AN OVERVIEW ABOUT PERCUTANEOUS TRACHEOSTOMY TECHNIQUES

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Abstract

Background: After tracheal puncture and guide wire insertion, tissues and anterior tracheal wall are dilated using either up to seven progressively larger dilators (basic technique), a curved, hydrophilic-coated single-step dilator (Blue Rhino), or a fluid-filled high-pressure balloon (Blue Dolphin**).** The procedure concludes with the insertion of a tracheal cannula. Regardless of the technique chosen, continuous bronchoscopic surveillance of the entire procedure is strongly recommended. Ciaglia Blue Rhino kit (Cook Critical Care Inc, Bloomington, IN): 14-gauge catheter introducer needle and syringe, guide wire (J-tipped Seldinger wire type), guiding catheter, introducer dilator, loading dilators, single tapering Blue Rhino dilator, Shiley size 8 double-cannula tracheotomy tube with curved obturator; fiberoptic bronchoscope

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Introduction

The tracheostomy is one of the oldest surgical procedure, It can be traced back to Egyptian tablets from 3600 B.C. 1546: first well –documented tracheostomy by Antonio Musa Brasavola. 1921: chevalier Jackson –standardized the technique of the tracheostomy. In 1955, Shelden et al reported the first attempt to perform PDT **(1)**

Types of Tracheostomy according to site :

1-high tracheostomy: (2)

It is made between 1st and 2nd tracheal rings above thyroid isthmus, indicated in emergency cases**.**

Disadvantages:

Perichondrities of the cricoid cartilage and 1st ring of trachea leading to permanent subglottic and tracheal stenosis.

2- Low tracheostomy: (3).

It is made between 4th and 5th tracheal rings below thyroid isthmus, used in glottis carcinoma

Disadvantages:

Injury of great vessels of the neck.

3-mid tracheostomy:

It is made between 3rd and 4th tracheal rings behind the thyroid isthmus. It is the operation of choice because it avoids the disadvantages of the high and low tracheostomies **(4).**

Tracheostomy tube:

A tracheostomy tube is a curved tube that is inserted into a tracheostomy stoma. **(5).**

A commonly used tracheostomy tube consists of three parts:

Outer canula with flange (neck plate), inner cannula, and an obturator. The outer cannula is the outer tube that holds the tracheostomy open. A neck plate extends from the sides of the outer tube and has holes to attach cloth ties or velcro strap around the neck. The inner cannula fits inside the outer cannula. It has a lock to keep it from being coughed out, and it is removed for cleaning. The obturator is used to insert a tracheostomy tube. It fits inside the tube to provide a smooth surface that guides the tracheostomy tube when it is being inserted.single tracheostomy tube has no inner canula, it is rarely used due to concerns blockage and difficulty in cleaning. **(5)**

After tracheal puncture and guide wire insertion, tissues and anterior tracheal wall are dilated using either up to seven progressively larger dilators (basic technique), a curved, hydrophilic-coated single-step dilator (Blue Rhino), or a fluid-filled high-pressure balloon (Blue Dolphin**).** The procedure concludes with the insertion of a tracheal cannula. Regardless of the technique chosen, continuous bronchoscopic surveillance of the entire procedure is strongly recommended **(6).**

Ciaglia Blue Rhino kit (Cook Critical Care Inc, Bloomington, IN): 14-gauge catheter introducer needle and syringe, guide wire (J-tipped Seldinger wire type), guiding catheter, introducer dilator, loading dilators, single tapering Blue Rhino dilator, Shiley size 8 double-cannula tracheotomy tube with curved obturator; fiberoptic bronchoscope. The Blue Dolphin technique is novel, using a combined dilator-tube introducer assembly, which uses a high-pressure balloon to dilate the stoma **(7).**

Ciaglia Blue Rhino Kit:

Figure 1: Ciaglia Blue Rhino Kit (7).

1-needle and syringe.
2-j-shaped guide wire.
3-catheter.
4-dilators.
5-scalpel.
6-gauze.
7-lubricating gel.

