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Endoscopic Percutaneous Tracheotomy in Prolonged Intubation of Mechanical Ventilated Patients Admitted in Cardio-Thoracic Intensive Care Unit

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1. Introduction

Recent advances in surgical and anesthesia technology and biotechnology have made the intensive management of patients who have undergone open heart procedures more demanding.

New interventions and treatment strategies are desirable to improve the outcomes of this specific group of patients. Tracheotomy was performed mainly to prevent laryngeal and upper airway damage due to prolonged tracheal intubation after cardiac or thoracic surgery or medical illness.

In this chapter we will review and discuss the percutaneous dilational tracheotomy (PDT) approach in cardiac surgery patients who need prolonged mechanical ventilation. Available data were located regarding the technique, timing, advantages and complications of the PDT. We also underlined the utility of bronchoscopy control during the procedure. We describe also our experience performing PDT with bronchoscopy control procedure on patients admitted to Cardiothoracic Intensive Care Unit (CTICU) patients. In our CTICU we have a long-term experience of tracheotomy with bronchoscopy control that yields better clinical practice and outcome.

2. New cardiac surgery patient profile

The features of cardiac surgery patients are changing, mainly regarding the increasing numbers of the elderly patients, re-operated patients, patients with advanced heart disease, and with many severe co-morbidities. The number of patients undergoing simultaneous coronary artery by-pass grafting (CABG) and valve replacement, ventricular aneurysmectomy, aortic surgery, or carotid endoarterectomy has also increased, as well as the number of patients undergoing transplant and/or implantation of ventricular assist device as a bridge to transplant by the Intensive Care Units (ICU).

This new profile of cardiac surgical patient has lead to an increasing demand for high-tech medical interventions, such as mechanical ventilation in ICU.

Many of these patients are able to resume spontaneous ventilation as soon as they recovered from the anesthesia. The decision to extubate a patient depend on the recovery of physiological homeostasis, through return to normothermia, adequate heart and lung function, intravascular volume replacement, electrolyte normalization and optimization of pain relief. The extubation can be perform 24 hours a day as soon as these criteria are met.

The clinical and economic advantages of early extubation (within 4-8 hours after the ICU admission) are widely documented and show very positive results (Rajakaruna et al., 2005). This procedure has mainly reduced the adverse effects of positive pressure ventilation, including barotraumas. It has also decrease the potential incidence of infections and has minimized patient discomfort. Many studies have also shown that it reduces the length of intensive care unit, and therefore hospital stay and related costs (Rajakaruna et al., 2005).

However, approximately 2.6% to 22.7% of patients still require prolonged mechanical ventilation (PMV). This large variability depends on the selected criteria and guidelines adopted to define PMV. For example, Rajakaruna et al (Rajakaruna et al., 2005) conducted an observational study of 7553 patients and concluded that the PMV condition should be defined by a time period of more than 96 hours; while Alfieri et al (Pappalardo et al., 2004), studying the long-term survival and quality of life of 4827 adult cardiac surgical patients, define the PMV duration as more than seven days. Our literature review does not indicate a consensus regarding the exact definition of PMV.

3. Risk factors and clinical and economic effects of the PMV

Prolonged mechanical ventilation after cardiac and thoracic operations has become increasingly common over the past years. To rationalize the ICU work, improve the outcomes of this patients and contain the health care cost in literature (Trouillet et al., 2011) we identified a list of risk factors of PMV. Many authors (Cislaghi et al., 2009; Murthy et al., 2007; Trouillet et al., 2011) found implication of *preoperative* variables such as old age, higher BMI, diabetes mellitus, high pulmonary arterial blood pressure, New York Heart Association (NYHA) class higher than 2, ejection fraction under 50%, preoperative intraaortic balloon pump, creatinine clearance lower than 50 mL/min, operative priority. *Intraoperative* variables include the type of surgery (multiple valve replacement, aortic procedures, heart transplantation and reoperation), cardiopulmonary bypass (CPB) duration, intraaortic balloon pump. *Postoperative* variables include SAPS II higher than 45, neurologic event, lung injury, renal failure, internal bleeding, major arrhythmia.

Moreover several studies (Cislaghi et al., 2009; Trouillet et al., 2011) suggest that PVM is associated with higher in-hospital morbidity, mortality, and costs.

4. Technique

4.1 Lab studies

Many tracheotomies are electively performed on patients with secure airways (eg, for prolonged intubation) therefore it is reasonable to control hematologic parameters including hemoglobin (Hb), platelet count (PC) prothrombin time (PT), partial prothrombin time (PTT), and INR since it became available in 1998. A adequate correction must be eventually assured to take PC to a value greater than 50, and INR to a value of less than 1.5.

As with any procedure, the decision to perform an emergency tracheotomy is not influenced by lab parameters.

4.2 Setting and patient preparation

The old method of performing tracheotomy in critically ill patients requires transport from the intensive care unit (ICU) to the operating theatre, were the surgical team performed the tracheotomy. The percutaneous technique, for the limited dissection, results in less tissue damage and lower bleeding, and can be performed at the bedside on the ICU avoiding the risks related to the patients transportation. Furthermore, this technique can be successfully managed by intensivists, without specialized surgical training.

The patient usually has already a translaringeal endotracheal (TE) tube in place before tracheotomy. Continuous vital signs, pulse-oximetry, and complete ventilatory parameters are monitored throughout the procedure, antibiotic prophyaxis is necessary with a single dose of second generation cefalosporin.

General anesthesia is performed, using propofol, fentanyl, and pancuronium. Ten minutes before the tracheotomy procedure the positive end-expiratory pressure was reduced stepwise to 5 mm Hg if required, and all patients received positive-pressure ventilation with 100% oxygen throughout the tracheotomy.

4.3 Cricothyroidotomy

This approach requires to place a tube through the cricothyroid membrane.

Cricothyroidotomy can be used to gain emergency access to the airway, but as it is associated with numerous complications, it is suggested to replace this tube within 48–72 hours with a standard tracheotomy.

4.4 Open surgical tracheotomy

Elective surgical tracheotomy (ST) is ideally performed in the operation room. However, bedside tracheotomy can be performed.

