Basic principles of respiratory care for patients with tracheostomy

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Abstract

Tracheostomy is a commonly performed procedure in the intensive care unit. Selection of patients for this procedure should be done carefully after understanding the individual risks and benefits. Optimal care begins with the selection of an appropriate tube for the patient from the wide range of tubes available today. Care of the cuff, proper patient positioning, humidification of inspired gases and a well secured tube would avoid undue complications. Adequate support needs to be given to facilitate communication and swallowing. Emergency equipment for tube change should be readily available. A good tracheostomy care plan also includes oral hygiene, infection control practices, wound care and provision of adequate nutrition. Decannulation may fail, if performed without proper assessment of functional and anatomical changes in the airway. A good understanding of the basic principles of respiratory care will provide better outcome in patients with a tracheostomy.

Keywords: Mechanical ventilation, artificial airway, tracheostomy, weaning.

Introduction

Tracheostomy has become a very common procedure in the management of patients who are predicted to have difficulty in weaning from mechanical ventilatory support. Patients who have delayed emergence from coma, cranial nerve dysfunction, high spinal cord injuries, and repeated pulmonary aspiration associated with dysphagia, repeated extubation failures, significant neuromuscular weakness or chronic lung pathology would get benefited from tracheostomy. Advantages of early tracheostomy include faster weaning from mechanical ventilation, shorter ICU stay and decreased risk of hospital acquired pneumonia.[1-3]

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Decision making for tracheostomy

Recent guidelines state that tracheostomy should be performed only after considering clinical benefits and risks for the individual selected. Previously, tracheostomy was recommended only when the patient was on ventilator for a certain period of time.[4] Factors to be considered in the decision making include projected time the patient may need an artificial airway, patient's tolerance of the endotracheal tube (ETT), ability to tolerate a surgical procedure and finally, relative risks of continued tracheal intubation *versus* tracheostomy.

Advantages and complications of tracheostomy

Tracheostomy can reduce the work of breathing (WOB), improve oral and tracheobronchial hygiene,

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encourage early weaning, and improve patient comfort and communication. Major complications associated are failure of cuff to form a seal, subcutaneous emphysema, accidental tube displacement and accidental decannulation. Those with cognitive dysfunction or in post-traumatic amnesic states after major head injury are at great risk. Sputum or blood causing progressive encrustment of the inner surface of tracheostomy tubes may also cause the formation of bronchial cast as shown in *Figure 1*.[5,6]

Figure 1: Bronchial cast removed from a tracheostomised patient on the third day

Implementing care plan

A proper care plan for delivering quality care for tracheostomised patients including selection of tubes, wound care, dressings, oral hygiene, humidification and nutrition must be present. It may be a respiratory therapist driven protocol or based on a nursing model of frame work. A care plan should be creative, responsive, holistic and individualised. It should be based on sound knowledge and in accordance with the local policies and available resources.

Selection of tracheostomy tube

1) Choice of material of the tracheal tube (Table 1): The tube is required to be rigid yet so as to provide adequate respiratory support and comfortable for the patient. It should be checked whether the patient is allergic to any material used for production.

2) Based on the indication: Initial and ongoing indication for the tracheostomy should be considered such as the need for prolonged positive pressure ventilation (PPV), protection of the airway from aspiration, upper airway obstruction or as an access to aspirate secretions/bronchial toileting. The choice of the type of tube may vary based on the underlying requirement *(Table 2)*. This includes conditions where prolonged ventilation is required and situations where only tracheal toileting is required.

Table 1: Features of various tracheostomy tubes based on the material.

Materials	Features
PVC	Economic, thermosensitive to body temperature, disposable/single use, retain bacteria.
Silicone	Soft, unique characteristic of reducing the adherence of secretions and bacteria to the tube by promoting easier passage of mucus. Can be resterilised.
Siliconised PVC	Has sufficient rigidity and can also conform to the individual patient's airway at body temperature, to provide maximum patient comfort.
Silver	Pure silver tube would be less liable to chemical erosion. Silver tubes can fracture with prolonged use. They are usually made from 92.8% silver, copper and phosphorus (trace) with silver plating.
Silver coated	Newer technology - Reduces the incidence of bacterial film formation that may occur on the wall of the tracheostomy tube

3) Length of the tube: The length of the tube should be appropriate for the patient. Longer tube can result in endobronchial intubation and unilateral ventilation where as a short tube can lead to surgical emphysema where the tip of the tube may rest in the pretracheal fascia.