Guide wire dilator forceps (GWDF) technique

Figure 2: Gide wire Dilator Forcepse Kit (8)

GWDF kit (Sims Portex): 14-gauge needle and syringe, guide wire (J-tipped Seldinger wire type), scalpel, Howard-Kelly forceps modified to produce a pair of GWDF (seen in the image above)

Shiley size 8 double-cannula tracheotomy tube with curved obturator, fiberoptic bronchoscope. When percutaneous tracheostomy was steadily gaining acceptance in the community of intensivists worldwide, the Australian surgeon William Griggs invented another tracheostomy technique – the guide wire dilating forceps technique (GWDF). The stoma is created with a modified Howard Kelly forceps, in which the guide wire passes through a central hole in the tip of the closed forceps**. (8)**

Steps

First, the trachea is punctured in midline between the first and second or second and third tracheal rings with a fluid-filled syringe. Correct intratracheal placement is confirmed by bronchoscopy and double checked by aspirating air bubbles **(8)**

Relying on aspiration alone is not sufficient. The needle is withdrawn, leaving the Teflon cannula in place through which the guide wire is inserted. Thereafter, a 10 mm transverse skin incision is made, and the 14 F punch dilator is used to widen the puncture channel. Then, the closed Howard Kelly forceps are passed over the guide wire, and by pulling the handles apart, pretracheal tissues are dilated. The forceps are now removed in open position. For final dilation, the forceps are passed over the guide wire again in closed position until the tips of the blades can be seen entering the tracheal lumen. Again, the blades are opened by pulling the handles, and the anterior tracheal wall is now dilated until the desired degree. **(9).**

The final step consists of removing the forceps in open position, leaving the guide wire in place, and inserting a lubricated tracheostomy tube with its obturator into the tracheal lumen. The obturator and the guide wire are now removed, and correct intratracheal position of the cannula is confirmed bronchoscopically before the tube is connected to the ventilator **(10).**

Many studies report on a significant incidence of fractures of tracheal cartilages during dilation with the GWDF device, which is attributed to the high and sudden force exerted on the tracheal rings during opening of the blades **(10).**

Translaryngeal Tracheotomy (TLT)

This was first described by Fantoni and Ripamonti in 1997. It is little cumbersome to perform and involves passage of guide wire retrogradally through the vocal cords after needle puncture of trachea. This is followed by putting the combined dilator and tracheostomy tube over the guide wire into the larynx and out through the anterior tracheal wall. Tracheostomy tube is then separated from the dilator and rotated by 180° such that it faces the carina. This procedure requires an experienced operator **(11).**

Procedural Adjunct:

Brochoscopy:

Use of bronchoscope during the procedure has certain obvious advantages such as real-time confirmation of needle placement, midline position of the needle, tube placement, and avoidance of posterior tracheal wall injury. There have however been concerns regarding its routine use. It has been found to be associated with measurable increases in intracranial pressure and alveolar derecruitment related fall in oxygen saturation. It should be thus used with caution in patients with acute neurological condition and high ventilator requirements. Most of the guidelines do not recommend routine use of bronchoscope as there are insufficient data at present. However, it is usually considered essential if operator is inexperienced and if there is a difficult neck anatomy. Some authors prefer use of a Bonfils semirigid scope over flexible scope to prevent needle damage to the scope during the procedure **(12).**

Ultrasound:

Ultrasound has been increasingly used in recent times to estimate the distance from skin to the trachea. This ensures the accurate placement of the introducer needle into the trachea. Preoperative identification of aberrant vessels and enlarged thyroid isthmus with ultrasound helps in avoiding complications. Its use has been found to change the intended tracheostomy site in about 24% of cases. It is an inexpensive and readily available bedside modality. It can also be used to localize tracheal rings and in ensuring midline punctures. **(13)**

Indications and timing of tracheostomy:

1-Airway obstruction due to the following:

