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The role of tracheotomy in patients with moderate to severe impairment of the lower airways

Il ruolo della tracheotomia nei pazienti affetti da disfunzione moderata o severa delle vie aeree inferiori

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SUMMARY

Patients affected by severe acute respiratory distress syndrome due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection have a high likelihood of needing prolonged intubation. As observed worldwide during the Coronavirus Disease 2019 (COVID-19) pandemic, the need for tracheotomy in patients with prolonged respiratory failure has dramatically increased. Tracheotomy in these patients offers several advantages over prolonged translaryngeal intubation: improved patient comfort may allow a reduction in intravenous administration of analgesics, sedatives and muscle relaxant drugs, enhance mobility with particular regard to respiratory muscles, and patients may achieve autonomy earlier. However, there is still debate about the optimal timing and surgical technique of tracheotomy. Similarly, debate is still open regarding the relative merits of open surgical tracheotomy (ST) *versus* percutaneous dilatational techniques (PDT). In general, PDT is commonly used in elective tracheotomy in adult patients in intensive care units; ST may be preferred depending upon the practitioner's experience and patient's characteristics. Correct timing of tracheotomy should be individualised and the indication for tracheotomy should balance the problems related to prolonged intubation and the risk of early or late complications related to the surgical procedure.

KEY WORDS: tracheotomy, intensive care, respiratory insufficiency, respiratory failure, mechanical ventilation

RIASSUNTO

Durante la pandemia di COVID-19 la necessità di eseguire una tracheotomia nei pazienti con insufficienza respiratoria prolungata è drammaticamente aumentata, poiché i pazienti contagiati dal virus SARS-CoV-2 manifestano una sindrome da distress respiratorio acuto grave che spesso necessita di un'intubazione prolungata. La tracheotomia offre diversi vantaggi rispetto all'intubazione translaringea prolungata: un migliore comfort del paziente può infatti consentire una riduzione della somministrazione di analgesici e sedativi, può migliorare la mobilità con particolare riguardo ai muscoli respiratori e i pazienti possono raggiungere un'autonomia più precocemente. Tuttavia in letteratura è ancora aperto un dibattito su quale sia, nell'esecuzione della tracheotomia, la tempistica ottimale e la tecnica chirurgica più appropriate, così come se sia più indicate la tecnica a cielo aperto (ST) rispetto alla dilatazione percutanea (PDT). In generale, in terapia intensiva, la PDT in elezione è più comunemente usata; la ST può essere preferita a seconda dell'esperienza del medico e delle caratteristiche del paziente. La tempistica di esecuzione deve essere individualizzata sulle condizioni del paziente e l'indicazione deve considerare i problemi legati all'intubazione prolungata e il rischio di complicanze legate alla procedura chirurgica.

PAROLE CHIAVE: *tracheotomia, terapia intensiva, insufficienza respiratoria, ventilazione meccanica*

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Introduction

A tracheotomy is usually performed for one of the following reasons: to bypass an obstructed upper airway, to clear secretions from the airway, or to deliver oxygen to the lungs more easily and more safely in patients who require prolonged mechanical ventilation [1]. The most frequent indication for tracheotomy is to assist mechanical ventilation, followed by head and neck surgery and upper airway obstruction. In addition, the need for tracheotomy in patients with prolonged respiratory failure has recently increased due to the COVID-19 pandemic. Patients affected by severe acute respiratory distress syndrome due to SARS-CoV-2 infection have a high likelihood of needing prolonged intubation and may require tracheotomy [2]. It is important to recognise the complications of tracheotomy, and measures should be taken to prevent them. Optimal timing and surgical technique for tracheotomy are still being debated, and well-designed studies to establish clear guidelines regarding the timing of tracheotomy are not available [1]. On the other hand, early tracheotomy may decrease the need for sedation and length of stay in intensive care units. However, it does not decrease rates of ventilator-associated pneumonia or mortality [3]. Similarly, debate is still open regarding the relative benefits of open surgical tracheotomy (ST) *versus* percutaneous dilatational techniques (PDT) [2,4]. There are also continuing developments in materials like the preferential use of more flexible tracheotomy tubes [5]. Tubes with removable inner cannula greatly reduce the risk of tube obstruction by encrusted secretion. As opposed to the abovementioned debates, tracheotomy currently has an established role in the management of lower airway impairment and intensive care. It is usually performed in critically ill patients affected by moderate to severe lower airway impairment to provide airway care or ease weaning from assisted ventilation [5]. The aim of this narrative review is to describe the role of tracheotomy in patients affected by lower airways impairment.

