A Comparison of Percutaneous Dilatational Tracheostomy Versus Conventional Surgical Tracheostomy

Retrospective Study in 378 Patients 2003 – 2008

Vergleich der perkutanen Dilatationstracheotomie gegenüber der konventionellen chirurgischen Tracheotomie

Retrospektive Studie mit 378 Patienten, 2003 – 2008

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Abstract

Background: Percutaneous dilatational tracheostomy (PDT) and surgical tracheostomy (ST) are widely accepted techniques and frequently performed in clinical practice. We compared PDT with ST tracheostomies in view of the benefits and drawbacks, time of duration, indication and complication rate of the respective procedures.

Methods: The evaluation was based on data from 378 tracheostomies. 209 of these tracheostomies were performed at bedside as PDT in the intensive care unit. These were compared to 169 ST tracheostomies performed in the operating room. All interventions were performed by the same team of surgeons or intensivists, however, at different training levels.

Results: The mean duration of the operation was shorter for PDT than for ST (18.2 ± 10 min versus 38.2 ± 14.2 min, p = < 0.001). The PDT was a simpler procedure and performed predominantly by physicians in postgraduate training. The rate of complications was low in both groups (8.6 % PDT, 8.3 % ST, p = 0.909).

Conclusion: Although both interventions are safe and achieve comparable results, PDT can be applied in a shorter time. PDT is easier to perform and seems particularly suitable for physicians in postgraduate training.

Zusammenfassung

Hintergrund: Die perkutane Dilatationstracheotomie (PDT) und die chirurgische Tracheotomie (ST) sind beide anerkannte Verfahren. Diese Studie vergleicht PDT- mit ST-Tracheotomien im Hinblick auf die Vor- und Nachteile, Eingriffsdauer, Indikationsstellung und Komplikationsrate der jeweiligen Prozeduren.

Patienten: Die Daten von 378 Tracheotomien wurden retrospektiv ausgewertet. 209 der Tracheotomien wurden als PDT bettseitig auf der Intensivstation ausgeführt, 169 ST-Tracheotomien wurden im OP ausgeführt. Alle Eingriffe wurden vom selben Operationsteam ausgeführt, deren Operateure jedoch einen unterschiedlichen Ausbildungsstand hatten.

Ergebnisse: Die Eingriffsdauer war bei der PDT kürzer als bei der ST (18,2 ± 10 min versus 38,2 ± 14,2 min, p < 0.001). Die PDT war eine einfachere Prozedur und wurde überwiegend von Ärzten in Weiterbildung durchgeführt. Die Komplikationsrate war in beiden Gruppen vergleichbar gering (8,6 % PDT versus 8,3 % ST, p = 0.909).

Schlussfolgerungen: Beide Methoden stellten sich als sicher heraus und erzielten vergleichbare Resultate. PDT kann in kürzerer Zeit durchgeführt werden und erscheint als die einfachere Methode. Die PDT ist somit auch von Operateuren in Ausbildung gut durchführbar.

Introduction

In recent years, percutaneous dilatational tracheostomy (PDT), performed according to the technique by Ciaglia, has gained widespread acceptance for airway access in patients requiring prolonged mechanical ventilation. Reasons for the preference for PDT over surgical tracheostomy (ST) include its simplicity of performance, its rapid placement, the lower rate of postoperative complications and better cosmetic results.

The traditional method of performing tracheostomies in critically ill patients requires transfer from the intensive care unit to the operation theatre where a surgical team performs a surgical tracheostomy. This involves a full dissection of the pretracheal tissue and the insertion of the tracheostomy tube into the trachea under direct vision.

So far ST and PDT for prolonged mechanical ventilation have been compared in terms of benefits and drawbacks, time of duration, indication and complication rate of the respective procedures.
We studied a large number of patients managed with PDT or ST in order to compare the factors related to the choice of intervention, duration of intervention, as well as complication rate.