- Inflammatory disease
- Congenital anomaly (e.g., laryngeal hypoplasia, congenital web)
- Supraglottic or glottic pathologic condition (e.g., neoplasm, bilateral vocal cord paralysis)
- Laryngeal trauma or stenosis
- Facial fractures that may lead to upper airway obstruction (eg, comminuted fractures of the midface and mandible)
- Edema (eg, trauma, burns, infection, anaphylaxis**). (14).**

2- Need for prolonged mechanical ventilation in cases of respiratory failure.
3-Need for improved pulmonary toilet:
- Inadequate cough due to chronic pain or weakness.
- Aspiration and the inability to handle secretions (The cuffed tube allows the trachea to be sealed off from the esophagus and its refluxing content. However, some argue that secretions can leak around the cuffed tube and reach the lower airway). **(15).**

4- Prophylaxis (as in preparation for extensive head and neck procedures and the convalescent period). **(16).**

5-Severe sleep apnea not amendable to continuous positive airway pressure (CPAP) devices or other, less invasive surgery. **(17).**

Timing of tracheostomy for intubated patient:
Many studies reported that early tracheotomy was defined as performed in days 1–7 after orotracheal intubation and late if it was performed any time after the early tracheostomy **(18)**

Complication of prolonged indotracheal entubation:
1-ulceration of the larynx.
2-granuloma of the vocal cord.
3-posterior glottis stenosis.
4-subglottic stenosis.
5-vocal cord paralysis **(19)**

Contraindications of percutaneous diltational tracheostomy:
Absolute contraindications are as follows:
- Patient age younger than 8 years.
- Gross distortion of the neck anatomy due to the following:

1. Hematoma.
2. Tumor.
3. Thyromegaly (second or third degree)**. (19)**

The relative contraindications are as follows:
- Patient obesity with short neck that obscures neck landmarks.
- Medically uncorrectable bleeding diatheses.
- Prothrombin time or activated partial thromboplastin time more than 1.5 times the reference range.
- Platelet count less than 50,000/μL.
- Bleeding time longer than 10 minutes.
- Evidence of infection in the soft tissues of the neck at the prospective surgical. **(20).**

Complications of tracheostomy:
Complications of tracheostomy can be categorized as early or late. There are no exact guidelines to distinguish early complications from late complications, but more commonly the ones labeled as "early" are seen within 1 week of tracheostomy placement. **(21)**

Immediate:
Complications present at the time of operation until 24 hours after procedure.
- Haemorrhage e.g., from thyroid isthmus.
- Hypoxia.
- Trauma to recurrent laryngeal nerve.
- Damage to the oesophagus.
- Pneumothorax.
- Infection.
- Subcutaneous emphysema **(21)**

Early:
Complications develop during first few hours or days after tracheostomy (from day 1 to day 7).
- Tube obstruction or displacement.
- False passage formation.
- Aspiration.
- Bleeding from the tracheostomy site.
- Infection. **(22)**

Late:
Complications develop when the tracheostomy tube is left in place for a prolonged period (more than day 7).
- Airway obstruction with aspiration.
- Damage to larynx – e.g., stenosis.
- Tracheal stenosis.
- Tracheomalacia.
- Aspiration and pneumonia.
- Fistula formation – e.g., tracheo-cutaneous or tracheo-oesophageal**. (13)**

Early complications of tracheostomy are those occurring within the first week following placement, as the tracheostomy stoma takes approximately 1 week to mature. Stomal infections and bleeding are the most common complications following ST, while PDT has a higher incidence of injury to the posterior wall of the trachea. **(23)**

Bleeding:
Minor bleeding can be life threatening if it results in airway obstruction. Bleeding during tracheostomy or within first 48 hours is most commonly due to injury to superficial veins. Superficial bleeding can be easily treated with local measures such as packin, cauterization or suture. Bleeding after 48 hours should always be thoroughly investigated as it can be the result of

erosion of the tracheostomy tube into major vessels such as innominat artery **(24)**

