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12.1 Introduction

Cancer incidence and mortality is on the rise across the globe. The 2011 political declaration on prevention and control of non-communicable diseases aims to reduce the mortality due to non-communicable diseases by 25% till year 2025 [1]. Global Burden of Disease Cancer Collaboration has estimated that there were 24.5 million new cancer cases in the year 2017 [2]. In the same year, there were 9.6 million deaths and 233.5 Disability Adjusted Life Years (DALY) lost due to cancer [2]. In India also, deaths due to cancer have doubled from 1990 to 2016 [3]. It is estimated that there were 1.15 million new cancer cases in India in 2018 and this figure is likely to double by the year 2040 [3].

Over last few decades, the advances in management of cancer have resulted in a substantial increase in number of patients living with cancer. This has increased the number of patients with cancer requiring admission in intensive care unit (ICU). ICU admission contributes to a significant proportion of health care costs. In a study conducted at University of Texas, Anderson Cancer Centre, authors investigated the use of ICU care and outcomes among patients admitted to a comprehensive oncology care centre between 1st January 1994 and 31 Dec 2013 [4]. There were over 380,000 patient admissions during the study period and the ICU utilization rate was 12.9%. For all inpatients, sepsis, pneumonia and other infections were the cause for highest mortality (8.5%) [4]. Various studies have shown that 5–10% of cancer patients will develop a life threatening illness requiring ICU admission [5]. Patients with hematological malignancies have higher utilization of ICU [5]. The survival rates in cancer patients admitted to ICU have been meaningful in recent times, albeit higher than general population of critically ill patients [6]. Hospital mortality in mechanically ventilated cancer patient has also shown a decline from 90 to 60%

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over time [6]. These improvements may be attributable to improved cancer care as well as improvement in supportive care such as availability of better drugs for management of neutropenia and fungal infections [6].

12.2 Requirement of ICU in Oncology Patients

Acute respiratory failure is a common and dreaded complication in both hematological and solid organ malignancies. Azoulay et al. [7] conducted a 5-year study at a teaching hospital in Paris. During the period, a total of 3782 patients with hematological or solid organ malignancies were admitted to the centre. Of these, 203 (5.4%) required ICU admission for Acute Respiratory Failure (ARF) and 97 (47.7%) of the patient with ARF died. The most common cause of ARF in this study was infectious pneumonia (58%). No cause could be identified in 21% patients [7]. This is relevant as the mortality in this subset noted in this study was 64% which was more than the overall mortality noticed in patients with ARF.

Anisoglou et al. studied the outcomes of 105 lung cancer patients admitted to ICU with ARF [8]. The authors noted an in hospital mortality of 56.1%. These studies show the seriousness of ARF in a patient with underlying hematological or solid organ malignancy. They also reflect that approximately one out of two patients requiring ICU admission with ARF and an underlying malignancy is likely to survive.

Causes of ARF in patient with underlying malignancy are variable [9]. ARF can be due to the underlying malignancy or drugs used for the treatment. The causes of ARF among patients with malignancy are summarized in Table 12.1.

Table 12.1 Causes of Acute Respiratory Failure (ARF) in patients with Malignancy

Compartment involved	Related to underlying malignancy	Related to treatment
Parenchymal	<ul style="list-style-type: none"> • Mass Lesion—large mass causing V/Q mismatch • Lymphangitis • Carcinomatosis 	<ul style="list-style-type: none"> • Pneumonitis or ARDS: due to infection, chemotherapy, or radiotherapy • HSCT: Peri-engraftment syndrome, diffuse Alveolar Haemorrhage, Bronchiolitis obliterans organizing pneumonia (BOOP) • Drugs—bleomycin, methotrexate etc.
Vascular	<ul style="list-style-type: none"> • Acute pulmonary thromboembolism • Tumour embolism 	
Pleural	<ul style="list-style-type: none"> • Malignant pleural effusion 	<ul style="list-style-type: none"> • Drug induced pleural Effusion—bleomycin, methotrexate, cyclophosphamide etc.
Chest wall disorders	<ul style="list-style-type: none"> • Chest wall tumor • Rib fractures 	
Airway	<ul style="list-style-type: none"> • Endobronchial metastasis 	
Respiratory Drive/ Neuro-Muscular Disorder Related	<ul style="list-style-type: none"> • CNS metastasis • Paraneoplastic syndromes • Lambert Eaton Syndrome, myasthenia gravis 	<ul style="list-style-type: none"> • Overdose of narcotics

12.3 Respiratory Interventions in Oncology ICU

Respiratory interventions in patients with malignancy and admitted in ICU are important armamentarium for the diagnosis of the cause as well as the management of ARF. For example, bronchoscopic BAL is the investigation of choice for the microbiological diagnosis of pneumonia in these patients. Similarly, there are rigid bronchoscopic interventions which may be life-saving for the patients with malignant central airway obstruction (CAO). The summary of possible respiratory interventions in critically ill patients with solid organ or hematological malignancy is provided as Table 12.2.