Methods

Patient population

The study population included all consecutive medical, surgical and neurological ICU patients in the medical intensive care unit requiring elective tracheostomy. Medical records were retrieved retrospectively between May 2003 and December 2008. The PDT and ST were evenly distributed over the study period. After the indication for tracheostomy, the choice of operation method was determined by patient factors. Typical factors such as high BMI, short neck in obese patients, increased thyroid volume, previous damage of upper airways, previous head and neck operations, affect the choice for the ST method. The PDT was preferred in patients without the before mentioned factors.

Data recording

The following variables were recorded: ICU category (medical, surgical, neurological), age, gender, comorbidities, reason for admission, reason for tracheostomy, duration of intubation before tracheostomy, duration of the procedure, intraprocedural complications, postprocedural complications, techniques used to perform the tracheostomy (patient factors), physician (surgeon or anaesthetist), location (operating theatre or ICU), indication (respiratory failure), acute physiological score (APS) and concurrent antibiotic therapy.

Procedures

General approach

Cuffed tracheostomy tubes were used in both groups. Tube sizes varied from 8 to 10. Cuff pressure was the minimal occluding pressure and was checked regularly. Cervical anatomical features were evaluated for the presence of a palpable cricoid cartilage at least 3 cm above the sternal angle on appropriate extension.
Both groups were examined bronchoscopically prior to the tracheostomy procedure. The endotracheal tube was withdrawn into the subglottic larynx and the trachea was inspected in order to evaluate the presence of any tracheal lesion and to aspirate bronchial secretions. At the end of the procedure, another bronchoscopy was performed: the bronchoscope was passed through the tracheostomy tube and then through the mouth in order to check the stoma and the tube in order to evaluate the presence of endotracheal hemorrhage and to aspirate bronchial secretions.
Tracheostomy wound dressings were changed once a day or as often as necessary to maintain a dry stoma.

Surgical techniques

A team of thoracic surgeons performed all of the surgical tracheostomies in this study. The surgical team consisted of the head of the department of thoracic surgery, one surgical consultant and residents. Procedures performed with open surgical technique included additionally an anesthetist for general anaesthesia and endotracheal tube removal.
A modification of the surgical technique described by Grillo [1] was used.
A 2 cm horizontal incision was made. The superficial fascia and strap muscles were retracted laterally to expose the cricoid cartilage and thyroid gland. The thyroid was retracted either superiorly or the isthmus ligated depending on individual anatomy. Hemostasis was archieved prior to entering in trachea. A horizontal incision was made between the second and third tracheal rings and an inferiorly based tracheal flap (reversed H-shaped incision) was sutured to the skin (Björk flap). The stumps of the two divided rings were retracted with two clamps and a tracheostomy tube of appropriate size was inserted into the trachea. The strap muscles were reapproached with one or two 2 – 0 Vicryl sutures and the skin was loosely sutured with one stitch at both sides of the tracheostomy tube. The endotracheal tube was removed, and the tracheostomy tube inserted under direct visualization. After cuff inflation, confirmation of placement was registered by auscultation of lung fields and bronchoscopy.

Nonsurgical approach

The technique according to Ciagla [2] was used in all patients. For procedures performed percutaneously, the Ciaglia Percutaneous Tracheostomy introducer set was used in all cases of PDT. PDTs were done in the ICU, bedside, under general anesthesia. All PDTs were performed under fiberoptic control to monitor the tracheal puncture and the insertion of the dilators and the tracheostomy tube. The patient was positioned with the neck extended and ventilated with 100 % fraction of inspired oxygen. The endotracheal tube was withdrawn under direct vision until the tip was at the level of the subglottic larynx. The cricoids and the first tracheal rings were identified by palpation. A 1 – 1,5 cm skin incision was made and the catheter-introducer needle was inserted into tracheal lumen between the first and second ring under fiberoptic control. The J-tip wire and the guiding catheter assembly were then used to introduce the percutaneous dilators until the required-size tracheostomy tube could be inserted.