Stomal Infection:
Wound infection is more common in ST as compared with PDT. Appropriate wound care is generally sufficient for minor wound infection. Severe cases of necrotizing tracheal infection are rare and require oral tracheal intubation followed by debridement of involved tissue**. (25)**

Subcutaneous Emphysema:
Subcutaneous emphysema is caused by formation of a tissue tract anterior to trachea secondary to positive pressure ventilation or forced coughing against a tightly sutured or packed wound. Air driven by positive pressure ventilation can extend into to pleural space, leading to development of pneumothorax. This can be prevented by not suturing tissue around the wound tightly. Chest x-ray to identify subcutaneous air is recommended only when placement of the tracheostomy tube is technically challenging or in patients with signs and symptoms of subcutaneous air. Such complications are treated conservatively by removing the suture and are typically self-limited **(21)**

Posterior Tracheal Wall Injury:
Injury to the posterior tracheal wall is a well-recognized and potentially fatal complication of tracheostomy placement. The incidence of posterior tracheal wall injury is higher in PDT compared with ST. Posterior wall injury commonly occurs due to poor control of the guide wire and guiding catheter. Most posterior wall tears are small and heal without further intervention, whereas larger tears may present with airway bleeding, air leak around the tube, or into the mediastinum. Larger tears may be life threatening and require emergent surgical intervention. The use of covered, self-expanding, metallic stents may represent a treatment option in patients with posterior wall tears who are not candidates for surgical repair. Placement of metallic stents can be performed at the bedside and have a lower complication profile. Postprocedure surveillance with flexible bronchoscopy is recommended following stent placement to identify the formation of granulation tissue, detect stent migration, and to identify infections, which may present as halitosis. **(26)**

Tracheostomy Tube Obstruction:
Tracheostomy tube obstruction can be life threatening and requires immediate intervention. Airway obstruction may result from plugging due to mucus or clotted blood. In addition, obstruction may occur following passage of the tracheostomy tube into a false lumen (paratracheal soft tissue) or due to angulations of tube orifices against the tracheal wall. Tracheostomy tube obstruction may present with acute deterioration of respiratory status and could result in death. Obstruction due to a mucous plug or blood clot can be relieved immediately by suctioning of tracheostomy tube. If the obstruction cannot be relieved, try exchanging the inner tube. In addition, use of flexible bronchos-copy during tracheostomy tube placement can help prevent formation of false tracts **(27).**

Tracheostomy Tube Dislodgement:
Tracheostomy tube dislodgement within 7 days of placement is a medical emergency. The absence of a mature tracheostomy tract may make replacement of the tube difficult and could lead to the creation of a false tract. A myriad of causes may lead to tracheostomy tube dislodgement, including loose tracheostomy ties, accidental displacement while turning patient, or self-extubation. If the tracheostomy tube is accidentally dislodged, replacement of the tracheostomy tube using bronchoscopic guidance is encouraged in a timely manner (never blindly reinsert the tube). If the tracheostomy tube cannot be confidently reinserted, oral endotracheal intubation is necessary. To minimize the risk of this complication most experts will recommend suturing the flange of the tracheostomy tube to the skin in addition to the use of a tracheostomy tie. **(28).**

Late Complications:
Prolonged tracheostomy tube placement in critically ill patients with multiple comorbidities can lead to a number of late complications **(28).**

Tracheal Stenosis:
Tracheal stenosis describes a pathologic narrowing of tracheal lumen and can result from prolonged tracheostomy tube dependence. Tracheal stenosis is considered the most common late comp-lication of tracheostomy tube placement. Tracheal stenosis is typically seen at the level of the tracheostomy stoma or suprastomally, but below vocal cords . **(29)**