The technique has changed very little since its original description by Chevalier Jackson (Jackson, 1909). Briefly, a 4 cm to 5 cm vertical or horizontal skin incision is made 1 cm below the cricoid cartilage over the second to fourth tracheal rings and the pretracheal tissues are dissected; the endotracheal tube is slowly withdrawn to just above the tracheotomy incision, but not removed, in case difficulty in tracheotomy placement requires its urgent reinsertion. Finally the tube is inserted into the tracheotomy under direct vision.

As animal experiments suggest, the injury to the cricoid cartilage was a major risk factor for subsequent subglottic stenosis, De Leyn recommended placing the tracheostoma well below the cricoid cartilage (De Leyn et al., 2007).

4.5 Percutaneous dilational tracheotomy

The theoretical basis for the development of all percutaneous procedures is represented by the Seldinger's method that, since 1953, planned the needle replacement over a wire-guided for arterial catheterization.

The wire-guided percutaneous technique for percutaneous tracheostomy was developed and reported in the same year by the American surgeon Ciaglia, who combined the Seldinger wire nephrostomy tube multiple-dilator placement technique with a special, low-profile tracheostomy tube (Ciaglia et al, 1985).

Several different methods of performing percutaneous tracheostomy have been subsequently described.

4.5.1 The main different percutaneous techniques

Ciaglia first described PDT in 1985. The technique is based on progressive dilatation of a small initial tracheal aperture created by a needle, using a series of graduated dilators.

In 1990 Griggs described the Guidewire Dilating Forceps (GWDF) technique of percutaneous tracheotomy. It is based on enlarging a small tracheal aperture with a forceps, having a blunt tip and blunt edges.

In 1997 Fantoni and Ripamonti introduced the retrograd translaryngeal technique (TLT), another minimally invasive procedure achieved using a single device under direct vision with a rigid tracheoscope (RCT), subsequently replaced by a flexible fiberoptic bronchoscope (FFB).

In 1998, a modification of the Ciaglia technique was introduced (Ciaglia Blue Rhino Percutaneous Tracheotomy Introducer Kit; Cook Critical Care Inc., Bloomington, IN), whereby the series of dilators was replaced with a single, sharply tapered dilator, permitting complete dilatation in one step. It has been shown that the single dilator technique decreased operative time compared with the serial-dilator technique without increasing the complication rate.

However in 2002 Frova and Quintel described another procedure named PercuTwist, consisting in a single-step rotating dilatation tracheotomy applied with the use of a screw-like dilatators. The device is threaded into the tracheal stoma using a lifting motion.

In the present study we want describe in detail the Single Dilatator Ciaglia Blue Rhino Percutaneous Tracheotomy Technique with endoscopic guidance.

4.6 Ciaglia technique

The patient has usually endotracheal tube in place (regarding lab study, general anesthesia and antibiotic prophylaxis see above); the whole procedure is performed in direct vision with flexible bronchoscopy (BF-P240 or BF-40; Olympus; Tokyo, Japan) via translaryngeal tube.

Ciaglia technique is performed using the Ciaglia single dilator kit (Ciaglia Blue Rhino, Cook Critical Care, Bloomington, Illinois).

Vital signs are continuously monitored throughout the procedure, personnel are positioned with the operator to the patient's right, the bronchoscopist at the head of the bed, a circulating nurse is available to administer medications and otherwise assist in the procedure.

At the start the patient's neck is slightly reclined, inspected in detail, landmark points are indentified. The surgical area is cleansed and prepared with surgical drapes in the typical manner.

The broncoscopic placed in the endotracheal tube, having deflated endotracheal tube cuff with tapes loosened, together are withdrawn slowly to just below the vocal cords. Then the assistant held the tube with his hands continuously throughout the whole procedure and handles manual ventilation on a regimen of 1.0 FIO_2. The anatomical landmarks is identified by fiberoptic transillumination and digital manipulation of the trachea, approximately 2 fingerbreadths below the cricoid or 1 fingerbreadths above the sternal notch (Byhahn et al., 2000).

After identification of the translaryngeal puncture point, a 16-gauge Teflon introducer needle is inserted midline through the anterior wall of the trachea, between the first and second or second and third tracheal rings. The needle is withdrawn and replaced by the J-tipped guide-wire which is advanced through the Teflon sheath, toward the carina. The catheter sheath is removed and beveled plastic single dilator, held like a pen, and forced into the tracheal wall over the guide-wire, to create a tracheostoma. Once the tracheostoma has been dilated to the appropriated size, the loading dilator is removed to permit insertion of a specially tracheotomy tube into the trachea over the same guide-wire, using one of the dilators as a obturator. The cuff is inflated and ventilation resumes through the tracheotomy tube which is secured with a strap tied around the neck.

The bronchoscope, removed from the endotracheal tube, is placed through the tracheotomy tube to check its right position, to remove blood or bronchial secretions and, if necessary to collect the bronchoalveolar lavage (BAL), quantitative tracheal aspirate, or protected brush specimens (PSB).

The translaringeal tube is withdrawn when adequate ventilation is verified.

A dry dressing is applied to the neck and routine tracheotomy care is conducted, with cleaning and suctioning as required.

In 30% of the PDT, the tube passes through the thyroid isthmus, but bleeding is very rare, because the tracheotomy tube, being tightly fitting to the wall, acts as tamponade bleeding of vessels.

4.7 Comparison from different PDT techniques

The percutaneous techniques are based on the principle of tracheal puncture, stoma creation by dilation of the soft tissues of the neck and insertion of the tracheal tube, using the Seldinger technique. The differences are the shape and the managing of the dilator. Only the TLT is a reversed method in which, in contrast to the others procedures, the Seldinger wire is advanced cranially towards the larynx.

Few trials were published comparing these techniques, and very little information is available concerning the comparison of their early and late complications. Problems may be represented by the lack of precise definitions of outcome and early and late complications, or by the way in which these complications have been examined.

The studies that have been published so far on this topic are generally limited, and not adequately randomized. The follow-up of the tracheotomy patients can be difficult because of physical and mental problems. Therefore complications have not been investigated extensively (An˜ n et al., 2004; Ambesh et al., 2002).

