# Standard surgical versus percutaneous dilatational tracheostomy in intensive care patients

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## ABSTRACT

**Objective:** The present prospective randomized trial compared surgical tracheostomy (ST) and percutaneous dilatational tracheostomy (PDT) in intensive care unit (ICU) patients in terms of outcomes and complications.

**Methods:** Between January 2003 and December 2005 tracheostomies were performed on critically ill ICU patients in Medical Faculty Hospital in Prague, with a random allocation of 105 patients for ST and 100 for PDT.

**Results:** The 2 groups did not differ significantly in terms of basic demographic characteristics or length of endotracheal intubation prior to the procedure. Following the procedures, the 2 groups did not differ significantly in terms of the time required for decannulation, decannulated patients or mortalities. Post-mortem examination showed that both groups were similar in terms of placement of the tracheostomy tube. Surgical tracheostomy was found to take longer time to perform than PDT ($p$<0.001). In terms of early postoperative complications, PDT was associated with a higher rate of postoperative bleeding compared to ST ($p$=0.0302).

**Conclusions:** Percutaneous dilatational tracheostomy is a simpler and faster technique to perform, but is associated with a higher occurrence of early complications, particularly postoperative bleeding.

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Tracheostomy is one of the most frequently performed elective surgical procedures for critically ill patients in the intensive care units (ICUs).[1-6] Over 80% of current indications should provide long-term mechanical pulmonary ventilation, to allow easier toilet, and cleaning of the airways and to prevent complications involved in prolonged laryngotracheal intubation.[4,7] Tracheostomies are performed using either standard surgical methods (surgical tracheostomy [ST]) or percutaneous dilatational tracheostomy (PDT). Percutaneous dilatational tracheostomy is considered a "bedside method" in ICUs.[7-10] Surgical tracheostomy should not be substituted in patients at high operational risk or with complicated anatomical conditions around the neck area, however, there are no absolute contraindications.[11] The present report is a comparative study of tracheostomies performed on critically ill ICU patients. Such a study is important as it is not always relevant to compare the results and complications of tracheostomies performed in the operating theatre (namely prophylactic procedures for head and neck surgery) with those performed on ICU patients.[12]

**Methods.** Between January 2003 and December 2005, a prospective study of elective tracheostomies on critically ill ICU patients was undertaken. The Ethics Commission of the Medical Faculty Hospital approved the study protocol. Inclusion criteria were: the need for long-term mechanical pulmonary ventilation, tracheal toilet, or ICU physician indication, and patients aged >15 years. Exclusion criteria were: laryngotracheal intubation longer than 21 days, hemodynamic instability-coagulopathy, thrombocytopenia <$50.10^9$/l, or international nomralisation ratio >1.5 , positive end-expiratory pressure (PEEP) >15 cm $H_2O$, patients who had already undergone tracheostomy, or with oncological diseases in the head and neck