Indications for tracheotomy in lower airway impairment

Tracheotomy is usually performed in patients affected by lower airway impairment to remove secretions from the airway, to deliver oxygen to the lungs more easily and more safely in patients who require prolonged mechanical ventilation and to ease weaning from prolonged mechanical ventilation [1]. The lower airways can be impaired directly or indirectly by several diseases. Factors indicating the need for tracheotomy in critically ill patients include: prolonged weaning from assisted ventilation, acute or chronic neuromuscular conditions, poor cardiorespiratory reserve, bulbar dysfunction, or brain injury. Tracheotomy may also be required in patients with severe lung diseases who need prolonged respiratory support (such as in case of bronchopulmonary dysplasia), in chronic pulmonary disease to reduce anatomic dead space, in severe sleep apnoea not treatable with continuous positive airway pressure devices or other less invasive surgery, or for chest wall injuries. The lower airways can also be indirectly affected by other conditions, such as neuromuscular diseases paralysing or weakening chest muscles and diaphragm, anaphylaxis, aspiration related to pharyngolaryngeal motor or sensory impairment, fractures of cervical vertebrae with spinal cord injury, long-term coma and disorders of respiratory central control such as congenital central hypoventilation or central apnoea.

Potential advantages of tracheotomy *versus* translaryngeal intubation

Most of the aforementioned diseases require intensive care. Tracheotomy in the critically ill patient offers several advantages over prolonged translaryngeal intubation [1,3]. First of all, improved patient comfort may allow a reduction in intravenous administration of analgesics, sedatives and muscle relaxant drugs, thus enhancing mobility and speech so that patients may achieve autonomy earlier [6]. As the patient recovers, a fenestrated tracheotomy tube should be inserted to allow phonation. Clearance of airway secretions, oral hygiene and enteral nutrition are facilitated. When respiratory mechanics improve, weaning is facilitated. In the meantime, the risk of unscheduled accidental extubation decreases, since tracheotomy allows a gradual transition between different weaning modes avoiding attempts to extubate followed by reintubation. It should be noted that patients with COVID-19-related acute respiratory distress syndrome often require prolonged intubation. In addition, early extubating attempts frequently require a reintubation procedure. Reintubations should be considered a difficult procedure in severe COVID-19 patients for several reasons (i.e., no respiratory reserve, need for strict infection control, urgency, bulky personal protective equipment, psychological pressure). Tracheotomy offers several advantages that allow easier attempts of weaning from ventilator. Therefore, the procedure is frequently required not only to avoid complications related to prolonged intubation, but also to facilitate weaning process [8,9]. The anatomic dead space contained in the upper airway and the intrathoracic conducting airways is approximately 150 mL in an adult. This is clearly more than the volume in the tracheotomy tube, which is around 5 ml, plus connecting pieces. However, the difference in internal volume of

standard endotracheal tubes and tracheotomy tubes of same sizes is less than 20 ml, and it seems unlikely that such small volume differences could significantly affect lung mechanics in vivo. Anatomical dead space is reduced with both tracheotomy and translaryngeal intubation. A more plausible reason to facilitate weaning would be reduced work of breathing because of a decrease in flow resistance due to the reduction in the tube length. This difference increases with increasing inspiratory flows. Intrinsic positive end-expiratory pressure is also slightly reduced after tracheotomy [7]. Tracheotomy may allow earlier discharge from intensive care to lower intensity units. The risk of laryngeal and tracheal ulceration decreases, as the respiratory tube is taken out from the first digestive tract, eliminating the up and down movements and frictions related to deglutition. Endotracheal intubation can result in severe injury of the upper airways (tracheal stenosis, subglottic stenosis, arytenoid anchyloses) which can be largely prevented by early tracheotomy [10].

Potential disadvantages of the tracheotomy

Tracheotomy is a surgical act procedure associated with early and late complications [1].