Outcomes

All procedures were timed from skin incision to insertion of the tracheostomy tube. Perioperative (initiation of the procedure and 24-hours postoperatively) complications were routinely recorded. Possible perioperative complications included hemorrhage requiring exploration/ligation, tracheostomy tube displacement, pneumothorax, premature extubation of the endotracheal tube with consequently respiratory failure, deterioration in cardiopulmonary status requiring intervention, inability to complete PDT or conversion to open surgical tracheostomy, death secondary to a complication of the tracheostomy.
All patients were examined by the investigators daily until intensive care discharge to detect any complications. Postoperative complications were defined as those occurring from postoperative day 1 to day 21 or decannulation (tracheostomy site infection).

Statistics

Comparison between groups was performed by means of the Chi-squared test for categorical variables and by means of the t-test for continuous variables (or by nonparametric Mann-Whitney-U test in case of not normally distributed data). All analyses were performed using SPSS software (SPSS 19.0; SPSS Inc., Chicago, IL, USA). All tests of significance were two-tailed, and α was set at 0.05.

Parameters	PDT (n = 209)	ST (n = 169)	p
Age [years]	59.9 ± 14.1	62.3 ± 13.5	0.101
Gender [n/%]			
female	53/25.4	59/34.9	0.043
male	156/74,6	110/65.1	
BMI [kg/m²]	23.5 ± 4.2	26.2 ± 5.5	<0.001
Ventilated days, preoperative	10.1 ± 6.1	20.3 ± 51.2	0.431
Indications [n/%]			
weaning	158/75.6	105/62.1	0.005
long term ventilation	51/24.4	64/37.9	
Primary diagnosis [n/%]			
cardiac	12/5.7	18/10.7	0.065
pulmonary	120/57.4	76/45.0	
CNS	64/30,6	64/37.9	
diabetes	1/0.5	0/0.0	
neoplasia	0/0.0	2/1.2	
polytrauma	12/5.7	9/5.3	
Days in ICU	35.3 ± 23.5	25.8 ± 23.1	<0.001
ICU [n/%]			
none	4/1.9	29/17.2	<0.001
interdisciplinary	55/26.3	37/21.9	
thoracic surgery	50/23.9	28/16.6	
general surgery	36/17.2	23/13.6	
mixed	4/1.9	8/4.7	
neurology	60/28.7	44/26.0	
Previous operation(s)			
no	194/92.8	100/59.2	<0.001
yes	15/7.2	69/40.8	

Table 1 Demographic and preoperative, clinical characteristics.

Results

Patient Characteristics

The study population consisted in a total of n = 378 patients, including 112 women (29.6%) and 266 men (70.4%); the average age was 61.0 ± 13.9 years. Further demographical and preoperative clinical characteristics of the population, classified according to the tracheostomy method, are shown in **Table 1**.

Data from a total number of 378 tracheostomies were evaluated; of these, 209 were percutaneous dilatational tracheostomies (PDT) according to the Ciaglia [2] method and 169 open surgery tracheostomies (ST) according to the modified Grillo [1] method. In every case the indication for tracheostomy was the presence of respiratory failure necessitating prolonged weaning or permanent mechanical ventilation.

Preoperative comparison of groups

Age. There was no significant difference in age (59.9 ± 14.1 years (range: 24.3 – 88.5) *vs.* 62.3 ± 13.5 years (range: 17.8 – 86.7; $p = 0.101$).

Gender. Both groups consisted in the majority of male patients (75% in the PDT and 65% in the ST group). The greater proportion of male patients in the PDT group compared to the ST group was significant ($p = 0.043$).

BMI. The mean body mass index in the PDT group was 23.5 ± 4.2 kg/m², thus in the normal weight range (range: 15 – 36 kg/m²), whereas the ST group at 26.2 ± 5.5 kg/m² (range: 17 – 42 kg/m²) corresponded to a classification as pre-obese ($p < 0.001$).

Indication. Weaning was the indication in 75.6% of the PDT and 62.1% of the ST patients ($p = 0.005$).

Primary Diagnosis. More than 80% of the patients in both groups displayed pulmonary primary disease or CNS disease. The most frequent condition in the remaining patients was cardiac disease. Overall, differences between the groups were not significant ($p = 0.065$), however, pulmonary disease was more frequent in the PDT group.

