

A review of the complications of Surgical Tracheostomies versus Percutaneous Dilational Tracheostomies: with an additional focus on staff safety in critically ill COVID-19 patient management

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INTRODUCTION

A tracheostomy is a surgically made hole that enters through the front of the neck into the trachea¹ and plays a vital role in airway maintenance and management. The main role of these procedures, which have been around for thousands of years, is to establish a functional airway. Over recent years, these types of procedures have become increasingly common in the treatment and management of critically ill patients as a means of prolonged ventilation, particularly in chronic settings – some even arguing they are a better alternative to intubation.² Figures show that nearly 34% of critically ill patients requiring mechanical ventilation for more than 48 hours are sent for a tracheostomy.³ These procedures serve multiple purposes: to bypass a mechanical obstruction; to remove secretions and clear the airways; or most importantly, to deliver oxygen safely and effectively.⁴ There are two main types of tracheostomy: surgical and percutaneous dilational.

A surgical tracheostomy (ST) comprises of a surgically created stoma in the trachea, performed under direct vision the whole time. The procedure is performed in an operating theatre, under local or general anaesthetic.⁵ A percutaneous dilational tracheostomy (PDT) uses a modified Seldinger technique, which involves the passage of a guidewire through a needle and consequent dilation of the tracheal cartilages, in order to create an opening for the tracheostomy tubes.⁶ The clinician is usually guided by a bronchoscope to ensure they are in the correct place for insertion of the tracheostomy tube.⁶ This procedure has the potential to be performed 'bedside', giving it an advantage over ST in terms of timing, availability and cost-efficiency.

ANATOMY

The human respiratory system is formed from a series of cartilaginous and connective tubes, interconnected to create a network, which allow the passage of air to travel from the mouth and nose, to the alveoli.⁷ These alveoli are microscopical air sacs, which are the main sites for gas exchange – an essential function of the respiratory system. Without this vital function, the cells in the body would not receive enough oxygen and nutrients, and therefore would die, leading to tissue necrosis and eventually death. Therefore, any obstruction or threat to this function would be potentially life-threatening, thus highlighting the importance of establishing an airway.

In order to perform a tracheostomy, whether it be ST or PDT, it is fundamental that the underlying anatomy is understood. The aim of a tracheostomy is to create another airway; therefore, it must enter into part of the respiratory system. This is easiest done in the front of the throat, which is made up of the larynx and trachea. The anterior portion of the larynx is formed from two cartilages: the thyroid cartilage (a prominent structure made of hyaline cartilage), and the cricoid cartilage. The trachea is a 10-13cm tube⁷ that descends into the thorax, posterior to the sternum. It consists of 16-22 incomplete, C-shaped cartilaginous rings, that provide

support and some movement, and is the largest hollow conduit of the respiratory system.⁷

An ST is performed most commonly in the space between the 2nd and 3rd tracheal cartilages.⁸ The left and right recurrent laryngeal nerves run parallel to the trachea, as shown in figure 1 below. A horizontal surgical incision here must only be 2-3cm long⁸ in order to prevent severing these nerves – resulting in vocal cord paralysis. Another important consideration for the clinician is the location of the thyroid gland. Therefore, it must be either retracted, moved or even divided, depending on the type of tracheostomy technique being used.⁸

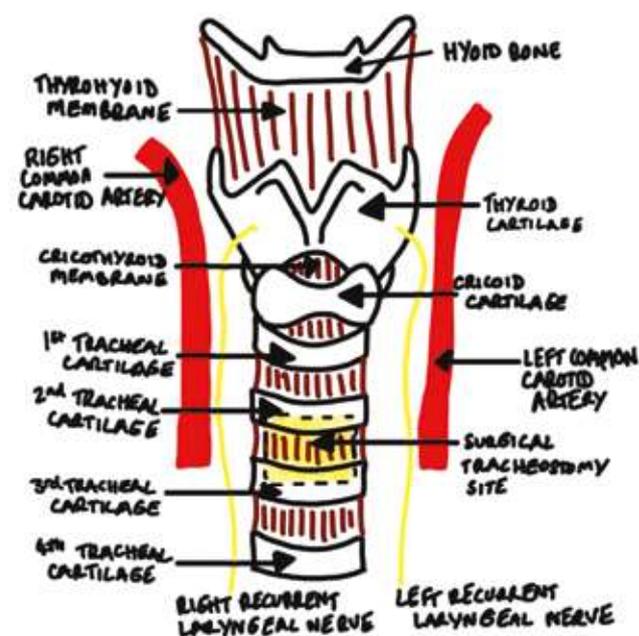


Figure 1: A diagram showing the relevant anatomy and surrounding structures of the larynx and trachea.⁹