12.3.1 Flexible Bronchoscopy

Flexible bronchoscopy (FB) has been used ICU, with a considerable success, for various diagnostic and therapeutic indications. However, use of FB in ICU has its own set of challenges. Therefore, it is important to know the indications and complications associated with bronchoscopy in critically ill patients.

Indications for bronchoscopy in oncology ICU may be diagnostic or therapeutic [10].

Diagnostic indications:

1. Evaluation of pulmonary infiltrates
2. Hemoptysis evaluation
3. Airway assessment in cases of suspected central airway obstruction (CAO) or bronchial obstruction
4. Suspicion of tracheo-esophageal Fistula (TEF)

Table 12.2 Respiratory interventions in the oncology ICU

Conditions	Diagnostic interventions	Therapeutic interventions
Pneumonia/ARDS	<ul style="list-style-type: none"> • Broncho alveolar lavage • Bronchial washings • Brush cytology • Trans bronchial lung biopsy 	<ul style="list-style-type: none"> • High flow nasal cannula (HFNC) • Non-invasive ventilation (NIV) • Invasive mechanical ventilation (IMV)
Tracheal/endobronchial tumour/metastasis	<ul style="list-style-type: none"> • Flexible bronchoscopy 	<ul style="list-style-type: none"> • Cryo-extraction • Diode laser • Argon plasma coagulation • Photodynamic therapy • Rigid bronchoscopy with mechanical debulking
Malignant Pleural Effusion	<ul style="list-style-type: none"> • Diagnostic pleurocentesis/pleuroscopy 	<ul style="list-style-type: none"> • Small/large bore ICD placement • Indwelling pleural catheter • Pleurodesis (thoracoscopic or via ICD)

Therapeutic indications:

1. Lung/Lobar collapse not improving with physiotherapy
2. Management of CAO/bronchial obstruction
3. Bronchoscopic intubation
4. Percutaneous tracheostomy

Critically ill patients are at a higher risk of complications during bronchoscopic procedures [11]. The factors which predispose ICU patients to a higher complication rate include presence of hypoxemia, hypotension, renal failure, thrombocytopenia and use of anticoagulant/anti-platelet drugs. It should be noted that partial pressure of oxygen (PaO_2) usually falls by 10–20 mm Hg after bronchoscopy even in non-critically ill patients, hence, there is risk of pre-exiting hypoxemia [12]. In critically ill patients, FB is frequently performed on patients who are on invasive or non-invasive ventilation. There are general principles guiding the FB procedure in ICU [10, 11]. We suggest following step to minimize the complications—

1. Pre-oxygenation with 100% Oxygen for 5–10 min prior to procedure
2. Titrate FiO_2 and PEEP during the procedure to maintain $\text{SpO}_2 > 90\%$ during procedure and in the immediate post procedure period
3. Controlled mode should be preferred in patients on mechanical ventilation. Increase in PIP (Peak Inspiratory Pressure) alarm limits to allow adequate volume delivery is also recommended
4. Continuous monitoring of vital parameters (Heart rate, Blood pressure, SpO_2 , ECG) is essential
5. In patients on Endotracheal/Tracheostomy tube the diameter of tube should be at least 2 mm more than the outer diameter of the bronchoscope. This helps in allowing delivery of tidal volume (V_T) and reduces development of auto PEEP.

It usually takes 24 h for the respiratory mechanics in critically ill patients to return to baseline after FB. Close monitoring for initial 24 h after procedure is essential [12]. It is important to note that although use of FB for removal of retained secretions (pulmonary toilet) is often practiced, it's routine use is not evidence based [12]. Respiratory therapy alone has performed equally well in randomized control trials and should be utilized before resorting to FB [11]. Routine use of BAL for diagnosis of VAP in critically ill patients is not recommended due to lack of mortality benefits as compared endotracheal aspirate ET aspirates.