The pathogenesis of tracheal stenosis involves inflammation and the formation of granulation tissue. Trauma resulting from tracheostomy, mucosal ischemia due to excessive cuff pressures, persistent mucosal irritation stemming from the tip of tracheostomy tube, pooling of secretions, and

gastroesophageal reflux disease are predisposing factors for development of ulceration and inflammation of cartilage, leading to the formation of granulation tissue. Subsequently, granulation tissue matures into a fibrous tissue layer covered with epithelium, leading to tracheal stenosis. Patients with tracheal stenosis are often asymptomatic until the size of trachea has reduced to <5 mm or 25% to 50% of the original diameter. Tracheal stenosis may be detected when the patient is still mechanically ventilated and can be clinically manifested as difficulty in weaning from the ventilator. Elevated peak airway pressures may be present for infrastomal stenosis. Dyspnea, stridor, and respiratory failure, may be present after decannulation. In addition, clinical manifestations of stenosis may present weeks to years after development, but typically are evident within 2 months following decannulation. Flexible bronchoscopy remains the gold standard to diagnose and characterize lesions of tracheal stenosis. **(30)**

Flexible bronchoscopy permits direct visual evaluation of the stenotic lesion**(21)**

CT scans with 3-dimensional reconstructions can predict the size and location of stenosis. Stenotic lesions can be divided into simple (<1 cm, granulation tissue, web-like lesion, concentric lesion, no involvement of tracheal wall) and complex stenosis (>1 cm, scarring of trachea, presence of malacia). Correct classification of the stenotic lesion is essential in determining appropriate management. The initial approach to simple lesions is endoscopic dilatation. Recurrence of simple stenosis after multiple bronchoscopic treatments often requires surgical evaluation for definitive treatment. Complex lesions require a multidisciplinary approach often resulting in surgery. Endoscopic dilatation can be performed in emergent cases or as a bridge to definitive surgical correction. The preferred surgical approach depends on involvement of the larynx and extent of tracheal involvement. Laryngotracheal reconstruction is performed when subglottic tracheal lesions involve the larynx, whereas tracheal resection and reconstruction is performed when complex lesions involve only the trachea **(31).**

Tracheoesophageal Fistula:

Tracheoesophageal fistulas are rare complication following tracheostomy tube placement. This complication occurs secondary to increased tracheostomy tube cuff pressures and subsequent ischemia of the tracheal mucosa. Prolonged ischemia can lead to tracheal wall necrosis, ulceration, and perforation, with subsequent erosion into the esophagus. Other possible mechanisms include erosion of the posterior tracheal wall by the distal end of the tracheal tube when it impinges posteriorly. Surgical correction is required with primary esophageal closure, interposition of viable tissue, and tracheal repair by tracheal or laryngotracheal resection with reconstruction in the presence of stenosis or a long tracheal defect. Patients who are not surgical candidates require a combination of tracheal stenting and esophageal stenting for palliative measures. Placement of the tracheal stent before placement of the esophageal stent is essential in this therapy, as the malleability of the esophagus can result in compression of the trachea due to excessive stent expansion. **(23)**

Tracheoinnominate Artery Fistula (TIF):

TIFs are due to erosion into the innominate artery by the tracheostomy tube because of elevated pressure from the tracheostomy tube cuff or contact between the distal end of the tracheostomy tube and the innominate artery. **(32)**

Formation of a tracheoinnominate fistula following tracheostomy placement is a medical emergency. Innominate artery injury resulting in massive hemorrhage following tracheostomy. Although less frequent, other vessels involved may be the common carotid artery, inferior thyroid artery, innominate vein, or the aortic arch. Risk factors for TIF include high tracheostomy tube cuff pressures, low tracheostomy insertion, and repetitive head movements resulting in repeated contact of the tracheostomy tube and the area over the innominate artery. Physicians identifying bleeding from the tracheostomy site or within the tracheostomy stoma 48 hours or later following tracheostomy should harbor a high suspicion for TIF. **(13)**

Management of possible sentinel bleeding should take place in the operating room using a rigid bronchoscope to examine the stoma and anterior wall with the tracheostomy tube removed. Equipment for prompt surgical intervention should be readily available. In case of a massive bleed, the rigid bronchoscope can be used to compress the innominate artery against the sternum, while providing adequate suction, oxygenation, and ventilation. **(21)**