4) Resistance of the tube: The resistance of any tube is described by Poiseuille's law which relates the pressure drop across a tube to be inversely

proportional to the fourth power of the radius in the presence of laminar flow. This is particularly important when tracheostomy is considered in children.

5) Width of the tube: A wide tube can lead to granulation tissue formation at the tip of the tube or tracheo-oesophageal fistula formation. A narrow tube can considerably increase the work of breathing (WOB). Leak around a narrow tube can also result in inefficient ventilation and increases the risk of aspiration.

An *ideal tracheostomy tube* should be rigid enough to maintain an airway and yet flexible to limit the tissue damage and maximise patient comfort.[7]

Types of tracheostomy tubes[8]

Table 2: Types of tracheostomy tubes

Type	Subcategories	Specifications
Specialised cuffed tubes	Foam cuffs	Spontaneously inflates on insertion and will then conform to the patient's trachea. Can avoid complications of overinflation
	Tight to shaft cuff	When deflated it has the profile of an uncuffed tube; less traumatic, easy to insert
	Suction ports	The suction port above the cuff allows regular removal of subglottic secretions
	Double cuffs	Alternation of the cuff inflation to allow pressure relief on high risk tracheal mucosa
	Lanz system	Automatically controls and limits cuff pressure for the entire duration of use of tracheostomy tube.
	Cuffed talking tubes	Additional airflow line is attached to the outer cannula which opens above the cuff, acts as an external source of air for phonation
Uncuffed tubes		For those who do not require positive pressure ventilation, those with no risk of aspiration. Tracheostomy required only for bypassing upper airway
Fenestrated tubes		Single cannula Double cannula (Cuffed/ Uncuffed)

Securing the tracheostomy tube

Tracheostomy tubes are often secured by suturing the flange or tying with a twill tape.The tapes should be tied after flexing the neck as the circumference of the neck is smallest in this position. The main drawback with the use of ribbon tapes is the risk of skin ulceration. The stretchable moisture repellant tracheostomy collars/bands are preferable as they are easy to apply and adjust. They are more comfortable for the patient and less abrasive to the skin. A loose tie around the neck will result in freely moving tube. This can cause enlargement of the stoma. Furthermore, constant irritation of the tracheal mucosa caused by the movement of the tip can result in granuloma formation or bleeding. Too tight a tie around the neck can be uncomfortable to the patient and also result in ulceration of the skin. A useful indicator to establish the ideal fitting is to be able to insert one to two fingers between the collar and the neck.[7]

Care of the cuff

The function of the cuff is to effectively seal the trachea by exerting minimal compression force. Modern tubes have a barrel shaped cuff with high volume and low pressure (HVLP), which allows a wider distribution of pressure on the tracheal wall aimed at reducing the complications. As the tracheal mucosal perfusion pressure is between 20–30 mm Hg, it is advisable to maintain the cuff pressure below 20 cm H_2O by using a cuff pressure manometer. Once inflated, the pressure against the tracheal wall varies according to the airway pressure acting upon it. When the peak airway pressure (Paw) exceeds the cuff pressure, the inferior aspect of the cuff is compressed against the tube. This compression displaces the volume laterally and raises the pressure within the cuff proportionally and maintains overall integrity of the seal. As Paw falls, the cuff returns to the resting pressure of 20 mm Hg. This cycle of change in pressure should allow capillary refill resulting in less tracheal damage.

The cuff may be inflated in two ways: (a) Minimal occluding volume technique – Air is injected into the pilot balloon while auscultating over the patient's

neck near the tracheostomy tube. The air is injected till the air leak is no longer heard which means the airway is sealed. (b) Minimal leak technique – The procedure is the same as in the minimal occluding volume technique except that after the airway is sealed, a small amount (approximately 1 cc) of air is withdrawn so that a slight leak is heard at the end of inspiration. Both the techniques have their advantages and disadvantages.

Complications of the cuff: (Figure 2) Shows the major complications associated with improper management of the tracheal tube cuff.

