The role of fiberoptic bronchoscopy monitoring during percutaneous dilatational tracheostomy and its routine use into tracheotomy practice

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Abstract

Objective: To evaluate percutaneous dilatational tracheostomy with and without the use of the bronchoscope and compare the safety and complications of the procedure.

Methods: The prospective, randomised-controlled study was conducted at the Professor A. Ilhan Özdemir State Hospital, Giresun, Turkey, between October 2013 and February 2014, and comprised patients $\geq$18 years of age who were dependent on mechanical ventilation for an extended duration and were scheduled to undergo percutaneous dilatational tracheostomy with Griggs technique. The patients were randomly divided into two groups; group A received standard c that was opened without using fiberoptic bronchoscopy, while group B received percutaneous dilatational tracheostomy that was opened using fiberoptic bronchoscopy. Complications and number of applied needle approaches were recorded.

Results: Of the 60 patients, 35(58.3%) were women. The patients were divided into two groups of 30(50%) each. None of the patients developed pneumothorax, subcutaneous emphysema, or oesophageal perforation. The numbers of needle interventions and total complications were significantly higher in group A than group B ($p<0.05$). Procedure duration was significantly longer in group B ($p<0.05$).

Conclusion: Percutaneous dilatational tracheostomy was reliable when applied with fiberoptic bronchoscopy due to the significantly lower complication rates.

Keywords: Percutaneous tracheostomy, Fiberoptic bronchoscopy, Peroperative complications, Griggs technique, Intensive care units, Critical illness, Mechanical ventilation. (JPMA 66: 83; 2016)

Introduction

Percutaneous dilatational tracheostomy (PDT) has almost completely replaced surgical tracheostomy in patients in the intensive care unit (ICU) due to its various advantages, such as being performed at the bedside. Tracheostomy is recommended for patients who have undergone endotracheal intubation in ICUs and will probably receive mechanical ventilation for an extended duration.[1,2]

Some researchers[3,4] have recommended use of fiberoptic bronchoscopy (FOB) during PDT as it can be used to guide the tracheostomy tube. The use of FOB reduces the rate of complications, such as pneumothorax, paratracheal placement, and tracheal back-wall damage, and is beneficial for treating complications such as endobronchial haemorrhage.[5] One study reported that it was unnecessary to use FOB as a routine method.[6]

We hypothesised that the use of imaging methods such as FOB while performing PDT would reduce the frequency of complications resulting from the procedure. PDT can be applied by specialists using two methods. The current study was planned to compare the complication rates and durations of both techniques and to determine the necessity of FOB for PDT.

Materials and Methods

The prospective, randomised-controlled study was conducted at the Professor A. Ilhan Özdemir State Hospital, Giresun, Turkey, between October 2013 and February 2014, and comprised patients $\geq$18 years of age who were dependent on mechanical ventilation for an extended duration and were scheduled to undergo PDT with Griggs technique. Written consent was obtained from the institutional ethics committee and first-degree relatives of the patients. Patients included were on a mechanical ventilator with mechanical ventilation needed for more than 7 days; a long weaning time; and had brain damage with Glascow coma score (GCS) <7. Patients with tracheal or neck abnormalities, soft tissue infection in the neck, neck surgery history, oxygenation problems (positive end expiratory pressure $\geq$15cm H2O, fraction of inspired oxygen (FiO2) $\geq$0.80), coagulation disorders or coagulation parameter changes (thrombocyte count < 50,000 mm³, time of active partial

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thromboplastin 1.5-fold higher than the control value, prothrombin time international normalised ratio < 1.6), and those requiring urgent surgery were excluded.

All PDT procedures were carried out by two anaesthetists, both having 3 years of ICU experience, working at the same time, one of them holding the FOB and the other performing the PDT under elective conditions. Physicians were assisted by a technician and an ICU nurse. The anaesthetists had received training on how to use FOB and had performed the PDT procedure on a minimum of 30 patients. The PDT procedure was applied with the Griggs method in all patients.