12.3.2 Rigid Bronchoscopy

Rigid bronchoscopy is an invasive procedure that can visualize oropharynx, vocal cords, trachea and main bronchi and done under general anesthesia either in operation theatre or bronchoscopy suite. Rigid bronchoscopy provides a better airway control, hence is ideal tool for therapeutic purposes. The indications of rigid bronchoscopy include therapeutic interventions for management of CAO, hemoptysis, deeper biopsies etc.

Central airway obstruction (CAO) is defined as an obstruction involving trachea or main stem bronchus and can occur due to a primary or metastatic thoracic malignancy [13]. Primary endoluminal malignancies as cause of CAO are less common as compared to airway metastasis [14]. Common malignancies causing metastasis to airway include renal, breast, thyroid and colon [14]. CAO can be classified as endoluminal, extraluminal or mixed (having both endoluminal and extraluminal components) [14].

Usual symptoms of CAO include breathlessness, wheeze or stridor. Respiratory distress develops with advanced airway obstruction (usually tracheal lumen <5 mm) and majority of these patients present with acute respiratory failure without any significant previous symptoms [14]. Extent and location of CAO is important for choosing appropriate therapeutic modality. While a unilateral wheeze indicates focal airway obstruction, stridor is indicative of severe laryngeal or tracheal obstruction. Chest radiographs have limited utility for diagnosis, location and extent of lesion causing CAO [13]. Computerized tomography (CT) scan of the thorax is the imaging modality of choice for evaluation of CAO. Virtual bronchoscopic evaluation of the endoluminal airways and 3-D reconstruction of structures surrounding the airways can provide a comprehensive evaluation of CAO [13]. Also, CT scan can be helpful in determining minimum size of the airways, length and site of obstruction, and patency of airways distal to the obstruction [14].

The principles of CAO management follow the standard guidelines for any unstable patient with airway stabilization being the first priority. For patient with doubtful airway stability, rigid bronchoscopy is the procedure of choice; as it will help in securing the airway, provide excellent oxygenation and ventilation and also allow a therapeutic intervention such as “coring” or “debulking” of a tumor, dilatation of a stenosis, and placement of stent [14]. In patient deemed to have relatively stable airway with CAO, tracheostomy in proximal CAO and endotracheal intubation in patients with distal obstruction may be tried in a controlled environment with availability of intervention at a short notice. The various modalities employed for management of CAO could include “hot therapies” such as electrocautery, Argon Plasma Coagulation, Laser therapy, Photodynamic therapy or “Cold therapies” such as cryotherapy [14]. Although success rate of therapeutic bronchoscopy is high, there are significant complications—hypoxia, pneumothorax, bleeding, hypotension and increase in level of care [13]. Patient with poor ASA (3 or 4) and poor performance status (Karnofsky Performance Scale below 70) are at a higher risk of complications [13].

12.4 Tracheostomy in Oncology ICU

In oncology patients, apart from upper airway obstruction and airway protection, prolonged mechanical ventilation may be an indication for tracheostomy [15]. Tracheostomy may be performed via surgical or percutaneous methods [16]. Surgical tracheostomy in critically ill patients is a cumbersome process requiring transport to surgical operation theatre [16]. While surgical tracheostomy involves full dissection of pre tracheal tissues followed by insertion of tracheostomy tube under direct vision, percutaneous tracheostomy (PCT) utilizes Seldinger technique and blunt dissection of pretracheal tissues [17].

a. **Indications—**

1. Upper airway obstruction
2. Difficult weaning
3. Management of trachea bronchial secretions
4. Prevention of aspiration

b. **Absolute contraindication -**

1. Uncontrolled coagulopathy
2. Unstable cervical spine
3. Infection at the planned site

c. **Procedure:**

Various procedures described to perform PCT include Ciaglia Blue Rhino, Blue dolphin, Grigg's Percu Twist or Fantoni technique. Among these, Ciaglia blue rhino technique is comparatively better than other techniques. There are commercially available PCT sets (Fig. 12.1). In blue rhino technique, a hydrophilic coated curved dilator is used for dilatation of stoma. The dilator is passed over a J-guide wire which is passed into the tracheal lumen through a cannula. Incision is made midway between cricoid and sternal notch [17]. Before initiating the procedure, patient should be placed in a position of neck extension and endotracheal tube (ET) should be