Surgical treatment of TIF involves sternotomy with ligation of affected vessel, interposition of viable tissue, and tracheal wall repair. **(21)**

Tracheocutaneous Fistula (TCF):

TCFs are generated when cutaneous epithelium has healed into the tracheal epithelium. Risk factors include prolonged tracheostomy tube placement, steroid use, old age, and malnutrition. A TCF is present when the tracheostomy stoma fails to close 3 to 6 months following decannulation. Treatment by secondary intervenetion, tract excision, and closure using a strap muscle flap. **(33)**

References

1. Adedeji, T. O., Tobih, J. E., Olaosun, A. O., et al. (2014). Indications and outcomes of tracheostomy: An experience in a resource-limited environment. Journal of Health Research and Reviews, 1(2), 40.
2. Raimonde, A. J., Westhoven, N., & Winters, R. (2020). Tracheostomy. StatPearls [Internet].
3. Mehran, R. J. (2018). Fundamental and Practical Aspects of Airway Anatomy. Fundamentals of Airway Surgery, Part I, An Issue of Thoracic Surgery Clinics, E-Book, 28(2), 117-125.
4. Furlow, P. W., & Mathisen, D. J. (2018). Surgical anatomy of the trachea. Annals of cardiothoracic surgery, 7(2), 255.
5. Trouillet, J. L., Collange, O., Belafia, F., et al. (2018). Tracheotomy in the intensive care unit: guidelines from a French expert panel. Annals of intensive care, 8(1), 1-15.
6. Brass, P., Hellmich, M., Ladra, A., et al. (2016). Percutaneous techniques versus surgical techniques for tracheostomy. Cochrane Database of Systematic Reviews, (7) : CD008045.
7. Hejazi, M. E., Rezazadehsaatlou, M., Namvar, L., et al. (2017). Safety of bronchoscopic guided percutaneous dilatational tracheostomy in ICU patients in Tabriz City. Universa Medicina, 36(3), 173-178.
8. Byhahn, C. (2016). Percutaneous Tracheostomy: The Guide Wire Dilating Forceps Technique. In Percutaneous Tracheostomy in Critically Ill Patients (pp. 51-55). Springer, Cham.
9. Heinemann, L., Fleming, G. A., Petrie, J. R., et al. (2015). Insulin pump risks and benefits: a clinical appraisal of pump safety standards, adverse event reporting, and research needs: a joint statement of the European Association for the Study of Diabetes and the American Diabetes Association Diabetes Technology Working Group. Diabetes Care, 38(4), 716-722.
10. Mehta C, and Mehta Y (2017): Percutaneous tracheostomy. Ann Card Anaesth; 20 (1) :19-25.
11. Pardo, M. A., Sumner, J. P., Friello, A., et al. (2019). Assessment of the percutaneous dilatational tracheostomy technique in experimental manikins and canine cadavers. Journal of Veterinary Emergency and Critical Care, 29(5), 484-494.
12. Rajajee, V., Williamson, C. A., & West, B. T. (2015). Impact of real-time ultrasound guidance on complications of percutaneous dilatational tracheostomy: a propensity score analysis. Critical Care, 19(1), 198.
13. Cipriano, A., Mao, M. L., Hon, H. H., et al. (2015). An overview of complications associated with open and percutaneous tracheostomy procedures. International journal of critical illness and injury science, 5(3), 179.
14. Cohn, E. C., Robertson, T. S., Scott, S. A., et al. (2018). Extubation failure and tracheostomy placement in children with acute neurocritical illness. Neurocritical care, 28(1), 83-92.
15. Krisciunas, G. P., Langmore, S. E., Gomez-Taborda, S., et al. (2020). The Association Between Endotracheal Tube Size and Aspiration (During Flexible Endoscopic Evaluation of Swallowing) in Acute Respiratory Failure Survivors. Critical Care Medicine, 48(11), 1604-1611.
16. Dort, J. C., Farwell, D. G., Findlay, et al. (2017). Optimal perioperative care in major head and neck cancer surgery with free flap reconstruction: a consensus review and recommendations from the enhanced recovery after surgery society. JAMA otolaryngology–head & neck surgery, 143(3), 292-303.
17. Baillieul, S., Revol, B., Jullian-Desayes, I., et al. (2019). Diagnosis and management of central sleep apnea syndrome. Expert review of respiratory medicine, 13(6), 545-557.
18. Siempos, I. I., Ntaidou, T. K., Filippidis, F. T., et al. (2015). Effect of early versus late or no tracheostomy on mortality and pneumonia of critically ill patients receiving mechanical ventilation: a systematic review and meta-analysis. The Lancet Respiratory Medicine, 3(2), 150-158.
19. Ullah, R., Doerfer, K., Khampang, P., et al. (2020). Real-Time Optical Monitoring of Endotracheal Tube Displacement. Biosensors, 10 (11): p.174.
20. Camadan, Y., Özdemir, H., & Gulcin, İ. (2016). Purification and characterization of dihydropyrimidine dehydrogenase enzyme from sheep liver and determination of the effects of some anaesthetic and antidepressant