Preoperative duration of ventilation. The preoperative duration of ventilation was not significantly different (10.1 ± 6.1 versus 20.3 ± 51.2 days, p = 0.431), however, distribution of ventilation duration in the ST group was extremely wide as expressed by a high standard variation.

ICU stay. Duration of ICU stay in PDT patients was 35.3 ± 23.5 days (range: 0 – 156 days) and significantly longer than that of ST patients (25.8 ± 23.1 days; range: 0 – 151 days). The mean difference was 9.5 days ($p < 0.001$).

Intensive Care Unit/Specialist Field. The breakdown according to specialist fields of the intensive care unit indicated a significant difference between the groups ($p < 0.001$).

Previous operations. 40.8% of the ST group of patients had one or more previous surgeries, compared to only 7.2% in the PDT group ($p < 0.001$).

Comparison of methods PDT vs. ST: perioperative and postoperative clinical parameters

The results of the comparison of peri- and postoperative parameters in both groups are summarized in **Table 2**.

Duration of the procedure. On average the PDT lasted 8.2 min (range: 2 – 60 min), the ST 38.2 min (range: 12 – 88 min). The mean group difference was 20 min ($p < 0.001$).

Diameter of the Tracheal cannula. In the case of PDT, significantly smaller tracheal cannula were used then in the case of ST (8.4 ± 0.5 mm vs. 9.1 ± 0.7 mm; $p < 0.001$).

Airway infection. Investigation of tracheobronchial aspirates revealed higher rates of pathogens in the pre-interventional bronchoscopy (59% of the PDT patients and 44% of the ST patients $p = 0.005$).

Parameter	PDT (n = 209)	ST (n = 169)	p
Duration of procedure [min]	18.2 ± 10.0	38.2 ± 14.2	< 0.001
Diameter of tracheal cannula [mm]	8.4 ± 0.5	9.1 ± 0.7	< 0.001
Days of ventilation, postoperative	14.7 ± 20.2	12.7 ± 18.7	0.152
Tracheostomy occlusion [n/%]			
yes	1/0.5	15/8.9	
no	207/99.0	146/86.4	< 0.001
unknown	1/0.5	8/4.7	
Pathogens [n/%]			
no	86/41.1	94/55.6	0.005
yes	123/58.9	75/44.4	
Antimicrobial treatment [n/%]			
no	106/50.7	122/72.2	< 0.001
yes	103/49.3	47/27.8	
Complications [n/%]			
no	191/91.4	155/91.7	0.909
yes	18/8.6	14/8.3	
Surgeons [n/%][1]			
head physician/senior physician	82/39.2	118/69.8	
specialist in advanced training	94/45.0	50/29.6	< 0.001
junior doctor in advanced training	33/15.8	1/0.6	
Number of revisions [n/%]			
0	202/96.7	165/97.6	
1	7/3.3	3/1.8	0.346
2	0/0.0	1/0.6	
Fatalities [n/%]			
no	149/71.3	142/84.0	0.003
yes	60/28.7	27/16.0	

Table 2 Method comparison PDT vs. ST: peri- and postoperative clinical parameters.

[1] „none" refers to patients who were transferred immediately postoperatively to the neurological early rehabilitation ward.

Furthermore, the differentiation according to pathogen groups showed a significant group difference ($p = 0.019$). An overview of the pathogen distribution is shown in **Fig. 1**.

Antimicrobial treatment. It was administered in 49.3% of the PDT patients compared to 27.8% of the ST patients ($p < 0.001$).

Complications. Both groups showed almost the same complication rates of 8.6% (PDT) and 8.3% (ST) ($p = 0.909$). However, the type of complications was different. Subglottic tracheal stenosis was observed in 6 ST patients (3.6%) but none in PDT patients ($p = 0.006$). On the other hand, 11 patients (5.3%) of the PDT group displayed injury to the tracheal posterior wall but none of the ST patients ($p = 0.002$) (**Fig. 2**).