The largest prospective randomized trial, comparing the most widely used percutaneous tracheotomy technique, was conducted by G.B. Fikkers (Fikkers et al., 2004, 2011). The author performed a meticulous observation of the procedures and follow-up. He involved in its study 120 patients, comparing the guide-wire dilating forceps (GWDF) and the single step dilatational tracheostomy (SSDT) technique, showing a trend toward less major perioperative complications with SSDT compared to GWDF technique. All procedures were conducted with bronchoscopic guidance, so that the optimal position of the cannula between the rings in the midline was always facilitated. However, more patients would be needed to detect smaller differences between the methods.

The rotating dilation (PercuTwist) and Griggs' forceps dilational tracheotomy methods were compared by Montcriol, in a recent prospective randomized study, involving 87 critical ill patients. The author found the PercuTwist significantly longer to perform than forceps dilational tracheotomy technique (five minutes vs three minutes), the complications were 20/87 (23%), and 18/20 were minor complications. He didn't found significant differences between the two groups of patients and concluded that the PercuTwist technique is safest, despite the longer duration of the procedure (Montcriol et al., 2011).

Since single dilator technique decrees operative time compared to the serial dilator technique, and without increasing the complication rates, the modified Ciaglia Blu Rhino technique is suggested as the technique of choice (level 2C, according to levels of evidence by American College of Chest Phisicians) (De Leyn, et al., 2007). Therefore, this is the only technique used in our centre, always under bronchoscopic guidance.

5. Timing of the tracheotomy

Overall, advances in clinical treatment and ICU practices are based on suitable mechanical ventilation. Many critical ill patients benefit from a prolonged ventilatory support program and subsequently from a meticulous weaning protocol from mechanical ventilation. In addition, the best clinical practice should always ensure patient comfort, safety, ability to communicate, clean oral and airway, as well as shorter days of mechanical ventilation, ICU and hospital stays. For these reasons tracheotomy is very beneficial, in fact with the now widespread use of the percutaneous technique with broncoscopic control, tracheotomy has become a very common practice in modern ICUs and in recent years, it has increased by nearly 200%. This raises the following three questions. The first is whether it is better to place early or late tracheotomy. The second is how to define "early" or "late tracheotomy". Finally, the third is the major methodological challenge, regarding how to define and predict the need for prolonged ventilation in different and specific groups of the patients.

For the first question, the best timing of tracheotomy has been a subject of debate and, still today, it has not found unanimous agreement. An analysis of a large database showed considerable variation in the timing and incidence of tracheotomy. In 1989 the consensus conference indicated that tracheotomy should be carried out after 3 weeks of endotracheal intubation (Plummer & Gracey 1989).

After, several studies have reported that tracheotomies which were performed earlier provided many benefits that include more rapid weaning from mechanical ventilation, shorter hospital length of stay (LOS), less complications from translaryngeal intubation,

better patient's comfort and safety, facilitating progression of care in and outside the ICU (Rumbak et al., 2004).

Yaseen Arabi et al., in a cohort study and review, analyzed 136 trauma ICU patients who required tracheotomies, confirmed all these benefits of early tracheotomy and moreover he found, with a multivariate analysis, that late tracheotomy was an independent predictor of prolonged ICU stay (Arabi et al., 2004).

However others studies, including the large multicenter TracMan (Tracheostomy management in critical care, 2011) trial have found no differences between early and late timing of the procedure.

In a large prospective trial, Trouillet et al., randomized patients who required prolonged mechanical ventilation after heart surgery, assigning to early tracheotomy (5 days after surgery) or prolonged intubation followed by tracheotomy 15 days after randomization. In this study early tracheotomy provided no benefits in term of mechanical ventilation duration, LOS, mortality rate, or frequency of infectious complications, but it was associated with a lower rate of agitation or delirium, with less sedative, analgesic and neuroleptic consumption and better patient comfort, fewer unscheduled estubation and re-intubation, earlier oral nutrition and bed-to chair transfer (Trouillet et al., 2009).

A systematic review, including randomized and non-randomized studies, has not been able to support the effects of tracheotomy on duration of mechanical ventilation in all patients (Griffiths et al., 2005). The effects of early tracheotomy on mechanical ventilation, VAP, hospital outcome and LOS, remaining hotly debated. Therefore, there is still no consensus about "early" or "late tracheotomy" definition, many clinicians use their own specific time window.

In 2001 Guidelines, created jointly by the American Association for Respiratory Care, the American College of Chest Physicians, and the American College of Critical Care Medicine, make no specific recommendations about tracheotomy timing, but suggest that the procedure should be considered if the patient will require prolonged ventilator assistance (De Leyn et al., 2007).

In 2005 surveys involving a large number of ICU from France and the United Kingdom documented variability for both the timing and the indications for tracheostomy (Blot & Melot 2005).

Contemporary the group of Rumbak in a prospective, randomized study, comparing early with late tracheotomy, he defined "early tracheotomy", if performed within 48 hours and "late tracheotomy" if performed at 2 weeks. The authors showed a decrease of mortality by 50% in first group (Rumbak et al., 2004).

The same authors in a 2007 study confirmed that early tracheotomy reduces time in the ICU, on mechanical ventilation, and in the hospital, whereas benefits regarding incidence of pneumonia and mortality are variable according to the different patient population ().

An analysis of the US National Trauma Databank showed that the rate and timing of tracheotomy varied significantly across ICUs (Nathens et al., 2006).

Finally in answer to the third question, the lack of the population homogeneity is frequently evocated as a limit for these studies which aim to define the criteria in order to determine if

a patient will require prolonged mechanical ventilation, and then identify the best timing to perform the tracheotomy. However, up to now, despite many efforts, no scoring system has been able to correctly identify patients for whom MV duration will be prolonged and, therefore, the early tracheotomy might be justified.

Especially after cardiac surgery, several studies have investigated factors associated with prolonged MV and many models have been developed in attempt to predict when the patients are designed to prolonged MV more than 48 hours.

Some authors in their studies refer alternatively to preoperative, intraoperative and immediately postoperative parameters, others showed that hemodynamic status on ICU admission and early postoperative events were more important than intraoperative variables, to predict ventilatory dependence, defined as MV greater than 72 hours after cardiac surgery (Cislaghi et al., 2009; Rajakaruna et al., 2005).