Early complications (< 7 days) [1]:

- *Haemorrhage.* The cuff of the tracheotomy tube should be inflated immediately. Minor haemorrhage can be controlled by packing. Major bleeding may require reoperation.
- *Wound infection.* This complication often requires local antibiotics. In case of necrotising tracheal infection, conversion to orotracheal intubation, debridement of necrotic tissues and systemic antibiotics may be needed.
- *Subcutaneous emphysema and pneumothorax.* These complications can be caused by positive pressure ventilation. Subcutaneous emphysema can be also caused by coughing against a tightly sutured or packed wound. It can be prevented by removing the suture and packing around the tube. The emphysema will resolve spontaneously within a few days. A chest radiograph should be obtained to rule out a pneumomediastinum.
- *Tracheotomy tube obstruction.* The tube can be obstructed by mucus, secretions, blood clots, or angulation of the tube against the tracheal wall. Failure to re-establish adequate ventilation by suctioning through the tube requires immediate replacement of the inner cannula or the entire tube.
- *Early tube displacement or false passage.* The tube can displace into surrounding soft tissues. Early displacement of the tube can create an airway emergency. Replacement of the tube should be attempted immediately, caring not to create a false tract. Orotracheal intubation could be needed when correct replacement is not obtained.

Late complications (> 7 days) [11,12]:

- *Dysphagia.* Factors that contribute to swallowing impairment are decreased laryngeal elevation, decreased laryngeal sensibility and oesophageal compression from the tube cuff.
- *Tracheal stenosis.* Tracheal stenosis occurs in approximately 1-2% and usually results from tracheal ischaemia, caused by forced angulation of the tube or hyperinflation of the cuff. It is recommended to monitor the cuff pressure (< 20 mm Hg) [1]. Stenosis could also be caused by tracheal ring fractures or posterior tracheal wall injuries occurring during surgical manoeuvers.
- *Tracheomalacia.* It can develop because of ischaemia and necrosis of tracheal cartilage. Causes are the same seen for stenosis.
- *Tracheo-innominate artery fistula.* The tube can erode into the artery if tracheotomy is too low or innominate artery is high riding. This severe and potentially deadly complication usually occurs at 7 to 14 days after the tracheotomy. Sentinel bleeding may be present and should be carefully investigated.
- *Tracheo-oesophageal fistula.* Due to pressure and erosion against the posterior tracheal wall by the tracheotomy cuff or angled tube. This condition can otherwise cause further complications such as ab ingestis pneumonia which, if not promptly treated, can induce major lower airways complications such as pulmonary fibrosis.
- *Persistent stoma.* Epithelialisation between the skin and the tracheal mucosa can occur when the tube has been left in position for a prolonged period. Surgical closure can be proposed.
- *Granuloma formation.*

Timing of tracheotomy

Timing of tracheotomy is controversial and strongly influenced by the indications for the procedure [1]. In most institutions, tracheotomies are performed within 2 weeks of prolonged mechanical ventilation. Median timing is 11 days [13,14]. The decision about the most appropriate time to perform tracheotomy in patients undergoing invasive mechanical ventilation should balance the problems related to prolonged intubation and tracheotomy. Firstly, the risk of laryngeal injury with the prolonged use of an endotracheal tube. Secondly, the possibility that surgical complications occur during or following tracheotomy. Previous studies [15,16] showed that very early (< 48 hours) tracheotomy significantly reduced the duration of mechanical ventilation, mortality, pneumonia and length of stay in the intensive

care unit compared to late (14-16 days) tracheotomy. However, data regarding ventilator-associated pneumonia and mortality are conflicting [3,17]. As yet, there are not enough well-designed studies to establish clear guidelines regarding the timing of tracheotomy. The decision to perform a tracheotomy should be individualised and take into consideration factors other than time: improved patient comfort as well as enhanced nursing care. Early tracheotomy at 7 days of mechanical ventilation could be appropriate for patients in whom weaning and extubation are not likely before day 14.

In patients needing prolonged invasive mechanical ventilation for severe COVID-19, tracheotomy may be needed. In this particular case, viral load and risk of viral transmission must be taken into consideration when deciding the timing of tracheotomy. The American Academy of Otolaryngology – Head and Neck Surgery issued a position statement on March 27, 2020 (revised 22 April 2021) [18], recommending that tracheotomy be performed no earlier than 2 weeks after intubation. Recommendations of the ENT UK and British Laryngological Association [19] suggest waiting a minimum of 14 days of intubation to allow prognostic information to become clear and for viral load to potentially decrease [20]. Similar recommendations have been issued by others [21]. In contrast, other authors proposed shorter timings if patients are far from reaching weaning targets [22]. Up to now, timing of elective tracheotomy in the intensive care unit for intubated patients with severe COVID-19 is still unclear.