Operating surgeons. Over two thirds of the open tracheostomies were performed by the chief surgeon and residents. Most of the percutaneous dilatational tracheostomies (45.0%) were performed by specialist doctors in advanced training (**Fig. 3**). The group difference was significant ($p < 0.001$).

Revisions. In 7 patients (3.3%) of the PDT group and 3 patients (1.8%) of the ST group revision was indicated, in one further patient of the ST group even 2 revisions. The group difference was not significant ($p = 0.346$).

Fatalities. 28.7% and 16.0%, respectively, of the patients died in the PDT and the ST group.The higher fatality rate in the PDT group was significant ($p = 0.003$).

Discussion

Main Results

The main results of our study are the following: 1) patients with a high BMI and associated difficulties predominantly underwent ST. The ST was more frequently performed by experienced operators; 2) PDT is a faster and more straightforward procedure than ST; 3) a few complications were observed and related to procedure complications in PDT and long-term complications in ST.

Comparability

The two groups were similar in terms of age and underlying disease.

All ST- and PDT-procedures were performed by the same team of thoracic surgeons and intensivists, respectively, each invariably using the same technique. Therefore, the results obtained are not affected by complications related to the operative learning curve. Nevertheless, in our study PDT was carried out on many occasions by doctors undergoing specialist training and junior doctors; this was quite the opposite of ST which in two thirds of cases was primarily been carried out by the head of department and (senior) consultant. The ST procedure obviously was regarded as an increased-risk procedure and hence was carried out by experienced surgeons.

Techniques

Our technique of ST involved gaining access to the airway through a reversed H-shaped incision between the second and third tracheal ring so as to reduce the potential risk related to tracheostomies performed at higher levels (laryngo-tracheal stenosis) or at lower levels (trachea-innominate artery fistula). We preferred a reversed H-shaped incision since it seems to ensure optimal healing of the stoma by preserving vascularization of the two tracheal flaps which close up like the shutters of a window after decannulation.

Our technique of PDT involved gaining access to the airway between the first and second tracheal ring to reduce any risk of damaging the cricoid cartilage and to prevent bleeding from lesions to the thyroid isthmus. All PDTs were performed under

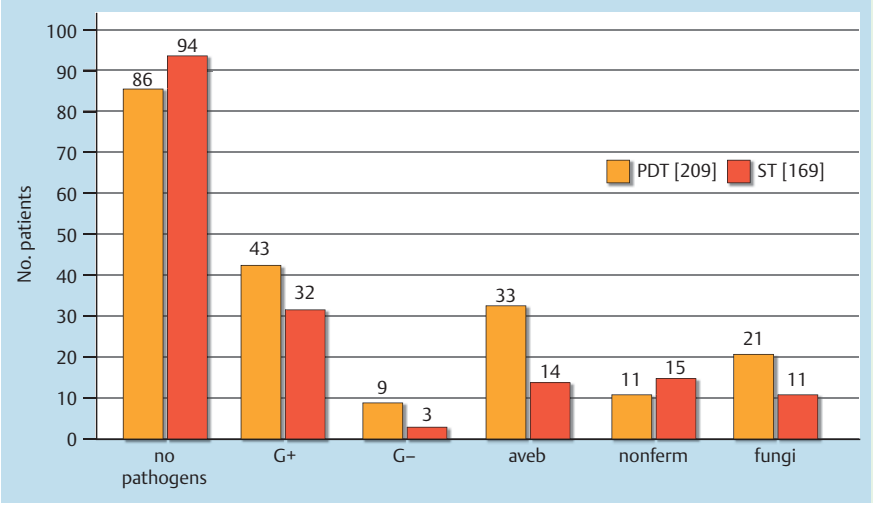

Fig. 1 Microbial pathogens in tracheobronchial samples. Investigation of tracheobronchial aspirates revealed higher rates of pathogens in the pre-interventional bronchoscopy, 59 % of PDT patients and 44 % of the ST patients (p = 0,005).The differentiation according to pathogen groups showed a significant group difference (p = 0.019); G+, gram positive bacteria; G–, gram negative bacteria; aveb, anaerobic organism; nonfarm, non fermenter; fungi,fungal infection, ST, surgical tracheostomy; PDT, percutaneous dilatational tracheostomy.