area, or with unsuitable anatomical conditions such as kyphoscoliosis of the cervical spine, enlarged thyroid, cervical spine injury, or skin infection in the neck area. The intensive care physicians included patients with laryngotracheal intubation and long-term artificial pulmonary ventilation (APV) for tracheostomies. Those patients who had suitable criteria were randomized using the sealed envelope method between PDT or ST. Unless contraindicated, tracheostomies were performed under intravenous analgosedative and neuromuscular blockade agents. Immediately before initiating the procedure, secretions were removed from the airways using suction, the fraction of inspired oxygen was increased to 100% and a roll was placed under the shoulder and head supported in correct position, unless this was contraindicated. The area surrounding the point of incision was infiltrated with anesthetic, generally 1% trimecaine hydrochloride with adrenaline ($5\times10^{-6}$ dilution). Blood pressure, oxygen, and carbon dioxide levels, and electrocardiogram were monitored continuously throughout the procedure. Surgical tracheostomy was performed by making a horizontal incision in the skin: 1-1.5 cm above the edge of the sternum and opening the trachea using the modified inferior-based pedunculated flap of the Björk technique. Surgical tracheostomy was performed by one of the 4 otorhinolaryngologists. Percutaneous dilatational tracheostomy was performed following the Griggs technique using Howard-Kelly forceps (Portex Limited; Hythe Kent, UK). One of 3 ICU physicians and one otorhinolaryngologist performed the PDT procedures. It took time to perform PDT, and ST was measured, with the initial skin incision defined as the beginning of the procedure and the introduction of the tracheostomal cannula as the end. Complications were divided into 3 categories: perioperative, early postoperative, and late postoperative. Perioperative complications were defined as those which occurred within 24 hours of the beginning of the procedure and included injury to the posterior tracheal wall, pneumomediastinum, bleeding, subcutaneous emphysema, difficulties in inserting the cannula and technique conversion. Early postoperative complications were defined as those which occurred between the second and seventh day, including major bleeding, which required surgical exploration of wounds and electrocoagulation or ligation of vessels. Minor bleeding could be stabilized by simple compression and replacement of the covering dressing (more than 4 times per 24 hours) aspiration of blood, difficulties with the cannula, pulmonary atelectasis and hematoma of the anterior wall of the neck. Late postoperative complications were defined as those occurring after the seventh day including tracheal stenosis, tracheoesophageal fistula, infection and deterioration of wounds, and unsightly scar formation. At the following period of study, all decannulated patients were in agreement and underwent fibroscopic examination over the course of 2-3 months and were invited to attend further checkups 6 months later. A post-mortem examination of expired tracheostomy patients was performed to assess the location of the tracheostomies in the trachea and any microscopic mucosal changes in relation to the duration of cannulation (number of days of laryngotracheal intubation and cannulation by tracheostomal cannula). Related variables are expressed as medians, standard variations, and ranges, while categorical variables are expressed as frequencies and percentages. The differences between tracheostomy methods were analyzed using t tests, or non-parametric Mann-Whitney tests (for related variables), and Fisher tests (for categorical variables). All statistical tests were paired, and *p*-values of $<0.05$ were considered to indicate a significant difference. The Spearman correlation coefficient was used to calculate the correlation. The data were analyzed by STATISTICA statistical software Version 6.1.

**Results.** Over a 3-year period, elective tracheotomies were performed on 205 patients, 105 of whom were randomized to ST and 100 to PDT. In one case, PDT was converted to ST. Percutaneous dilatational tracheostomy and ST patients were similar in terms of basic demographic characteristics and the average period of endotracheal intubation (ETI) prior to the procedure (**Table 1**). The average operation time for PDT was 5.5 minutes (SD 3.2; median 5.0; range 2-22 minutes), which was shorter than the average time for ST, which was 15.1 min (SD 6.4; median 15.0; range 4.5-60 minutes) ($p<0.001$). The average time required for the PDT group for decannulation was 30.2 days (range 4-122 days), and for the ST patients 32.2 days (range 4-159 days); these data were not significantly different. At the time of the study termination, 20 patients were cannulated (9.9%), 15 after PDT and 5 after ST. During the monitored period, 93 patients were decannulated (46%), 44 after PDT (median age of 62.1 years, SD 13.5; range 2-85 years), and 49 after ST (median age of 64.3 years, SD 13.5; range 28-84 years), and these proportions of decannulated patients within each group were not significantly different. A total of 87 patients (43%) died from causes that is unrelated to the procedures, 40 patients after PDT (median age of 72.7 years, SD 9.0; range 54-88 years), and 47 patients after ST (median age of 67.4 years, SD 14.3; range 25-96 years). Data analysis showed that there was no significant difference between the 2 groups in terms of mortalities. Complications occurred in 33 PDT patients (16%) and 18 ST patients (8.8%). There

were 11 perioperative complications (5.4%), which occurred in 7 patients. The most serious perioperative complication was perforation of the posterior tracheal wall resulting in pneumomediastinum during a PDT (n=1), and the patient required conversion to ST. The complication was successfully treated using a conservative approach and there were no further problems. Two perioperative complications involved bleeding in damaged subcutaneous vessels during PDT, which were arrested using electrocoagulation. In one of those cases, subcutaneous emphysema in the anterior neck wall was found following PDT. In 3 PDT cases and 2 ST cases there were difficulties in post procedure introducing the tracheostomal cannula. Early postoperative complications occurred in 31 patients (15%). The most frequent complication was postoperative bleeding, which occurred in 21 cases (10%), comprising 17 PDT and 4 ST patients, and this difference was found to be significant ($p$=0.0302). Of the 17 PDT patients, 10 underwent surgical revision, with 2 cases of fibroscopic suction for blood aspiration. Surgical revision was required in 2 of the 4 ST patients. Late complications were diagnosed in 9 patients (4.4%), comprising 2 PDT and 7 ST patients. Of the 2 PDT late complication patients, one had a suborificial tracheal stenosis that was identified 53 days after decannulation and the other patient had wound decay, which occurred between the 14th and the 21st day. Of the 7 ST late complication patients, 2 had tracheal stenosis, comprising an orificial stenosis that appeared 81 days after decannulation in a patient suffering from postoperative hemorrhage and who underwent surgical revision, and a suborificial stenosis, which appeared on the 87th day after decannulation. Three ST late complication patients had a wound decay between the 21st and 30th day, comprising one with postoperative bleeding and a subcutaneous hematoma on the anterior wall of the neck, and 2 with cosmetically unsightly scarring after healing, which required plastic surgery. Postmortem examination of the trachea was performed on 26 patients (8 PDT and 18 ST). Analysis showed that the 2 patient groups did not significantly differ in terms of the location of the tracheotomy in the trachea ($p$=0.967; **Table 3**). Descriptive statistics (Wilcoxon test) revealed that the average duration of post procedure trachea cannulation was 33.5 days in PDT patients (SD 21.8; minimum time 10 days; median 30.5; maximum time 70 days) and 31.7 days in ST patients (SD 31.1; minimum time 5 days; median 22.5; maximum time 132 days) ($p$=0.598). Analysis found that the longer the cannulation duration, the greater the risk of microscopic mucosal changes, which in time can manifest as chronic fibro productive inflammation and squamous metaplasia of the respiratory epithelium (**Table 2**).

