.

Step 7: Weaning

- Initially, give NIPPV continuously as long as possible.
- Once the patient is tolerating periods off NIPPV, start discontinuing during daytime and give during nighttime. In 2–3 days, the patient can be weaned off the NIPPV.
- A brief outline of the application of NIPPV is shown in Fig. 3.1.

Questions

Q1. How do you assess the need for NIPPV?

Q2. Describe the protocol for the application of the NIPPV

Q3. How do you monitor a patient who is on Noninvasive positive-pressure ventilation?

Q4. What are the types of complications to look for for a patient undergoing NIPPV and how do you manage them?