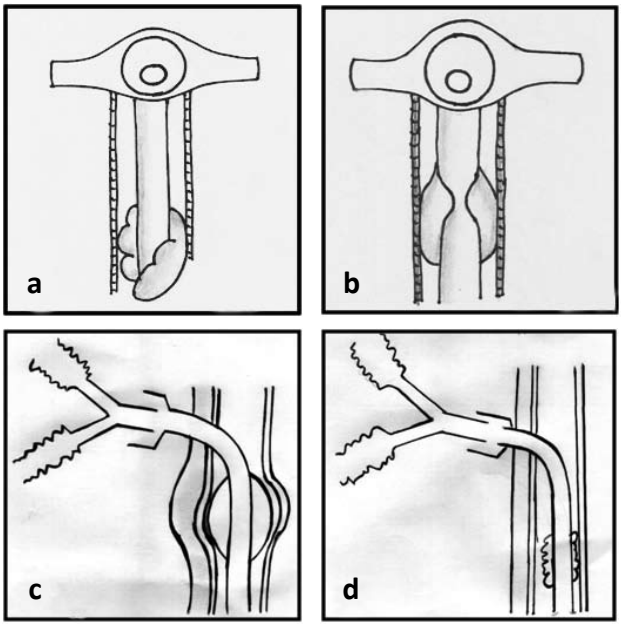

Figure 2: Complications that can arise due to improper management of the tracheal tube cuff. a) Herniation of the cuff b) Compression of tracheostomy tube by over inflated cuff c) Tracheomalacia d) Inadequate seal.

Silent aspiration: It is often assumed that an inflated cuff will prevent aspiration. Elpern *et al.* found that an inflated tracheostomy tube cuff was associated with an increased incidence of aspiration. In a study of long term ventilator dependent patients receiving oral feeds, Elpern found that many of these patients aspirated because of impairement of cough reflex due to inflated tracheostomy cuff.[10] Dave *et al* conducted a study on effect of tracheal tube cuff shape on fluid leakage across the cuff and found that the fold and channels in the high volume low pressure cuff (HVLP) can lead to silent aspiration.[11]

Positioning the patient

The gravity induced atelectasis in the dependent areas of the lung is very common. The reduction in the transverse diameter of the chest wall due to change in position reduces the functional residual capacity (FRC). Immobility induces progressive muscle weakness and atrophy. The elevation of the head more than 40° has to be strongly supported as a preventive strategy to lower the risk of aspiration. Semirecumbent position is a low cost and effective measure. Deep breathing exercises, chest physiotherapy, postural drainage and early mobilisation reduce this risk.

Importance of humidification of inspired gases

When a tracheostomy tube is in place, the inhaled gases bypass the normal upper airway which is usually responsible for humidification of the inspired gases. Hence, it is essential that humidification is provided to ensure optimal respiratory function *(Figure 3)*.[12]

Consequences of underhumidification: Heat loss and hypothermia (especially in infants), moisture loss and ciliary destruction due to inhalation of dry gas, mucosal ulceration, cytoplasmic and nuclear degeneration are common. There will be a downward shift of the isothermic saturation boundary (ISB), impaired surfactant activity and atelectasis.

Consequences of overhumidification: Heat gain can lead to burning of mucosa, pulmonary oedema and hyperthermia. Gain in moisture impairs efficacy of mucus elevator. The ISB gets shifted upward, leading to reduction in the FRC and inactivation or decreased activity of surfactant by excess water. Effectiveness of humidification may be described in terms of sputum volume, tenacity and colour as well as the presence of blood in the sputum.

An *ideal humidification system* should have the ability to deliver adequate levels of heat and moisture safely with no risk of malfunction, electrical hazard or microbiological contamination, possess appropriate physical properties and be economical to use. The patient should be instructed to drink more water if there is no risk of aspiration. The efficacy, safety, cost and convenience should be considered for each individual application.

Figure 3: Methods used to humidify the inspired gas. ***A***-Bubble Humidifier, ***B***-Passover Humidifier, ***C***-Thermovent HME

Tracheal toileting and suctioning

Suctioning is not recommended as a routine procedure. Frequency of suctioning will depend on the individual patient's need.[13] If the tracheostomy tube is fenestrated ensure that the unfenestrated inner cannula is in position before proceeding for suctioning. If the catheter is not passing smoothly, instill mucolytic agents instead of normal saline/ bicarbonate solution.[14]

Use of tracheostomy tubes with 'suction aid' will help to remove the pooled and accumulated oral secretions above the cuff and thereby preventing microaspiration *(Figure 4)*. Continuous application of low suction can prevent the development of ventilator associated pneumonia (VAP).[15]