**Table 1 -** Patients demographic data and the length of time of endotracheal intubation.

| Demographic | PDT | ST |
|---|---|---|
| *Gender* | | |
| Male | 62 | 63 |
| Female | 38 | 42 |
| *Age* | | |
| Years | 65 | 64 |
| Mean±SD | 8±13.6 | 9±15.2 |
| Range | 22-88 | 17-96 |
| *Previous intubation (ETI)* | | |
| Years | 7 | 8 |
| Mean±SD | 3±3.4 | 0±3.2 |
| Maximum intubation | 17 | 21 |

PDT - percutaneous dilatational tracheostomy, ST - surgical tracheostomy, ETI - endotracheal intubation

**Table 2 -** Location of the tracheostomy on the trachea and microscopic changes mucosa.

| Tracheal ring | PDT | ST | Total |
|---|---|---|---|
| 1st-2nd ring | 5 | 8 | **13** |
| 1st-3rd ring | 2 | 5 | **7** |
| 2nd-3rd ring | 1 | 2 | **3** |
| **Total** | **8** | **15** | **23** |

In a further 3 cases, the ST was performed between the 1st and 4th, 2nd and 4th, and the 4th and 6th ring. PDT - percutaneous dilatational tracheostomy, ST - surgical tracheostomy

**Table 3 -** Microscopic findings of tracheostomy.

| Microscopic findings | PDT | ST | Average exposure time |
|---|---|---|---|
| Superficial epithelial defects | 2 | 3 | 16.8 days |
| Residue of the respiratory epithelium | 2 | 10 | 18.4 days |
| Metaplasia of the respiratory epithelium | 4 | 5 | 54.5 days |

PDT - percutaneous dilatational tracheostomy, ST - surgical tracheostomy

**Discussion.** Tracheostomy is the artificial opening of the trachea at the neck, and is performed by standard surgical methods or using PDT. Tracheostomies represent the most frequently performed intervention on the