Trouillet, in is prospective observational study, considers, with a simple score, the clinical answer of the patient to the medical treatments during the first 3 days of the MV is more indicative of the prognosis than of any data gathered in a pre-operative or post-operative period. None of these models has been fully validated yet (Trouillet et al., 2011). However the message is to achieve a valid score to avoid a probably unnecessary invasive procedure, such as early tracheotomy in patients with a strong likelihood of rapid and successful MV weaning. Instead tracheotomy might be a right option in patients requiring longer MV and the highest safety may be achieved if it is performed with bronchoscopic guidance.

In our opinion, waiting further studies aimed to answer these important questions, for optimal management of critical ill patients, the decision regarding the best timing to perform tracheotomy depends on the physician, that should balance three problems: what is the patient expected recovery course, the risk of prolonged translaryngeal intubation and the risk of tracheotomy procedure.

6. The bronchoscopic guidance features

A problem with the PDT is the lack of visualization, therefore some studies suggested that the safety of the procedure may be enhanced by the use of ultrasound or bronchoscopic guidance (De Leyn et al., 2007; Kollig et al., 2000). However few randomized controlled trials have shown the utility of the bronchoscopic guidance during the percutaneous tracheotomy procedure.

In a clinical review, P. De Leyn et al, indicate in level 1C of the grading scheme classified recommendations, to perform any technique of PDT under bronchoscopic control. (De Leyn et al., 2007).

Over blind PDT, several goals are recognized by the video bronchoscopic guidance of puncture/dilatation process. Before initiating the procedure, the endoscopic survey can show any anatomic airway anomalies that may be encountered (Bobo et al., 1998).

During bronchoscopy proximal repositioning of the TE before introducing the guide-wire needle into the trachea can facilitate the procedure, and reduce the risk of the tube impalement; it shows the correct central area of the puncture and the appropriate tracheal rings with wound transillumination (Kost et al., 2005).

Initial needle placement in a midline, intercartilaginous position can be verified and corrected, as overpenetration of the lumen to the posterior tracheal wall. In a blind technique, tangential needle positioning is likely to go unrecognized, increasing risks of complications such as false passage, pneumothorax and pneumomediastinum (Kost et al., 2005).

Using endoscopic vision, technical difficulties can be recognized and corrected before life-threatening complications occur (Kost et al., 2005).

Finally it is an excellent tool for teaching PDT technique.

Nevertheless, some limitations of bronchoscopic guidance are recognized. They include impairment of mechanical ventilation and oxygenation, in fact manual ventilation is recommended, then the need for additional personnel, and added procedural time and expense.

During the procedure a potential increase in partial carbon dioxide tension and reduction in partial oxygen tension can raise intracranial pressure in susceptible patients (De Leyn et al., 2007). However, in many studies some authors confirms that percutaneous dilatational tracheotomy with endoscopy is a safe and acceptable alternative to open surgical tracheotomy.

7. Advantages of tracheotomy versus translaryngeal intubation

In recent years, the tracheotomy positioning has gained increased popularity as a resource to facilitate the patients weaning from the mechanical ventilation.

Several studies argue that early tracheotomy (within 7 days of mechanical ventilation) in ICU patients may help to reduce the duration of mechanical ventilation and length of stay in ICU (Carrer et al., 2009).

The tracheostomy allows to reduce the duration of mechanical ventilation, because of improves secretions removal with suctioning, decreases resistance to breathing and dead space, betters patient comfort with less needed of sedation or analgesia, preserves the glottic competence reducing incidence of ventilatory-associated pneumonia (VAP) and others lung infection (Durbin Jr, 2005).

Tracheostomy offers others advantages, it reduces the laryngeal injury as laryngeal stenosis and voice damage, reduces the oral injury, allows a better oral hygiene, improves the ability to communicate, preserves more the swallow with earlier oral feeding (Durbin Jr, 2005).

7.1 Potential advantages of PDT versus surgical tracheotomy

PDT is a cost-effective and safe alternative to surgical tracheostomy (ST) in critically ill patients in the ICU, and can be performed with very low morbidity by skilled and experienced practitioners (De Leyn, et al., 2007).

The main advantage of PDT is the possibility to perform it at the bedside in the ICU, avoiding a potentially dangerous transport of critically ill patients to the operating room. It prevents the inconvenience of long waiting lists for operating room scheduling and significantly decreases the delay between the decision to perform tracheostomy and the actual operation (De Leyn, et al., 2007).

In a retrospective analysis performed on clinical and financial outcomes, PDT resulted associated to less costs compared to surgical tracheostomy (Bacchetta et al., 2005).

This is predominantly a result of avoiding operating room charges (De Leyn et al., 2007).

In general, PDT appears to be a less traumatic and minimally invasive procedure than ST. In fact the incision in PDT is very small, the tracheotomy tube is fitted tightly against the stoma, and less dissection, tissue trauma and devitalisation occur; furthermore cartilage rings usually remain more or less intact during PDT, while most surgeons incise one or more tracheal cartilage rings during ST.

These advantages are probably responsible for the favorable outcomes, fewer overall postoperative complications described in short-term and long-term follow-up studies of patients undergoing PDT (Nieszkowska et al., 2005; Sue & Susanto 2003), including less postoperative and perioperative bleeding, fewer wound infection and subglottic stenosis and an aesthetically more favorable scar (Grillo, 2004).

7.2 Tracheotomy and lung infections

A potential, important benefit, without agreement in literature yet, attributed to tracheotomy, especially when it is provided at an early stage, is a lower ventilator-associated pneumonia (VAP) rate (Nseir et al., 2007; Rodriguez et al., 1990; Rumbak et al., 2004).

Micro-aspiration of oral secretions past the tube cuff can contribute to the development of pneumonia. In addition, dental plaques, the oropharyngeal cavity and the stomach are potential reservoirs for microorganisms in critically ill patients requiring mechanical ventilation through an endotracheal tube or a tracheotomy cannula (El-Solh, 2004; Frost & Wise, 2008). The most important underlying mechanism for the onset of VAP is the aspiration of oropharyngeal microorganisms into the distal bronchi, followed by bacterial proliferation and parenchymal invasion, leading to bronchopneumonia (El-Solh, 2004). The presence of an endotracheal tube and the aspiration of oropharyngeal contents, containing a large bacterial inoculum can overcome the host defenses that are already compromised by the critical illness and lead to the development of VAP (Frost & Wise, 2008; Kollef, 1999).