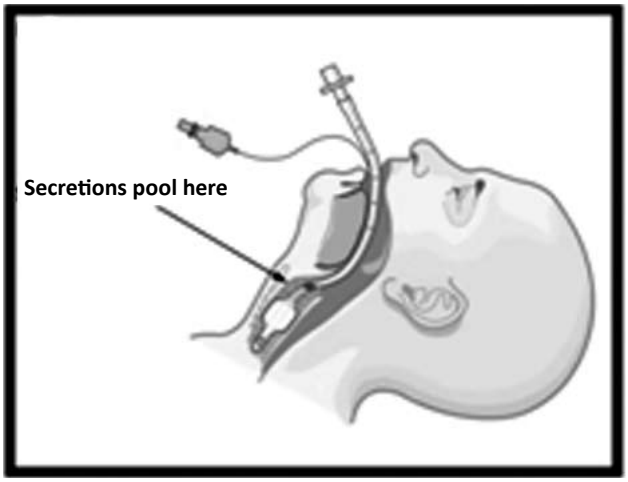

Figure 4: Endotracheal tube with suction aid

Tracheostomy wound care

The aim of managing a tracheostomy wound is to promote healing and to prevent the complications associated with surgical stoma or incision. It should be checked once daily. A healthy stoma appears red and moist with healed edge. Immediately after the procedure of tracheostomy, watch for active bleeding.

At each dressing change, the stoma site should be observed for bleeding, increase in size, appearance of edges and peristomal tissue, infection or breakdown of surgical incision and quantity of stoma exudates, offensive odour and pain *(Figure 5)*. It is important to use gauze instead of cotton wool. The cotton wool has loose fibres which can break off and enter the stoma. Attention should be paid to the skin under the flange (neck plate) as this is at risk of erythema and excoriation.

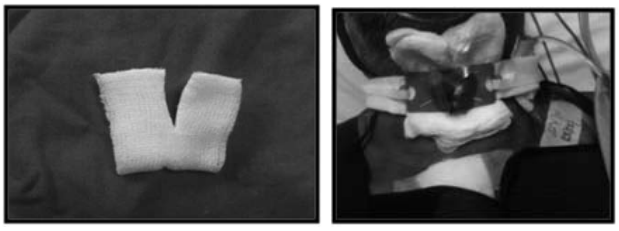

Figure 5: Ideal dressing of a tracheostomy wound

The dressing material should be slim to prevent movement of tracheostomy tube and potential dislodgement. It should not adhere and cause trauma to stomal edges. It should absorb tracheal secretions from the skin surface, prevent debris or foreign substance entering stomal opening and provide maximum patient comfort.

Communication

One of the key factors during weaning off from tracheostomy is the maximisation of a patient's ability to communicate consistently and effectively about the needs, feelings and opinions with the people around *(Figure 6)*. Factors affecting communication are *the mechanical impacts* such as laryngeal tissue changes resulting from endotracheal intubation or long term tube placement and *physiological impacts* such as loss or reduction of voice production.

Aphonia caused due to the presence of an inflated cuff or reduced subglottic pressures should be avoided. Options for communication are verbal, oral, nonverbal, speaking valves, hand writing, drawing and direct selection- commuboard/ electronic board *(Figure 6)*.

Figure 6: Alternative methods for communication

Swallowing

Swallowing can be affected by mechanical or physiological factors. The mechanical factors include altered laryngeal function for prolonged intubation or restriction to laryngeal elevation owing to surgical technique, tube size or weight of the equipment. An overinflated cuff can partially or completely occlude the oesophagus causing dysphagia. Physiological factors include loss or reduction in the airflow to the upper tract, absence of cough, absence of smell and taste.

Assessment of ability to swallow includes assessment of the rate, range and strength of movement of the lips, cheeks, tongue, jaw and palate, dentition, saliva control in the oral stage and the presence of primitive reflexes. Poor oral hygiene is a predictor of aspiration pneumonia in such patients.[16]

Tracheostomy tube change

Tracheostomy tube change may be an elective procedure or done in an emergency. The purpose is to achieve maximum patient comfort, avoid anxiety and facilitate weaning/speech production. On inspection, if the track is present, pass the new tube with the obturator *in situ*, or pass a guide wire or suction catheter through the stoma and reintroduce the new tube (widely known as rail road method) over it as shown in *Figure 7*.