COVID-19 IMPACT

Tracheostomies, however, have drawn criticism, most notably with the current pandemic. Currently affecting 60 million people worldwide,¹⁰ COVID-19 has proven to be a deadly and devastating disease, which has torn through society and overwhelmed public health systems across the globe. Mainly targeting the respiratory system, the COVID-19 virus has altered the way we treat people and the methods in which we do so. Multiple studies have been conducted in order to guarantee the safety of patients and staff carrying out these procedures, especially with a standard ST being considered as a high-risk procedure, in which many aerosol generated particles are produced.¹¹ For clinicians working with patients with COVID-19, there is guidance to ensure that safe practice is carried out, and for the need of unnecessary exposure to be reduced.¹²

COMPLICATIONS

As with any medical procedure, whether it's an ST or PDT, a tracheostomy comes with potential risks and complications. Complications are defined as unfavourable results of treatments, and can be categorised in relation to tracheostomies, as immediate, delayed or late.¹³ Immediate complications arise instantaneously or within hours of the procedure. Complications described as delayed usually occur within a period of seven days, whereas late complications arise after a seven-day period of the procedure being performed. The potential complications for both ST and PDT have been collated into figure 2 below.

Immediate	Delayed	Late
Haemorrhage	Tube blockage	Granulomata of trachea
Misplacement	Infection	Haemorrhage
Pneumothorax	Tracheal ulceration	Tracheal dilation
Surgical emphysema	Tracheal necrosis	Tracheal stenosis
Oesophageal perforation	Tube migration	Dysphagia
Infection	Occlusion of tube	Scar formation
Tracheal ring fracture	Trachea-oesophageal fistula	Tracheomalacia
Aspiration	Accidental decannulation	Pneumonia
Air embolus	Haemorrhage	Death
Occlusion of tube	Death	
Death		

Figure 2: A table showing the immediate, delayed and late complications of a both surgical and percutaneous dilational tracheostomies.¹⁴

FINDINGS

An article from Klotz et al. (2018)¹⁵ looked at various different studies and concluded that there was no significant difference between either technique of a life-threatening event happening (8.7% in the PDT group versus 7.4% in the ST group). This would include complications such as major bleeding or loss of airway, amongst many others. Also, there was no difference in mortality, with 0.3% of patients dying in the PDT group, and 0.7% in the ST group. However, the paper did determine that stomal infection was more common in patients who had received ST (7.6% for the ST group compared to 1.4% for the PDT group).

Johnson-Obaseki et al. (2016)¹⁶ found that when comparing ST and PDT, whilst looking mainly at haemorrhage and mortality, the data showed no difference in results. Nonetheless, the data obtained seemed to show a lower infection rate and operative time in the PDT group, compared to the ST group.

A study from 2015, conducted by Kiran et al.¹⁷ suggested that PDT is as safe as ST, provided the patients are correctly identified and the appropriate guidelines are followed. Ninety critically ill patients on long-term mechanical ventilation were included in this study. Two out of thirty patients who underwent ST were reported to have had major bleeding, which was controlled by cautery. Two out of sixty patients who were treated with PDT also had major bleeding. Two patients in the PDT group also had chip fracture of tracheal ring cartilage, and one patient had a false passage and kinking of the guidewire, which resulted in a change of guidewire and subsequent reinsertion. Postoperative complications were also reported in both groups, with two patients in the ST group having minor bleeding, two patients with subcutaneous emphysema, and one patient with purulent exudate at the stoma. In the PDT group, five patients were reported to have had haematoma formation, and two patients developed subcutaneous emphysema. All complications were managed. In terms of long-term management, successful decannulation was achieved in eleven (36.7%) of the ST patients and fifteen (25%) of the PDT patients. There was also reported granulations and narrowing of the trachea in both groups, with this occurring in six (20%) of ST patients, and seven (11.7%) of PDT patients. The report concluded that there was no statistical difference in the incidence of complications between the two groups.

A study from Riestra-Ayora et al. (2020)¹⁸ presented significant data on the safety of both ST and PDT techniques, when looking at 27 COVID-19 positive patients in intensive care. Results showed that there were no recorded cases of infection in the group of surgeons that performed the tracheostomies. However, the study found that the mortality rate for this cohort of patients far exceeded the normal, with 11 of the 27 patients dying within a seven-day period. There was no conclusive evidence to suggest that the high mortality rate was a direct result of the complications, or whether this was due to the effects of COVID-19, due to the small sample size. Therefore, further studies with larger cohorts would be needed in order to determine the cause of the high rates of death.

Chao et al. (2020)¹⁹ published a study looking at COVID-19 transmission between healthcare workers and determined that the risk both ST and PDT posed to staff was zero. The study recorded 53 intensive care patients, who were all COVID-19 positive, with no healthcare workers testing positive after the procedures.

In 2020, a study by Zhang et al.²⁰ looked at 11 cases of tracheostomies amongst COVID-19 positive patients. Five cases of ST and six cases of PDT were performed, with no severe postoperative complications being reported, and no healthcare workers testing positive for the COVID-19 virus, within 14 days of the procedure taking place.