Some studies indicate an increased incidence in lower respiratory-tract infections following tracheotomy. However no adjustment was performed for the duration of the MV, which is probably the most important risk factor for VAP.

In a large, randomized controlled trial of patients who require prolonged mechanical ventilation after cardiac surgery, Trouillet et al. showed that early tracheotomy did not modify the frequency of VAP during the first 60 days after randomization between early percutaneous tracheotomy and prolonged intubation groups possibly followed by late tracheotomy (Trouillet et al., 2011).

Other authors found tracheotomy protective against VAP using matching for several confounding factors, including duration of MV.

Considering the patophysiology of VAP in intubated patients, Nseir demonstrated in a retrospective case-control study, that tracheotomy was independently associated with a decreased risk of VAP compared to patients with translaryngeal intubation. The potential reasons include: liberation of the vocal cords in tracheotomised patients, that results in

normal closure and reduces the risk related to aspiration of contaminated secretions from the orofaryngeal cavity; in a reduction in bacterial biofilm formation along the inside of the tracheotomy cannula, associated with regular changing of the tube, once or twice a week; finally in a shorter duration of mechanical ventilation due to facilitation of MV weaning (Nseir et al., 2007). Furthermore, the oral care is better in tracheotomised patients than in intubated ones: in fact, the endotracheal tube may obscure the view of the oral cavity and predispose to xerostomia, which contributes to poor oral hygiene.

So, since some hospitals propose oral care programs for the VAP prevention, the tracheotomy must be considered (Schleder et al., 2002).

8. Complications of percutaneous dilational tracheotomy

Complications of tracheotomy can be divided into early and late incidences.

8.1 Early complications

Hemorrhage has been reported as the most common complication of PDT and occurs in 0 to 28.6% of cases. It is usually controlled by simply packing or suture ligation (Bobo et al., 1998). With open tracheotomy this rate dramatically increases in 3 to 36% of cases.

Another common complication is stoma infection: a tracheotomy is considered a clean-contaminated wound and for this reason antibiotic prophylaxis is necessary. Instead this infection is quite uncommon with PDT, occurring in up to 4% of cases (Bobo et al., 1998) while with the surgical tracheotomy the rates are higher generally occurring in 17 to 36% of cases.

Subcutaneous or mediastinal emphysema is another additional complication when subcutaneous emphysema can be caused by positive pressure ventilation or by cough against a tightly sutured or packed wound. The emphysema disappears spontaneously within a few days. Instead mediastinal emphysema is very uncommon and occurs in very few cases as pneumothorax which is caused by a false passage and is evidenced by chest radiograph (De Leyn et al., 2007).

A further complication is a tube displacement, caused either by inadequate securement of the tube around the neck or rapid cervical swelling. After the reinsertion of the tube, a false channel in the subcutaneous tissue anterior to the tracheal ostium may compress the trachea and cause an emergency. Then orotracheal intubation is needed when the tract cannot be restored immediately (De Leyn et al., 2007; Heffner et al., 1986). Finally, tube obstruction which can be caused by mucus or blood clots even displacement. If it is not possible to clean the tube, it must be replaced.

8.2 Late complications

One of the most common complications of tracheotomy is pulmonary infections mainly for pneumonia. A large proportion of ventilatory-associated pneumonia (VAP) develops within the first week after tracheotomy. The most common pathogens isolated are Pseudomonas aeruginosa and Gram-negative enteric bacteria that colonize the tracheobronchial tree in patients with long-term tracheotomy. The colonization of the airways depends on the severity of the disease, nutritional status of the patient and depression of mucociliary

clereance caused by tracheotomy. In this cases it is advisable to consider a periprocedural antibiotic prophylaxis (De Leyn et al., 2007; Heffner et al., 1986; Rello et al., 2003).

Tracheal stenosis occurs in 1 to 2% of cases and can affect the tracheal stoma differently, the cuff or the tip of the tracheotomy tube. This complication result from ischemic damage to the tracheal mucosa when the high-pressure cuff are used and the tracheal wall tension exceeds mucosal capillary perfusion pressure for significant periods of time. Within 15 minutes of a continuous tracheal wall pressure above 50 mmHg, destruction of columnar epithelium happens. Inflammatory histologic changes result within 24 to 48 hours with superficial tracheitis and mucosal ulcerations appearing after several days. If persists inflammation, chondritis develops with deterioration of cartilaginous support within two to three weeks. The granulation and fibrosis that appear during recovery, produce the tracheal stenosis. Clinical manifestations of tracheal stenosis after tracheotomy include dyspnea on effort, cough and difficult to remove secretions. The symptoms appear when there is a 75% of reduction in tracheal lumen diameter. The treatment of tracheal stenosis consists in surgical trachea resection or tracheal dilatation.

On the other hand, tracheo-innominate artery fistula is quite uncommon (<0.7%) and can be determined by high direct pressure of the cannula against the innominate artery or by a too low placed tracheotomy tube that erode directly into the artery, because the innominate artery crosses the anterolateral surface of the trachea at the level of the upper sternum. The result is airway bleeding in which a possible sudden massive hemmorhage can cause a life-threatening condition. The overall survival rate of this complication is 25%. Therefore in order to prevent such incidences, thacheotomy should be performed at the second or third cartilaginous ring and should avoid prolonged or excessive hyperextension of the neck, using a re-adjustable tracheotomy tube (De Leyn et al., 2007; Heffner et al., 1986). Tracheo-esophageal fistula is another complication which occurs in less than 1% of cases. Early onset results from poor surgical techniques with the incision of the posterior tracheal wall. Late onset results from tracheal necrosis caused by excessive cuff pressure. The patient presents excessive secretions, food aspiration and leaking around the cuff with abdominal distension, the respiratory parameters can worsen in such cases. Tracheoscopy or esophagography can be used for the diagnosis. The treatment consists in a cervical incision when the patient is clinically stable (De Leyn et al., 2007; Heffner et al., 1986).

Swallowing difficulties are caused by decreased laryngeal elevation, esophageal compression and obstruction from the tracheotomy tube cuff concur resulting in swallowing difficulties (De Leyn et al., 2007).

Granuloma may result from a foreign body reaction to the tracheotomy tube (De Leyn et al., 2007).