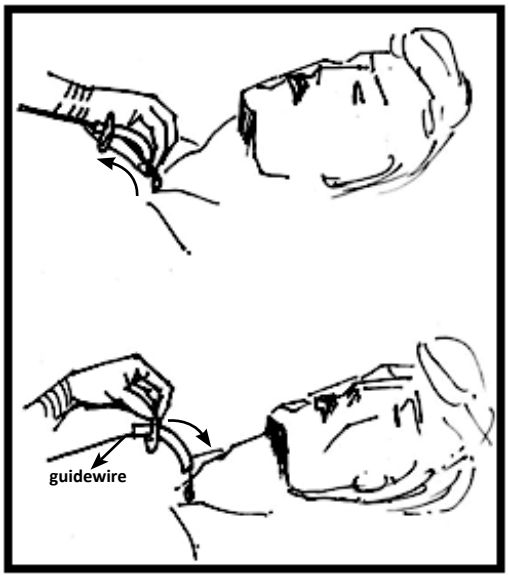

Figure 7: Railroad method for changing the tracheostomy tube

Misplaced tubes

Short thick neck, coughing, patient movement, low stoma placement, loose tracheal tapes, traction on the tube by ventilator or humidification attachments, positive pressure ventilation in patients with stiff lungs are the risk factors for tracheostomy tube misplacement. Signs of misplaced tube are ability to vocalise with cuffed tube which was not possible previously, decreasing oxygen saturation, pallor, absent or reduced expired air from tracheostomy, failure to pass down suction catheter beyond the tip of the tracheostomy tube, respiratory distress, stridor and agitation.

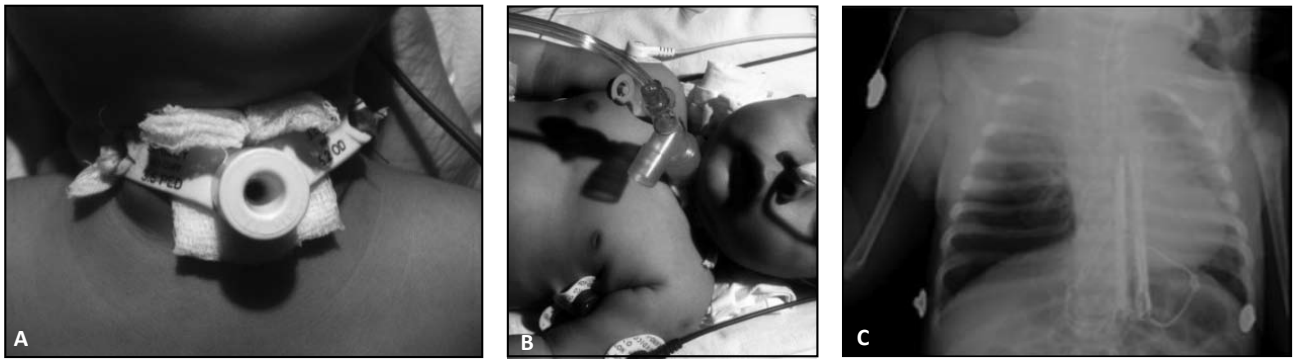

Figure 8: A - Poor accessibility, B - Oxygen therapy, C - Tube sitting on carina

Paediatric tracheostomy care

Certain points need to be emphasised regarding tracheostomy care among the paediatric population.[17] These include maintenance of a patent airway, cardiopulmonary assessment, providing airway humidity, maintaining hydration and fluid balance, prevention of infection, promoting child's comfort, effective pain management, emotional and educational support for the child and family.[17-19] *Figure 8* shows complications associated with paediatric tracheostomy such as accidental decannulation occurring due to absence of cuff or endobronchial intubation due to short necks excess length of the tube and poor accessibility.

Oxygen therapy in tracheostomy patients

Tracheostomy masks are recommended for delivery of oxygen in tracheostomised patients, and are specially designed to fit over the stoma and secure to the neck. A T-piece can also be used to deliver oxygen to patients with tracheostomy *(Figure 9)*. It is important to remember that the length of the tube attached with a T-piece can act as a reservoir for oxygen.

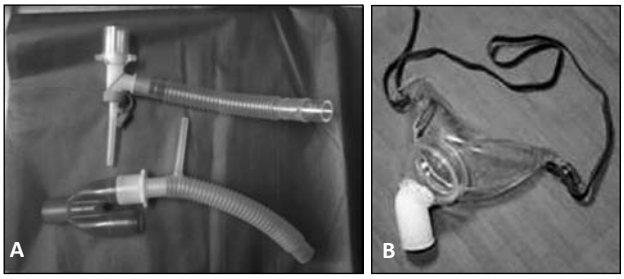

Figure 9: A) An indigenous T-Piece B) Tracheostomy mask

Nutrition

The patient who requires a tracheostomy will often be acutely unwell and/or have chronic problem with swallowing, therefore making it difficult to meet their nutritional requirements. The management of these patients should be in the same way as it is done with the patients without a tracheostomy. Ryle's tube feeding should be continued to ensure adequate nutritional intake.