Percutaneous dilatational tracheotomy *versus* open surgical approach

Tracheotomy can be performed with either a percutaneous or open surgical approach. Usually, the choice of the technique depends on the preference of practitioners and patient-related factors. Even if the debate is still open, several studies showed that when elective tracheotomy is indicated in critically ill adult patients, the technique of PDT [21] offers important advantages over ST (level 1B) [1,24-26]. Less wound infection is observed in PDT, probably due to minimisation of local tissue trauma and a tighter fit between the cannula and surrounding tissues. There is no difference in bleeding in PDT *versus* ST. The occurrence of long-term complications is not affected by the choice of technique [26,27]. The decision whether to perform PDT or ST in obese or short neck patients should depend upon the experience of the practitioner and the possibility to identify anatomical landmarks. Obesity is considered a risk factor for increased complications for many surgical procedures including tracheotomy. However, no data are available comparing PDT and ST in this subset of patients. Ideal selection of patients for PDT is not well defined [3]. The following criteria for PDT are well accepted: palpable cricoid cartilage at least 3 cm above the sternum with head extension, history of uncomplicated translaryngeal endotracheal intubation, positive end-expiratory pressure of less than 10 cm H_2O. Contraindications to PDT include neck masses, uncorrectable coagulopathy, high positive end-expiratory pressure (> 20 cm H_2O), need for emergent airway, or paediatric use [28,29]. Bronchoscopy and ultrasound use decrease procedural complications in PDT.

In case of patients with severe COVID-19, airborne spread of viral particles and limited time of apnoea must be considered in the choice of the safest technique. PDT could result in longer apnea and longer exposure to generated aerosol [30]. In our experience [4], a similar incidence of postoperative complication rates was reported in PDT and ST in patients with severe COVID-19. The incidence of overall complications was higher than the general population, but in line with the literature dealing with critically ill patients [31]. However, authors recommend considering either ST or PDT in COVID-19 patients at the discretion of the medical staff involved, according to the personal experience of the operators performing the procedure. Adjunctive safeguards are required when dealing with COVID-19. Since tracheotomy is considered a highly aerosol-generating procedure, the highest level of personal protective equipment and precise surgical planning are required [32-35].

Removal of tracheal cannula

In tracheotomised patients, weaning can be obtained through non-invasive ventilation applied via a nasal or full-face mask with the tracheotomy tube capped off and its cuff deflated [36]. After weaning from mechanical ventilation, removal of the tracheal cannula can be considered if patients are clinically stable, have adequate swallowing, are able to expectorate and do not have psychiatric disorders [37]. A deflated-cuff tracheotomy occlusion procedure should be performed before removing the tracheal cannula. After deflation of the tracheotomy cuff, the opening of the tube should be occluded and the patient observed for signs of respiratory distress. In case of problems, one promptly returns the patient to breathing through the tracheotomy tube and perform an endoscopic examination to rule out possible airway obstructions. In case of copious respiratory tract secretions or expectoration impairment, the tube can be downsized[1]. After tracheal tube removal, the wound spontaneously heals in 10 days in most cases.

Conclusions

Tracheotomy is increasingly needed to manage patients with prolonged respiratory failure. PDT is commonly used in elective tracheotomy in adult patients in intensive care units, but ST may be preferred depending upon the experience of the practitioner and patient's characteristics. Correct timing of tracheotomy should be individualised. The indication to tracheotomy in intensive care should balance the problems related to prolonged intubation and the risk of early or late complications related to the surgical procedure.

Conflict of interest statement

The authors declare no conflict of interest.

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Authors' contributions

CB, PR and AG: substantial contributions to the conception and design of the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

MM, CM, CP, DG and DP: substantial contributions to the acquisition, analysis, or interpretation of data for the work; final approval of the version to be published; agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethical consideration

Institutional Ethics Committee approval is not required for this review article.

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