The patients were randomly divided into two groups by a computer programme (GraphPadQuickCalcs Software). Group A received a standard PDT (SPDT) that was opened without FOB. Group B received PDT that was opened using FOB (FPDT). Age, gender, oral intubation time, Acute Physiology and Chronic Health Evaluation (APACHE) II parameters, and arterial blood gas values were recorded 90 min before and 90 min after the procedure. All patients were monitored during the procedure by electrocardiography, peripheral oxygen saturation, expired carbon dioxide concentration, and invasive arterial pressure. All PDT procedures were performed using a Percutaneous Tracheostomy kit (Portex, Hythe, Kent, UK).

All patients were put on fast for 6h before the procedure. The patients were intravenously administered $1\mu g$ kg^{-1} phentanyl, 2 mg kg^{-1} propofol, and 0.1 mg kg^{-1} rocuronium before the procedure and positive pressurised mechanical ventilation (MV) was applied by elevating FiO2 to 1.0. All medications were prepared by an anaesthetist who did not take part in the study. Following sedation and muscle relaxation, the head was brought to extension by placing a roll pillow under the shoulders. Povidone-iodine was used to cleanse the region, and the area was covered with a perforated compress. The patients were administered 2% lidocaine containing a 1:100,000 dilution of epinephrine to increase tolerance to the procedure and reduce haemorrhage.

The endotracheal tube (ET) cuff in the SPDT group was lowered and drawn back in such a way to remain immediately under the vocal cords. A 14-G intravenous cannula was moved between the second and third tracheal cartilage determined by palpation 1.5-2cm below the cricoid until air was inspired and it entered the tracheal lumen. After placing the guide wire in the tracheal lumen, the cannula was withdrawn and expanded with an 8-F dilator. The skin and trachea were enlarged with forceps. A No. 7 tracheostomy cannula was placed for female patients and a No. 8 tracheostomy cannula for male patients. ET was removed after confirming the location of the cannula by inflating the tracheostomy cuff and listening for respiratory sounds. The PDT procedures were monitored using FOB, but the physician who performed the procedure was not informed and was not given any instructions.

In addition to the procedures performed in the SPDT group, FOB in the FPDT group was inserted through the small hole in the cap of the catheter mounted on the ET by an expert physician who had experience of using FOB. The tracheal incision location was determined over the skin by transillumination of the FOB light inside the trachea, by palpation with fingers, and by monitoring finger pressure with FOB to accurately locate the needle puncture site. PDT procedures were monitored using FOB placed inside the ET. The physician who performed the procedure was informed during the procedure. PDT was applied in coordination with the physician who used FOB (Figures-1 and 2).

In both groups, the tracheostomy cannula was fixed on the neck with a collar tie after cleaning the area around the tracheostomy tube and rolling with a sterile sponge. FiO2 values in MV were returned to those before the procedure. Lung graphs of all patients were taken 6h after the procedure. Both groups underwent FOB again and were re-evaluated in terms of potential complications. Complications (minor haemorrhage, surgical haemorrhage, subcutaneous emphysema, pneumothorax, oesophageal perforation, rear-wall damage, wrong intubation, and cuff rupture) before and after the procedure, number of applied needle interventions, and procedure duration were recorded. Haemorrhage that could not be stopped by sponge wrapping the stoma after the procedure and/or blood coming with aspiration inside the tracheostomy tube was considered a minor haemorrhage. Continuous haemorrhage from the stoma and/or from the trachea with aspiration despite compresses was defined as a major haemorrhage. Furthermore, the procedure duration was taken as the time that elapsed from the placement of the needle to the placement of the tracheostomy cannula.