A study conducted in 2020 by Long et al.²¹ compared the complication incidence and mortality rate for both ST and PDT techniques. They concluded that out of 67 COVID-19 patients, 32 of which were tracheotomised with the surgical approach and 35 with the percutaneous dilational approach, 11 complications arose in 10 patients, most of which were minor bleeding. However, the study claimed that there was no statistical difference in complication incidence between either technique. There was a small percentage of mortality, with five patients dying with systemic causes; this was very small however, and the study determined that both ST and PDT were

safe procedures for COVID-19 patients.

Vargas et al.²² conducted a study in 2020, and looked specifically at the PDT technique, and how successful this can be in COVID-19 patients. A PDT technique was modified slightly so that a smaller endotracheal tube was cuffed at the carina, which increased patient respiratory function and comfort. Pausing the ventilators while the cuff was being placed was also a key focus in this study, decreasing the risk that aerosol generated particles would pose to the staff. It was also deemed safe for staff, as the procedure time was reduced, allowing for a decreased exposure time.

DISCUSSION

Each technique has its own advantages and disadvantages, which can be used to decide a patient’s treatment method. They have been outlined in figure 3 below.

PDT is considered to be cheaper and less time consuming due to its ‘bedside’ capability. This means it can be performed on the intensive care unit (ICU), without the need for preparation of an operating theatre. The nature of the procedure allows for scarring to be kept at a minimum, without the need to dissect and create incisions in the skin and tissues. This can be enormously advantageous for the patient, reducing the incidence of depression or anxiety over scars amongst patients. However, it can be disadvantageous when faced with a patient with ‘difficult’ anatomy. ST in this case would be the favoured option, due to the nature of the procedure being under direct visualisation of the operating clinician at all times, allowing them to avoid important anatomical structures.

With the effect of COVID-19 on most current-day medical procedures, we can see from Riestra-Ayora et al.,¹⁸ Chao et al.¹⁹ and Zhang et al.²⁰ that both ST and PDT procedures are safe for medical staff, with no incidence of positive tests in all groups within a 14-day period. This is reassuring for healthcare workers and ensures that after the appropriate guidelines are followed and adhered to, and suitable PPE is worn, that transmission of the virus is reduced to none.

From the studies, particularly Klotz et al.¹⁵ and Kiran et al.¹⁷ we can clearly see a distinct pattern between the type of tracheostomy and the incidence of complications. Neither ST or PDT have relatively high complication numbers, and therefore, either technique can be classed as safe as the other. Both techniques are used frequently in current practice but

depend heavily on specific patient parameters. Therefore, it is best practice to assess each patient before deciding which technique to use.

However, as COVID-19 is still a relatively contemporary disease, we do not fully understand it. Therefore, in order to determine the safety of tracheostomies for performing staff, there needs to be more studies and more data published. As a suggestion for future work, there needs to be more focus on specific, critically ill COVID-19 patients. This may include following them up within a year of a tracheostomy procedure in order to determine whether there are any complications as a result, and to possibly take it a step further and calculate the mortality rate for COVID-19 patients after undergoing a tracheostomy. Also, future studies could look at staff safety on a larger scale, for example between 50-100 staff, where they could be followed up within both a two week and one month period. This would therefore display if there is any potential transmission risk between staff during or after a procedure.

CONCLUSION

This review demonstrates that in current practice, tracheostomies are extremely useful and safe procedures, with very low mortality rates associated with them. Both ST and PDT techniques prove to be as effective as each other in critically ill patients with COVID-19. Because the effects of COVID-19 can be extremely damaging to the respiratory system, it is becoming increasingly prevalent to see prolonged mechanical ventilation in patients in ICU, who have tested positive for the virus. Subsequent to this, we have to be confident that there is a small risk of complications, and safe long-term care can be provided, if this is the chosen method of treatment. Additionally, it is of paramount importance to ensure the safety of staff involved in these procedures, whether it is ST or PDT, due to the added risks of being exposed to the virus. However, the studies looked at in this review have demonstrated the risk of transmission is extremely low, giving healthcare providers the confidence that these procedures can be carried out safely on a daily basis.

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Surgical Tracheostomy		Percutaneous Dilational Tracheostomy	
Advantages	Disadvantages	Advantages	Disadvantages
Direct visualisation	Time consuming	Decreased local infection	Less visualisation
Can avoid abnormal vessels	More bleeding	Less cosmetic deformity	Requires bronchoscopy
Easier for difficult cases	Higher risk of tracheal stenosis	Quicker	Risk of bronchoscope damage
Best control of airway	Expensive	Less planning	Pneumothorax risk
		Cheaper	
		Tighter fit	

Figure 3: A table comparing the advantages and disadvantages of ST and PDT.²³

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