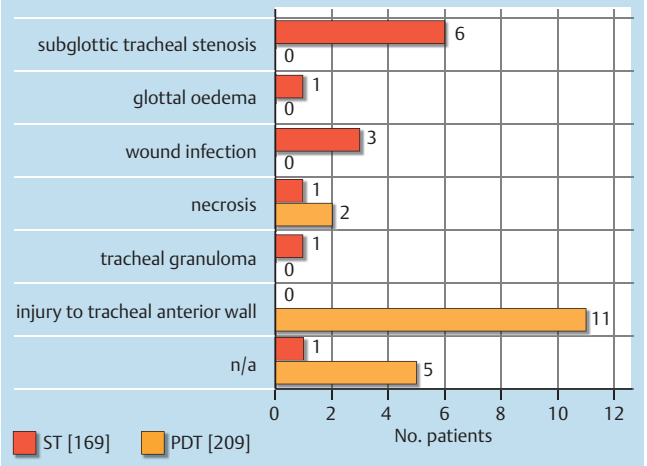

Fig. 2 Intra- and postoperative complications. Complications were observed in 31 patients from 378 (8.2 %). PDT n = 18 (8,6 %); ST: n = 14 (8,3 %). Both groups showed almost the same complication rates (p = 0,909). The types of complications were different in the groups. ST, surgical tracheostomy; PDT, percutaneous dilatational tracheostomy.

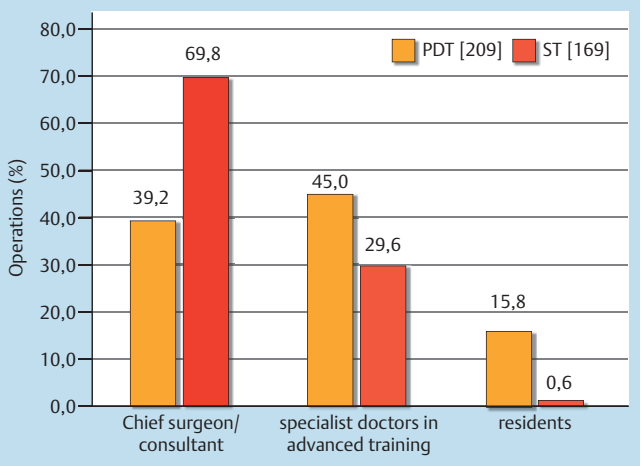

Fig. 3 The operating team. In this study the 209 percutaneous dilatational tracheostomies were performed by anesthesiologists and the 169 conventional surgical tracheostomies by thoracic surgeons. Over 2/3 of the surgical tracheostomies were performed by the chief surgeon and residents. Most of the percutaneous dilatational tracheostomies (45,0 %) were performed by specialist doctors in advanced training. The group difference was significant (p < 0,001).

endoscopic guidance to monitor the tracheal puncture and the insertion of the dilators and the tracheostomy tubes.

Factors related to the choice of intervention and operator

We observed that patients with a higher BMI, short neck in obese patients, increased thyroid volume, previous damage of upper airways, previous head and neck operations, predominantly underwent ST whereas PDT was preferred in patients without the before mentioned factors.

Interestingly, ST procedures were performed more frequently by experienced operators. This is comparable with the study of Melloni [3]. In this study he evaluated the surgical team, the technique and experience of each operator. However, the complication rate in this study is higher than in ours. The validity of the study is questionable because of the small number of patients. Other literature does not address the learning curve.

Time of the procedure

The average time taken for the procedure was 18.2 min for PDT and 38.2 min for ST. Comparable results concerning the significant time difference for the two groups were arrived at in the study by Jackson [4]. A lot of studies evaluated procedure time and show likewise results.