Finally, persistent stoma can result from epithelialisation between the skin and the tracheal mucosa when the tube is in place for a prolonged period (De Leyn et al., 2007).

9. Materials and methods

9.1 Study location and patient population

This study was conducted in the CTICU of the Civil Hospital, Brescia, Italy, and a 2400-bed, university-affiliated teaching hospital. This CTICU has 6 beds available, including 1 for

emergencies. Any patients undergoing heart and thoracic surgery, and occasionally other medical and surgical patients, are admitted to this CTICU.

Between 2006 and 2010, 184 patients required PMV (≥ 4 days), among these, 134 patients underwent percutaneous dilatational tracheotomy (PDT) with endoscopic guidance were retrospectively evaluated.

9.2 Study design and data collection

For all patients studied, the following data was retrospectively collected from ICU database: age, sex, origin (other ICU or hospital ward), SAPS II (Simplified Acute Physiology Score), reason for and diagnosis at ICU admission, mode of surgery (elective, urgent, emergent), duration of mechanical ventilation, re-intubation, timing of tracheotomy, complications of tracheotomy including pneumonia or other lung infections, ICU stay duration and outcome (patients transferred or died).

9.3 Technique

The patients enrolled in the study were those who required tracheotomy due to failure to be weaned from mechanical ventilation. The physicians in the department established the timing of tracheotomy. All tracheotomies were conducted at the patient bedside by experienced physicians in the ICU using the Ciaglia percutaneous technique (Ciaglia Blue Rhino, Cook Critical Care, Bloomington, Illinois) described before, in the technique section.

10. Results

10.1 Patients

Among the 3648 consecutive patients admitted in the CTICU from January 2006 to December 2010, a total of 184 were still intubated 4 or more days after CTICU admission. Therefore, a tracheotomy was performed on 134 patients of these patients.

Table 1 shows the preoperative and surgical characteristics, including the demographic, descriptive data of the patients and their department of origin.

Characteristics	Value* n = 134
Age, years	69.8 ± 9.2
Gender	
Male	94 (70.1)
Female	40 (29.9)
Department of origin	
Cardiac surgery	82 (61.2)
Thoracic surgery	15 (11.2)
Coronary care unit	14 (10.4)
Other medical or surgical wards	12 (8.9)

Characteristics		Value* n = 134
	Emergency rooms	9 (6.7)
	Other ICU wards	2 (1.5)
SAPS II		46.2 ± 20.3
Length of stay in CTICU		20.8 ± 13.5
Overall mortality		65 (48.5)

CTICU, Cardiothoracic Intensive Care Unit; PDT, percutaneous dilational tracheotomy
* Values are expressed as means ± SD or n (%).

Table 1. Characteristics of 134 study CTICU admitted patients requiring PDT.

Of the 134 patients, 94 (70.1%) were male, and the mean age ± SD was 69.8 ± 9.2 years (range: 32-85 years).

The mean ± SD SAPS II score on admission was 46.2 ± 20.3.

The mean ± SD length of stay in the ICU was 20.8 ± 13.5 days (Fig. 1).

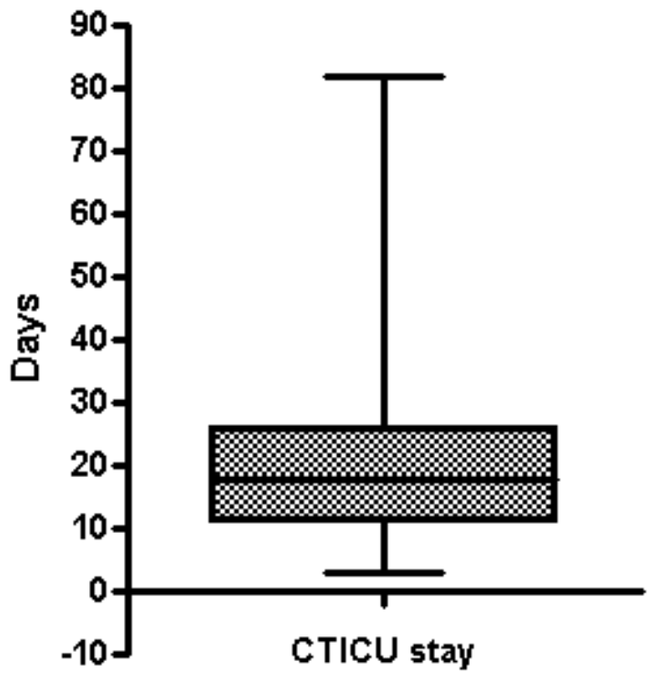


Fig. 1. ICU length of stay of patients received percutaneous dilational tracheotomy (PDT).

Of the 134 patients studied, 113 (84.3%) were surgical; of these, 39 (34.5%) underwent a valve replacement, 17 (15.0%) a coronary artery bypass graft (CABG), 22 (19.5%) a CABG with valve replacement, 16 (14.1%) an aortic surgery (ascending aortic surgery, aortic arch surgery, descending thoracic surgery), 12 (10.6%) a pulmonary resection for neoplasm, and 7 (6.2%) a surgery for miscellaneous conditions. Surgical intervention was performed in election in 92 (81.4%) cases, was urgent in 21 (18.6%) cases.

The twenty-one medical patients (15.7%) admitted to the ICU suffered from heart and/or respiratory failure.

10.2 Mechanical ventilation and tracheotomy

The mean ± SD duration of mechanical ventilation was 17.8 ± 12.2 days (Fig. 2).