drugs on the enzyme activity. Journal of enzyme inhibition and medicinal chemistry, 31(6), 1335-1341.
21. Fernandez-Bussy, S., Mahajan, B., Folch, E., et al. (2015). Tracheostomy tube placement. Journal of bronchology & interventional pulmonology, 22(4), 357-364.
22. Doherty, C., Neal, R., English, C., et al. (2018). Multidisciplinary guidelines for the management of paediatric tracheostomy emergencies. Anaesthesia, 73(11), pp.1400-1417.
23. Lerner, A. D., & Yarmus, L. (2018). Percutaneous dilational tracheostomy. Clinics in chest medicine, 39(1), 211-222.
24. Trouillet, J. L., Collange, O., Belafia, F., et al. (2018). Tracheotomy in the intensive care unit: guidelines from a French expert panel. Annals of intensive care, 8(1), 1-15.
25. Lam, Nathaniel. (2015). Upper Airway Disease: Tracheostomy. Small Animal Surgical Emergencies, 263-269.
26. Won, C., Michau, G., & Kryger, M. H. (2015). Upper airway obstruction in adults. Fishman's Pulmonary Diseases and Disorders. 5th ed. USA: McGraw-Hill, 739.
27. Francom, C. R., Javia, L. R., Wolter, N. E., et al. (2020). Pediatric laryngoscopy and bronchoscopy during the COVID-19 pandemic: a four-center collaborative protocol to improve safety with perioperative management strategies and creation of a surgical tent with disposable drapes. International journal of pediatric otorhinolaryngology, 134, 110059.
28. Muller, R. G., Mamidala, M. P., Smith, S. H., et al. (2019). Incidence, epidemiology, and outcomes of pediatric tracheostomy in the United States from 2000 to 2012. Otolaryngology–Head and Neck Surgery, 160(2), 332-338.
29. Cooper, J.D., (2018). Tracheal injuries complicating prolonged intubation and tracheostomy. Thoracic surgery clinics, 28(2), pp.139-144.
30. Reid, A. and Ha, J.F., 2019. Inhalational injury and the larynx: A review. Burns, 45(6), pp.1266-1274.
31. McDaniel, L. S., Poynot, W. J., Gonthier, K. A., et al. (2018). Image-Based 3-dimensional characterization of laryngotracheal stenosis in children. OTO open, 2(1), 2473974X1 7753583.
32. Laswi, M., Vega, J., Jones, K. et al. (2020). Tracheoinnominate Artery Fistula Treated With Endovascular Stent Graft at a Level I Trauma Center. Cureus, 12(8).
33. Wisniewski, B. L., Jensen, E. L., Prager, J. D., et al. (2019). Pediatric tracheocutaneous fistula closure following tracheostomy decannulation. International journal of pediatric otorhinolaryngology, 125, 122-127.