trachea. The expansion of PDT into clinical practice has led to studies comparing this procedure with ST. Some of these studies have reported that the 2 procedures differ in terms of the outcomes and complications.[2,3,12,13] In 1996, Friedman et al[14] claimed that the advantages of PDT were lower costs, a safer and easier procedure, and an operating theatre was not required. At present, ST can be performed at the bedside, although it requires more technical equipment than PDT. In 1999, Moe et al[15] reported that PDT was a safe and convenient method for intubated intensive care patients, but it did not bring any advantages to patients who need other interventions in the operating theatre. In 2000, Cheng and Fee[13] emphasized that PDT required a smaller skin incision and involved less damage to the soft tissues and vessels in the wound, resulting in a lower rate of infectious complications (4% for PDT and 29% for ST), faster wound healing after decannulation and less unsightly scarring on the neck after healing.[13] Gysin et al,[2] reported in 1999 that the incidence of cosmetically unacceptable scars was approximately 40% after ST and approximately 20% after PDT. The present study found that the PDT procedure required less time than the ST procedure, consistent with the findings of Griggs et al.[16] In agreement with other authors,[3,4,6,16] we have found that PDT can also be used in emergency tracheostomy situations. While the present study found that PDT was a faster procedure, it also found that PDT was associated with a higher incidence of complications, particularly perioperative complications, compared to ST. Madden et al,[17] described 2 cases of rupture of the posterior tracheal wall during dilation, both of which were treated using a metallic stent. In the present study, the most serious complication also involved perforation of the posterior tracheal wall during dilation. The perforation healed under conservative treatment and there were no further complications. We found that complications tended to occur early in the study, suggesting our initial lack of experience with PDT may have contributed to their occurrence, and other authors have made similar observations.[18-20] To prevent complications, endoscopic monitoring of PDT is generally recommended, as it provides a feeling of security during the procedure. Velmahos et al[21] and Reilly et al[22] reported that the routine use of bronchoscopes during PDT was not essential, and highlighted the risks of airway obstruction by the bronchoscope, deterioration of ventilation, hypercapnia, and respiratory acidosis with a subsequent increase in intracranial pressure. In 2004, Paran et al,[23] introduced the technique of PDT with no endoscopic assistance. In 2001, Van Heurn et al[3] reported a 31% complication rate after PDT, with the most frequent cause being the difficulty of inserting the tracheostomal cannula. In the present study, the most frequent complication was postoperative bleeding, which differs from other reports.[1,13,24] In particular, we found that postoperative bleeding after PDT was the most common complication, consistent with the findings of Dulguerov et al.[12] The risk of bleeding increases with restricted visualization of intervening vessels (particularly veins) in the surgical area. Damage may occur either to the superficial jugular veins (vv. jugulares ventrales) or in the sparse pretracheal connective tissue concurrent with the vv. thyroideae inferiores, which form the plexus thyroideus impar, or the infrequently appearing arteria thyroidea ima. In the present study, the most frequent complication after ST was infection and decay of the tracheostomata (2.9%). The reported rate of this complication is 0-36%.[13] Risk factors include the length of skin incision and preparation of the hypodermis, which is open to bacterial invasion from both the surface of the epidermis and oropharangeal or tracheobronchial secretions. Contributing factors include tissue strain and the presence of sutures in the wound. In the current study, monitoring late complications proved problematic because the patients were critically ill, and if they survived from the critical stage of their disease they often transferred to other departments or to other healthcare facilities even before decannulation. Some patients experienced serious health problems, which restricted further control and monitoring. One of the most serious late complications is tracheal stenosis, which represents an extremely serious medical problem. The most frequent cause is laryngotracheal intubation or tracheostomy. Zietk et al[25] considered the extended tracheal intubation (>48 hours) as more dangerous than tracheotomy, and suggested laryngotracheal intubation as the most frequent cause of benign laryngeal and tracheal stenosis. In contrast, Richard et al[26] and Isa et al[27] reported the rate of benign tracheal stenosis following tracheostomy was 29% and 31-65%, compared to 13% or 19% following ETI.[26-28] Clinical stenosis development is initially asymptomatic, and a tracheal lumen constriction of >20% is perceived to be a significant criterion. After the asymptomatic period (known as the free period), which generally lasts for 2-3 months, the first symptoms gradually appear as coughing fits mainly in the morning and more difficult expectoration. Fiala et al,[29] showed that the voluntary interval becomes longer with increasing cannulation duration and age. Increasing cannulation duration is the cause of a longer stenosis. An inspiratory stridor appears if tracheal lumen is reduced to 5 mm (20% of the original width of the lumina). Literature reports suggest that the incidence of stenosis is 0-43% after PDT and 0.6-21% after ST with stenosis, most frequently being located in the tracheostoma (orificial), and less often at the end of the tracheostomal cannula and the

inflated cuff (suborificial) or over the tracheostomata (supraorificial).[3,13] In the present study, 3 patients developed post-cannulation stenosis (one PDT and 2 ST). Two of these (one PDT and one ST) were resolved by surgical resection of the stenosis and creation of an end-to-end anastomosis, while the third was resolved using dilatation and electrocoagulation. The current study comparing PDT and ST found that both techniques had particular advantages and disadvantages. While PDT was found to be a faster technique, it was associated with a higher complication rate. Percutaneous dilatational tracheostomy was associated with more early complications, largely postoperative bleeding, which was unavoidable even under endoscopic monitoring. Apart from the length of time the trachea is exposed, additional factors such as the repair of surgical wounds, emphysema and hematoma of the anterior neck wall may also influence the occurrence of late complications, as well as the overall state of health of patients, their character, main diagnosis, and age. We believe that it is the experience and training of the nursing staff rather than the type of tracheostomy technique that will fundamentally influence patient outcomes and the complication rate.

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