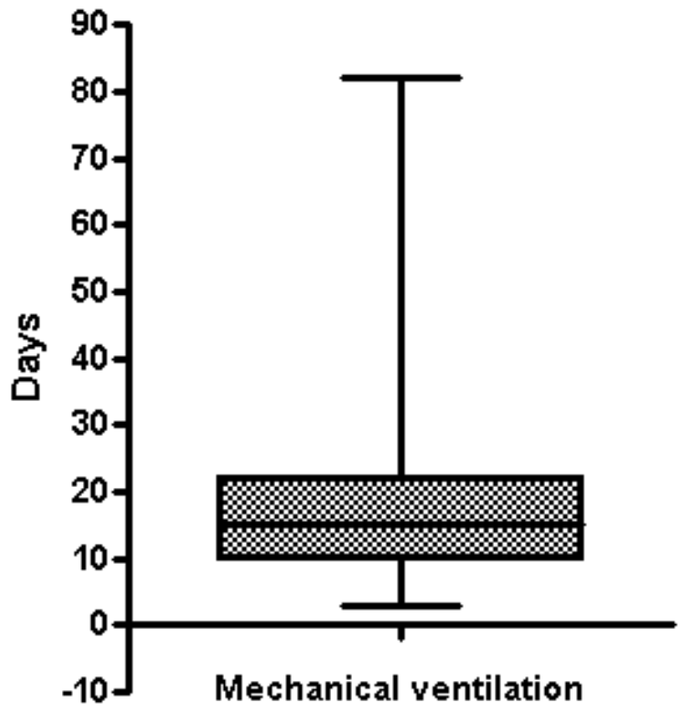


Fig. 2. Length of mechanical ventilation through endotracheal tube or tracheotomy.

Seventy patients (52.2%) were re-intubated.

The patients received a tracheotomy after a mean ± SD of 4.7 ± 2.5 days of endotracheal intubation (Table 2).

	Value*
During of ventilation, days	17.8 ± 12.2
Patients undergoing reintubation	70 (52.2)
Timing of tracheotomy, days	4.7 ± 2.5

* Values are expressed as means ± SD or n (%).

Table 2. Ventilation Data for 134 Patients Who Underwent Percutaneous Dilatational Tracheotomy

Any major side effect or technical problem that occurred during the procedure was recorded.

We assessed four minor complications: two episodes of tracheal rings fracture having no significant, and two minor stomal bleeding without transfusion requirements.

10.3 Pneumonia and other airway infections

Of the 134 patients, the cumulative incidence of VAP was 40.3% (n=54) and 19.4% of other airway infections (n=26).

10.4 Mortality and outcome

Overall, 65 patients (48.5%) died, while 69 patients (51.5%) who survived were transferred at day 2 or 3 after the tracheotomy to other departments, 42 (60.8%) requiring prolonged ventilation support, were weaned in a non-ICU department.

11. Conclusion

PDT is described as a safe technique, easier to perform with fewer overall postoperative complications, such as less pre and postoperative bleeding and fewer postoperative stomal infections than surgical tracheotomy (ST).

PDT is a procedure in rapidly evolving state regarding its technology and the number of the technique available. The safety of the procedure may be enhanced by the use of bronchoscopic guidance. The Tracheotomy Endoscope is just designed to prevent serious complications in dilational tracheotomies and facilitate their management, so that patients with tracheotomy, can be moved in SNF, even if ventilator support is necessary. It is also interesting that the method is very easy to learn.

The major indication of the PDT is prolonged mechanical ventilation (PMV), there are evidences supporting that PDT reduces work of breathing, facilitates the weaning and reduces length of MV.

Although there isn't agreement in literature about the PMV definition, many authors, so that in present study, judge "prolonged" the mechanical ventilation lasting for more than 96 hours, both continuously or after re-intubation.

Several authors showed that in medical ICU, PVM is a widely treatment that induces longer hospitalization and high costs. In CTICU, where it occurs in 2.6 to 22.7% according to various authors, is also associated with increased patient morbidity and mortality (range, 4.9–38%), its cost instead of 12% of the total.

Early weaning from MV, within 8–12 hours after open heart surgery, being associated with better cardiac function, and with a decrease in respiratory and infectious complications, should be the gold standard in the CTICU.

Continuously PMV begins necessary in selected, high-risk cardiac surgery patients, normally identified preoperatively, or recognized in the immediate postoperative.

Sometimes, in a not insignificant number of the patients without evident risk factors, activation of the inflammatory cascade due to the cardiopulmonary bypass (CPB), can be responsible for failing of the early extubation, making it necessary for re-intubation, and then for PMV.

As in most studies, our data showed a low rate of PMV in CTICU patients. Among 3648 admitted in our unit, over the past five years, 194 (5.3%) required PMV, of these 134 (69%) were underwent to PDT. Seventy PDT were performed to re-intubated patients.

We don't have data that could explain the reasons of PMV, why was not this the aim of the present study, therefore it will soon the object of the future work, to improve the management and the outcome of our patients.

It would be very important to find a score able to identify patients requiring PMV and consequently the best timing to perform tracheotomy. Many scores are developed, but due to their stiffness, poorly adapted to heterogeneous groups of admitted in ICU, none of these has been so far validated.

It is not shown in current literature yet, which is the right time when the tracheotomy must be performed, there is not even agreement regarding the exact definition of "early" and "late" tracheotomy.

Most well designed studies, focused on timing of tracheotomy, comparing tracheotomised with translaryngeal ventilator patients, showed a statistically significant reduction in mortality with "early" tracheotomy.

Rumbak et al., defined "early" (within 2 days from the MV) and "late" (days 14-16) tracheotomy, they compared the two methods and they showed a statistically significant reduction in mortality with early tracheotomy (31.7% vs 61.7% respectively) (Rumbak et al., 2004).

Driven by the need to not hinder the operating list and to optimize the resources, we performed tracheotomies after a mean ± SD of 4.7 ± 2.5 days from the beginning of the MV (Fig. 3), once a tracheostomy is in place, then we transferred patients to a skilled nursing facility (SNF), also with ventilator support.

Of all surviving, 69 (51.5%) were transferred to others departments at days 2 or 3 after tracheotomy, of these 42 (60.8%) requiring prolonged ventilation support, they were wean in non-ICU environment.

This appears rational and cost/effective, because if the tube is dislodged, no special equipment or skills are needed to replace it; after the stomal tract has matured, usually within 3–7 days, the tube can be easily reinserted without difficulty. The SNF are often able to wean from ventilator support.

Earlier transition of a patient from the ICU remains a major advantage of tracheostomy. To shorten ICU length of stay reduces health care costs.

The complication rates reported in most previously published large studies and meta-analyses ranging from 8.9 to 30%. They include severe complications in 1.5% of all cases and less dangerous complications that amounted to 6.5% (Bause et al., 1999). The most frequently complications related to the procedure concern malpositioning, tracheal stenosis, stomal infections, bleeding (rate of 3.2%) with transfusion requirements, respiratory failure (pneumothorax, pneumomediastinum) or need to change ventilator settings.