SPSS 17 was used for data analyses. When evaluating the data, frequency distributions, medians, min-max values, percentages and cross tables were used. The appropriateness of the normal distribution of the variables was assessed by Kolmogorov-Smirnov test. Mann Whitney U test was used to compare whether there were differences between groups, and Wilcoxon Signed Ranks test were used to compare whether there were

differences within the group. Yates ve Fisher's exact chi-square tests were used for comparison of quantitative data. The power of the study was determined 86% (n1 = 30. n2 = 30, d = 0.8 (Cohen's d: Effect Size Conventions-Large), α = 0.05; power (1-β) = 0.86) using the G Power statistical package (G*Power 3.0.10). A p value below 0.05 indicated significance and difference between the groups.

Results

Of the 60 patients, 35(58.3%) were women. Mean oral intubation time was 21.6±10.6 min; the successful tracheostomy placement time was 10.7±4.7 min; and the APACHE II value was 27.3±5.6.

The patients were randomly divided into two groups of 30(50%) each. No significant differences were observed between demographic characteristics, oral intubation times or APACHE II values of the patients in the two groups (Table-1).

Table-1: Demographic characteristics, oral intubation times, and APACHE II values. [n (%), Median (range)].

		SPDT (n=30)	FPDT (n=30)	
Gender	Female	17 (%56,7)	18 (%60,0)	χ^2=0,000
	Male	13 (%43,3)	12 (%40,0)	*P=1,000
Age		79,5 (56,0 - 89,0)	74,0 (46,0 - 87,0)	Z=-1,665
				**P=0,096
Oral intubation time		18,0 (8,0 - 42,0)	20,5 (9,0 - 61,0)	Z=-0,978
				**P=0,328
APACHEII		25,5 (20,0 - 38,0)	28,0 (13,0 - 45,0)	Z=-0,712
				**P=0,477

*Yates χ^2 Test
** Mann Whitney U Test
SPDT: Standard percutaneous dilatational tracheostomy
FPDT:Percutaneous dilatational tracheostomyusing fiberoptic bronchoscopy
APACHE: Acute Physiology and Chronic Health Evaluation.

Table-2: Numbers of needle interventions and complication rates. [Median (range)].

		SPDT (n=30)	FPDT (n=30)	
Successful tracheostomy placement time		7,0 (3,0 - 16,0)	14,0 (8,0 - 23,0)	Z=-5,062
				*P=0,000
Number of needle interventions		1,0 (1,0 - 5,0)	1,0 (1,0 - 2,0)	Z=-2,269
				*P=0,023
	1	16 (%53,3)	23 (%76,7)	
	2	7 (%23,3)	7 (%23,3)	
	3	5 (%16,7)	0 (%0,0)	
	4	1 (%3,3)	0 (%0,0)	
	5	1 (%3,3)	0 (%0,0)	
Pneumothorax		0 (%0,0)	0 (%0,0)	**P=1,000
Subcutaneous emphysema		0 (%0,0)	0 (%0,0)	**P=1,000
Oesophageal perforation		0 (%0,0)	0 (%0,0)	**P=1,000
Inaccurate extubation		6 (%20,0)	0 (%0,0)	**P=0,024
Major haemorrhage		2 (%6,7)	1 (%3,3)	**P=1,000
Minor haemorrhage		3 (%10,0)	3 (%10,0)	**P=1,000
Posterior wall damage		2 (%13,3)	0 (%0,0)	**P=0,492
Cuff rupture		5 (%16,7)	0 (%0,0)	**P=0,052
Total complications		18 (%60,0)	4 (%13,3)	χ^2=12,129
				***P=0,000

* Mann Whitney U Test
** Fisher's Exact χ^2 Test
*** Yates χ^2 Test
SPDT: Standard percutaneous dilatational tracheostomy
FPDT: Percutaneous dilatational tracheostomy using fiberoptic bronchoscopy.