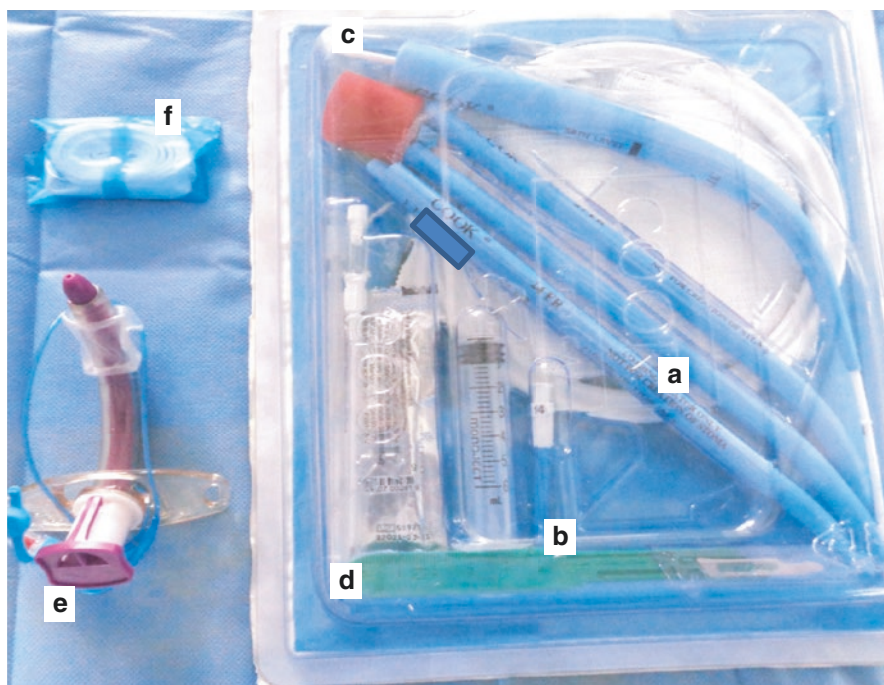


Fig. 12.1 Percutaneous tracheostomy set—various sizes of dilators (a), surgical blade with handle for incision (b), guide wire (c), introducer needle with sheath (d), tracheostomy tube (e), and tie (f)

withdrawn to a level just below the vocal cord. Ultrasonography (USG) should be used to screen the tracheostomy site to look for any blood vessel which may be injured during procedure. Bronchoscope should be passed through ET to visualize tracheal lumen during the procedure. Bronchoscope can also be used to confirm the position of tracheostomy tube once it is passed. The steps of the procedure are described below.

Box 1 Steps of Percutaneous Tracheostomy

1. Written informed consent must be obtained prior to the procedure
2. General anaesthesia is required for performing the procedure.
3. Correct neck position is essential for the procedure. Neck should be in full extension. Towels may be placed under shoulder blades to achieve neck extension
4. USG use is preferred to evaluate the neck anatomy and rule out any large vessels in the operative fields.
5. Sterile precautions must be followed during the procedure. Pre-procedure hand washing, use of sterile gloves and gowns, preparation of site and field with full aseptic measures must be done.
6. Identify the landmarks by palpation. Neck landmarks to be identified include thyroid cartilage, cricoid cartilage and second to third tracheal rings.
7. Make a horizontal incision approximately 2–3 cm between second and third tracheal ring.
8. Do a blunt dissection of pre-tracheal tissue till trachea is clearly palpable.
9. Flexible bronchoscope is introduced through the ET tube and kept inside just proximal to the tip of ET tube. This helps in visualization of the trachea while avoiding injury to bronchoscope during the procedure.
10. Deflate the cuff and withdraw the ET tube to a position where the cuff is just below the glottis. Re-inflate the cuff at this site while maintaining the position of bronchoscope inside the tube.
11. Puncture the anterior wall of trachea using the introducer needle under guidance of bronchoscope.
12. Withdraw the trocar while leaving the sheath in place. Introduce the guide wire through the sheath and visualise it going towards the carina. Once the guidewire is in position, remove the sheath over the guide wire.
13. Use the dilators over the guide wire to dilate the track to place tracheostomy tube.
14. Withdraw the dilator and gently pass the tracheostomy tube over guide wire. Once the tracheostomy tube is in place withdraw the ET tube and bronchoscope.
15. Bronchoscope may be passed through the tracheostomy tube to see the position and distance from carina.
16. Make sure hemostasis is achieved and there is no active bleed.
17. Tie the tracheostomy around the neck with help of tie. Make sure that the tie is not too tight as that may cause interruption of blood supply.

d. Complications

Complication of PCT are similar to surgical tracheostomy. Early complications include formation of false tract, iatrogenic trauma to airways leading to pneumothorax/pneumo-mediastinum/surgical emphysema, hemorrhage and injury to posterior tracheal wall.