In this study, no serious side effects both during and after the procedure have occurred.

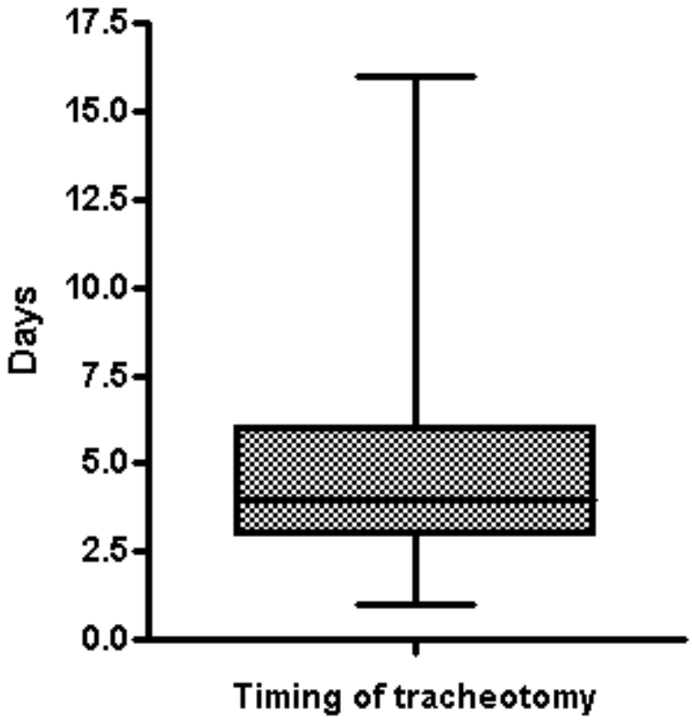


Fig. 3. Timing of tracheotomy after endotracheal intubation.

We assessed only four minor complications, regarding two episodes of tracheal rings fractures having no significant, and two minor stomal bleeding, without transfusion requirements.

One patient with enormous goitre was addressed directly to the ST, without consequence.

We attribute our low complication rates to careful evaluations of the right indications and the contraindications, and to the combination of the right timing of the procedure, and the fact that all procedures are performed in the CTICU by a team of experienced physicians, under bronchoscopic guidance.

In an our previous study (Mastropierro et al., 2009), we discovered bronchoscopy as an independent risk factor for VAP. Ever after, in our centre, the use of this technique is strictly controlled and decided by skilled and specialized health staff. Indications for this practice are well underlined in our protocols. PDT is a part of the indications, since, as demonstrated by literature and our experience, bronchoscopy has revealed to be useful for avoiding wrong insertions of tracheocannula and for finding possible endothracheal complications.

Among patients with tracheotomy, we detected an high mortality (48.5%), probably related to the high-risk profile of the patients referring to the heart and thoracic surgery, as preoperative comorbidities, complex surgery (19.5% was CABG combined with valve replacement), urgent surgery which was 18.6% of total. These factors increasing likelihood of prolonged MV, worsen the outcome. So the patients died with tracheotomy, but not for tracheotomy.

There is a paucity of clinical data describing the association of tracheotomy with patient outcomes, especially hospital mortality.

Marx et al. reported in their study a mortality rate of 0.39% (Marx et al., 1996).

Kollef in a prospective cohort study, describe outcomes of patients with respiratory failure in PMV, receiving a tracheostomy. They found the overall hospital mortality for patients receiving a tracheostomy (13.7%) was significantly less than the overall hospital mortality for patients with translaryngeal intubation (26.4%) (Kollef, 1999). Any reasons to explain this data are widely discussed.

Combining advances in technology and treatments with control healthcare costs, suggest that the effectiveness of patient care could be maintained or improved, and in meantime ICU expenses reduced.

The features of the cardiac surgery patients are changing, many of these suffering of multiple co morbidities. Concurrent with these changes, the needs for critical care service are increasing. Needham et al. estimated that the number of ICU patients who require MV will increase by 31% from 2000 to 2026 (Needham et al., 2005). PMV is commonly associated with substantially longer inpatient, ICU stay and higher cost.

In our experience PDT with broncoscopic guidance, that guarantees very low complications, must be considered as a best practice, aimed to reduce length of ICU and hospital stay, and to optimize healthcare resources.

Although we recognize some methodological limits in our study. First of all, it is an observational study and is not able to give strong messages. Missing data regard: the reasons of the failed early extubation in CTICU patients; the follow-up of the patients weaned from ventilator support in SNF, though there has always been a collaborative job between the CTICU and the SNF physicians. Current study also suggests to deepen the knowledge regarding both the incidence of VAP in patients with tracheotomy, performed with broncoscopic guidance and the real contribution of the early PDT to optimize healthcare recourses.

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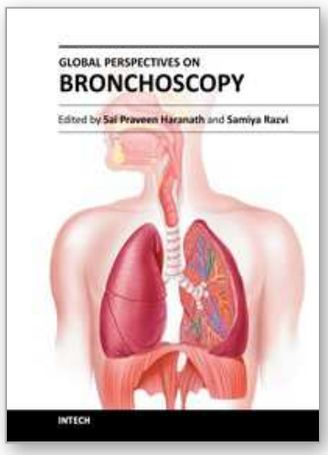
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Bronchoscopy has become an essential part of modern medicine . Recent advances in technology have allowed integration of ultrasound with this tool. The use of lasers along with bronchoscopes has increased the therapeutic utility of this device. Globally an increasing number of pulmonary specialists, anaesthesiologists and thoracic surgeons are using the bronchoscope to expedite diagnosis and treatment. The current volume on bronchoscopy adds to the vast body of knowledge on this topic. The democratic online access to this body of knowledge will greatly increase the ease with which both trainees and expert bronchoscopists can learn more .The contributions from around the world cover the breadth of this field and includes cutting edge uses as well as a section on pediatric bronchoscopy . The book has been an effort by excellent authors and editors and will surely be a often reviewed addition to your digital bookshelf. . In summary, this book is a great testament to the power of collaboration and is a superb resource for doctors in training, ancillary team members as well as practicing healthcare providers who have to perform or arrange for bronchoscopy or the associated procedures.

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