Infection control for the tracheostomised patients

The infections of the respiratory tract, pneumonia in particular, are serious and life-threatening. General hospital based infection control policies such as hand hygiene, use of personal protective equipment, waste management, decontamination of equipment, education and training for staff and families should be instituted. Precautions have to be taken to prevent stoma site infection. The humidification and suctioning equipment should also be kept clean.

Oral hygiene

The mouth is well known to harbour millions of both commensal and pathogenic micro-organisms, particularly in patients who have an oral endotracheal tube in place. These patients have impaired swallowing and laryngeal competence. Maintenance of oral hygiene, although often overlooked, is an integral part of nursing care. Kollef *et al* have advocated chlorhexidine oral rinse to reduce the oral bacterial load. However, its regular use may lead to chlorhexidine resistant organisms (Figure 10).[20] Several studies have shown that oral decontamination is an effective method for reducing VAP.[15]

Figure 10: Oral care kit with suction

How can we achieve successful weaning?

The patient needs to meet certain basic criteria for successful weaning of tracheostomy. They are haemodynamic stability, low supplemental oxygen requirement, ability to maintain upright posture in bed/chair, ability to cough out secretions and ability to stay awake for 15 minutes while sitting upright. Weaning is done by cuff deflation.[21,22] This will add extra workload on the patient. Hence, the patient should be observed for any signs of distress or clinical deterioration. The periods of cuff deflation can be increased gradually as per the patient's comfort levels. Information, reassurance, psychological support, early speaking and communication aids will aid in facilitating successful weaning.

Return of reflex cough when the trachea is stimulated by suction or sputum is an objective step in recovery. Abdominal and intercostal muscle strength can be assessed in the volume exchanged during a cough. The cough is less effective in tracheostomised patients as the open airway cannot block the expiratory flow and allow the buildup of pressure. Early use of a speaking valve facilitates coughing by returning function to the upper respiratory tract.

Work of breathing during weaning with tracheostomy

The tracheostomy tube being shorter imposes a lower resistance to gas flows and lower work of breathing as compared to an ETT. This may facilitate weaning from mechanical ventilation in patients who fail weaning with ETT. A reduction in WOB may result from a change in intrinsic PEEP which in turn depends on the respiratory rate and the minute ventilation with obstructive lung pathologies.[23] Reduction in these parameters have been observed after tracheostomy.

Long term tracheostomy and continuing care

Although most tracheostomies are temporary, there are circumstances where a long-term or even permanent tracheostomy will be necessary owing to impaired airway function or unresolved conditions. Key points to be noted before discharging the patient are determination of discharge destination such as home or nursing home, assessment of the ability to self-care, physical and mental activity, patient motivation, identifying a care-giver and care-giver training. It is important to ensure that the care-giver is vigilant and well-trained. Home care teaching should be individualised and must begin at the hospital itself.

Decannulation

Decannulation means removing the tracheostomy tube deliberately and permanently. It should be considered only when the indication for insertion of tracheostomy has resolved. A traditional decannulation technique involves sequential downsizing of the tube often with partial or complete plugging of the tube. Alternative method is one step decannulation. Decannulation may be considered if the reason for tracheostomy has resolved, patient is alert, responsive and tolerating cuff deflation for a minimum of 12 hours at a stretch.

The tolerance to occlusion trials, ability to expectorate around the tube into their mouth and ability to swallow should be evaluated. The benefit of occasional capping over three days prior to 24 h occlusion is not supported by current research. Decannulation may fail if it is performed without proper assessment of the airway for functional and anatomical changes, *i.e.*, granulation tissue above the stoma, tracheomalacia, stenosis *etc.*

After removal of the tracheostomy tube, a portion of gauze folded in four may be placed over the

stoma and clear dressings can be placed overlapping over the stoma site. The dressing should provide an effective seal to withstand airflow pressure. The patient should be encouraged to support the dressing and stoma opening with their hand across the dressing whenever they speak or cough. This will help to prevent loosening of the dressing from the air leaking through the stoma. The dressing should be easy to remove.

The stoma will heal from the trachea outwards. Following the removal of the tube, fresh or resterilised tracheostomy tube with dilator and guide wire/re-intubation kit should be kept on the bedside for minimum 48 h after decannulation. The wound should be dressed twice daily and taped tightly. Air leak and bubbling of secretions are very common until the stoma heals. In most patients stoma closes spontaneously within hours or days. The dressing can be removed when the air leak stops.

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