Late complications may include displacement, trachea-esophageal fistula, subglottic stenosis, stromal infection and voice change [17].

12.5 Interventions for Malignant Pleural Effusion

Malignant pleural effusion is most commonly seen in lung cancer, breast cancer and lymphoma [18]. Patients usually present with breathlessness (fresh onset or worsening depending on underlying disease), cough and chest pain. Development of malignant pleural effusion usually portends worse prognosis; its presence shifts the treatment goals from curative intent to palliative intent [18].

a. Modalities for management of malignant pleural effusion

Various modalities available for the management of malignant pleural effusion include repeated thoracentesis, placement of intercostal drain (ICD), pleurodesis and indwelling pleural catheter (IPC). The modalities for management of malignant pleural effusion and their indications [19] are as given in Table 12.3.

All pleural interventions in ICU should be carried out under USG guidance. All patients with MPE should initially undergo a therapeutic thoracentesis to confirm relief of symptom and re-expansion of lungs after pleural drainage [19].

Both IPC and tube thoracostomy followed by pleurodesis have been used in patients in MPE. The advantages and disadvantages [20] of both are listed in Table 12.4.

Although VATS/thoracoscopy guided surgical pleurodesis is also possible, it is usually not feasible in ICU patients due to their poor performance status.

Placement of either large-bore chest drain (ICD) or small-bore chest drain (pig tail catheter) may be undertaken for cases with MPE for symptomatic relief and subsequent pleurodesis. Small bore tubes have equivalent success rates as compared to large tube thoracostomy [20, 21]. The advantages of small-bore tubes include lesser pain and better patient comfort.

Table 12.3 Modalities for management of malignant pleural effusion and their indications

MPE management modality	Indications
Repeated therapeutic thoracentesis	<ul style="list-style-type: none"> • MPE with expected survival <3 month
Intercostal Drainage	<ul style="list-style-type: none"> • Therapeutic drainage and pleurodesis
Pigtail Catheter Drainage	<ul style="list-style-type: none"> • Outpatient management of MPE and pleurodesis
Indwelling Pleural Catheter	<ul style="list-style-type: none"> • Failed pleurodesis/symptomatic loculated effusion • Trapped Lung

Table 12.4 Comparison of pleurodesis with IPC

Procedure	Advantages	Disadvantages
Pleurodesis	<ul style="list-style-type: none"> • Rapid resolution of MPE 	<ul style="list-style-type: none"> • More Invasive • Failure is common • Not possible in trapped lung
IPC	<ul style="list-style-type: none"> • Less invasive • Spontaneous pleurodesis may occur over time • Effective in patients with trapped lung • Less requirement of repeated pleural intervention • Less median hospitalization 	<ul style="list-style-type: none"> • Prolonged drainage • Prolonged ongoing care • Costly