Detection of tracheobronchial pathogens during procedure

Overall, there was a high rate of positive tracheobronchial samples prior to the procedure. It was highest in the PDT group. This may be primarily explained by the higher rates of patients with underlying pulmonary disease and on antimicrobial treatment. As regards pathogen classes, gram-positive pathogens were predominantly found. All pathogens were regarded as colonization and in fact, no infectious complications related to any of the procedures could be observed.

Complication types and rates

The complication rates in our study were the same for both procedures (8.6% PDT and 8.3% ST). However, we observed a small number of intraoperative complications in the PDT group and a postoperative long-term complication in the ST group. Six ST patients developed a subglottic tracheal stenosis over time which did not occur with any of the PDT patients. On the other hand, 11 patients in the PDT group experienced an injury to the posterior wall of the trachea during the procedure. The risk for such complication is related to the lack of infrastructure in the intensive care unit as compared with the operating theatre. One should note the advantages of the operating theatre resulting from the size of the working area, lighting and optimum patient positioning thanks to the operating table functions which are not present with bedside PDT. The structural deficiencies of the intensive care unit include limited possibilities for positioning the patient owing to the soft mattress, and a working area which has limited space and is poorly lit.

We didn't observe any fracture of tracheal ring in both methods. We think, this is an advantage of the bronchoscopic guided procedure. The potential risk of damaging the cricoids during PDT must always be carefully considered, especially in elderly patients with heavily calcified larynxes.

The fatality rates of our study albeit significantly different in both groups were not related to the interventions, but caused by the underlying disease.

Several randomized clinical trials comparing PDT with ST have been performed, and usually show, that both operative and short-term post-operative complications are comparable.

Graham et al. in 1996 [5] retrospectively compared 31 patients who underwent surgical tracheostomy to 29 patients who underwent dilatative tracheostomy in the ICU. Their study did not demonstrate any significant outcome difference between the two groups. Holdgaard et al. [6] performed a prospective study evaluating short term complications and found statistically significant decreases in procedure time from 15 to 11.5 minutes, decreases in minor operative and postoperative bleeding and decrease in minor and major infections with the PDT method.

Crofts et al. [7] performed a prospective randomized study comparing surgical tracheostomy with bedside PDT found no statistically significant difference in morbidity between the two groups and no morbidities in either group. They concluded that both methods could be performed safely.

Practical advantages and disadvantages for PDT

One advantage of PDT is, that it can be carried out at any time in the intensive care unit without having to draw on planned operating theatre capacities. However, the above-mentioned disadvantages of carrying out the procedure in the intensive care unit remain to be considered. Care of long-term ventilated patients is simpler with ST in respect of tube-changing and caring for the tracheostoma. Changing the tube on a narrow dilated tracheostoma often leads over the course of time to bleeding as a result of the development of necrosis, lesions and increased granulation tissue with the consequent risk of tracheal stenosis. With patients who had previously undergone surgery in the neck area, the anatomical conditions are distorted due to scar tissue, which means that a ST is indicated in order to avoid unexpected complications.

Strengths and limitations

The strength of our study is the large number of patients treated over time by a very homogeneous operating team. Despite of being a retrospective study, all descriptive and operating data were completely recorded on a routine basis. Nevertheless, this was not a randomized study, and specific advantages of one method over the other could not be systematically assessed. Furthermore, we did not specifically evaluate the timing of the procedure (early versus late tracheostomy).

Conclusions

Both techniques applied in a large population proved to be safe. The advantages of PDT included a more rapid procedure and a lack of long-term complications. On the other hand, ST had comparable results. The choice of intervention was the patient factor (obesity, increased thyroid volume, previous damage of upper airways). In our opinion these factors will always dictate the choice of intervention. The results show, that both techniques are adequate for tracheostomy and exist side by side without replacing one another.

ST obviously requires higher skills and is more frequently performed by experienced operators.

Abbreviations

Min	minimum
Max	maximum
MW	mean value
ST	surgical tracheostomy
PDT	percutaneous dilatational tracheostomy
SD	standard deviation

Conflict of Interest

The authors have no conflict of interest.

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