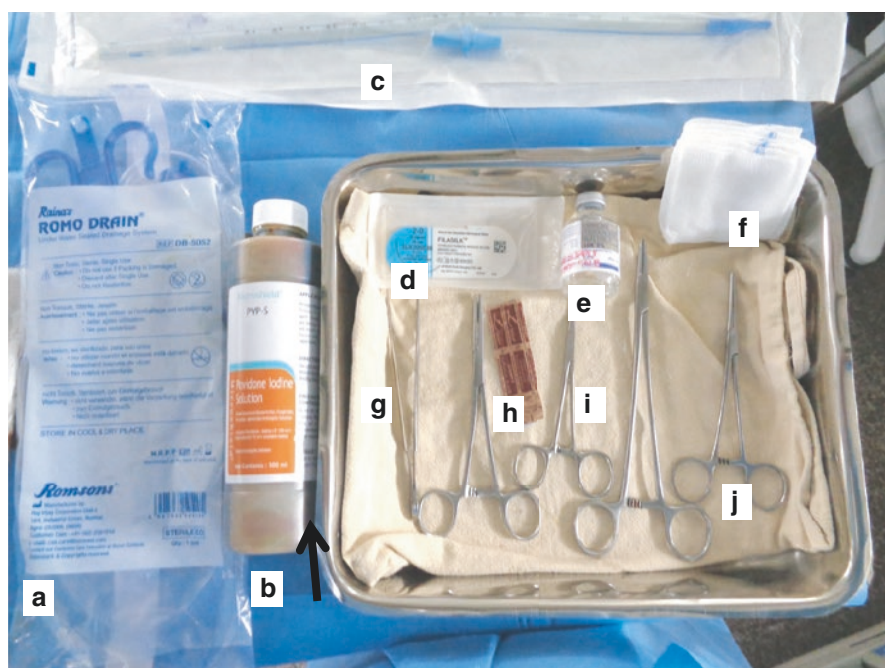


Fig. 12.2 The ICD-set showing various instruments required during the procedure—under water seal (a), povidone iodine (b), inter-costal tube (c), suture (d), lignocaine (e), gauze (f), non-tooth forceps (g), surgical blade (h), needle holder (i), and artery forceps

b. Procedure

Site of maximal effusion should be confirmed on USG and position marked on chest wall. Patient should preferably be in a sitting position, although it will not be possible in patients on mechanical ventilation; in that case patient can be kept in semi-recumbent. If on mechanical ventilation, PEEP should be reduced pre-procedure. We should check that the ICD set is complete (Fig. 12.2). The steps of ICD insertion are summarized in Box 2.

Box 2 Steps for Intercostal Drain Insertion (ICD) Insertion

1. Written informed consent must be obtained prior to the procedure
2. Use Ultrasonography (USG) to ascertain the site and size of effusion. It is essential that USG be used in these patients as localization of effusion on clinical basis will be difficult and to avoid complications related to trauma to vital organs during procedure.
3. Under USG guidance ascertain the depth of fluid from chest wall, site of maximum collection and approximate volume of effusion.
4. Sterile precautions must be followed during the procedure. Pre-procedure hand washing, use of sterile gloves and gowns, preparation of site and field with full aseptic measures must be done
5. Preferred patient position is patient lying at 45 degree with arm behind the head. However in ICU setting it may be required to place an ICD in supine position also.
6. Local infiltration with 2% lignocaine upto a maximum of 3 mg/kg may be used to provide pain relief during the procedure
7. Choose appropriate drain size. Intercostal drain are available in size varying from 12 FG to 34 FG. A small bore ICD may be used for pneumothorax and simple effusion while large bore tube may be used in hemothorax and empyema. Inter costal space available may also be a determining factor in deciding size of ICD. Patient with reduced intercostals space due to chronic collapse or pleural thickening may require a small bore ICD.
8. After adequate local anaesthesia insert a needle from above the lower rib at the site of maximum collection already ascertained. Aspirate fluid or air to confirm the correct position.
9. Make a skin and soft tissue incision using a sterile blade. Do blunt dissection of deeper tissues with forceps. Spread the intercostals muscles on the superior surface of ribs to avoid injury to intercostals bundle in the inferior rib surface.
10. After the track has been created insert the ICD through the track with help of forceps. After pleura is breached gush of air or fluid may be felt. Keep ICD closed till connected to underwater drain
11. Secure the ICD using 1/0 or 2/0 silk sutures
12. Connect the ICD to underwater drain and open the ICD.
13. Do sterile dressing around the tube. Change the dressing every 48 to 72 h.
14. Do a chest radiograph to confirm position of tube

c. Complications

Various complications which may occur during placement of intercostals drain include hemorrhage, lung injury resulting in alveolo-pleural fistula and hydropneumothorax, re-expansion pulmonary edema, vasovagal syncope.

Key Points

- Acute respiratory failure is a common cause for utilization of critical care in patients with haematological/solid organ malignancies. ARF can occur due to myriads of causes.
- Pulmonary interventions such as flexible and rigid bronchoscopy, placement of ICD, and tracheostomy may be very useful for immediate relief of symptoms and reversal of ARF. It is important to ensure correct indication and take adequate precautions while performing the procedure as chances of deterioration in 24 h of procedure are high
- Rigid bronchoscopy is the modality of choice for the management of CAO of malignant etiology.
- Tracheostomy may be required for patients having upper airway obstruction or requiring prolonged ventilation. Percutaneous tracheostomy is a relatively less invasive procedure than surgical tracheostomy and can be performed on bedside thus avoiding risking the transfer of a critically ill patient
- Management of MPE mainly depends on the status of underlying lung. Drainage and pleurodesis are preferable if the lung expands after drainage of fluid. However if the underlying lung is trapped repeated therapeutic thoracocentesis/indwelling pleural catheter may be preferred.

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