Table-3: Preoperative arterial blood gas values [Median (range)].

|		Group (SPDT) (n=30)	Group (FPDT) (n=30)	Z	*P
pH	Preop. 90 min	7,5 (7,4-7,6)	7,5 (7,3-7,6)	-1,459	0,145
	Postop. 90 min	7,5 (7,3-7,6)	7,5 (7,3-7,6)	-0,896	0,370
	Z	-1,127	-0,458		
	**P	0,260	0,647		
PO2	Preop. 90 Dk	118,0 (54,8-194,0)	105,9 (66,0-338,0)	-0,133	0,894
	Postop. 90 min	102,5 (54,0-213,0)	100,0 (72,0-255,0)	-0,333	0,739
	Z	-0,874	-3,222		
	**P	0,382	0,001		
PCO2	Preop. 90 min	42,0 (31,0-55,3)	41,0 (28,0-75,0)	-0,215	0,830
	Postop. 90 min	45,5 (32,0-64,0)	42,5 (26,7-87,0)	-1,088	0,277
	Z	-2,027	-0,062		
	**P	0,043	0,951		
SAT	Preop. 90 min	98,0 (90,0-100,0)	98,0 (93,6-100,0)	-0,067	0,947
	Postop. 90 min	97,0 (90,0-100,0)	96,8 (93,0-100,0)	-0,141	0,888
	Z	-1,466	-1,688		
	**P	0,143	0,091		

* Mann Whitney U Test
**Wilcoxon Signed Ranks Test
SPDT: Standard percutaneous dilatational tracheostomy
FPDT: Percutaneous dilatational tracheostomy using fiberoptic bronchoscopy
PO2:Partial pressure of oxygen
PCO2: Partial pressure of carbon dioxide
SAT: Saturation
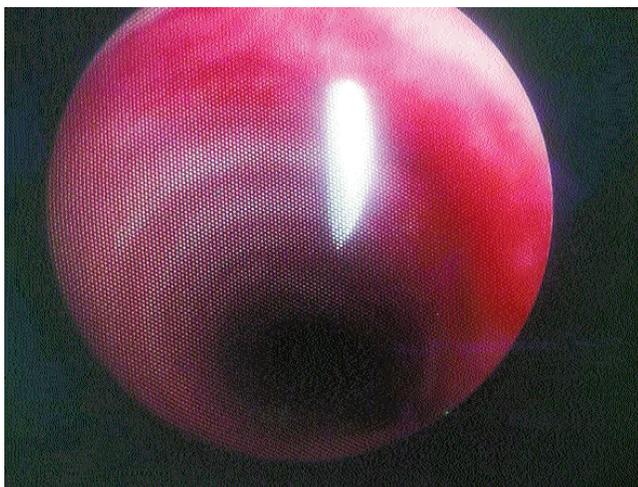
Figure-1: Puncture of the trachea.
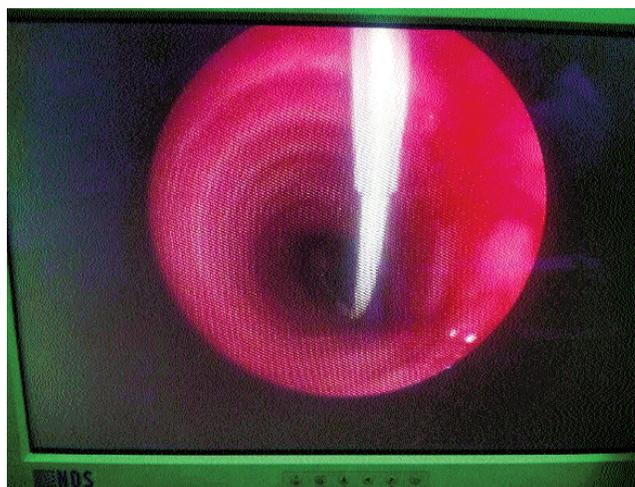
Figure-2: View inside the trachea during the guidewire process. The wall of the pars membranacea (PM) seems to be stressed.

The PDT procedure duration was significantly longer in the FPDT group than in the SPDT group (p<0.05). Needle intervention time was longer in the SPDT group than in the FPDT group (p<0.05). The initial needle success rate was higher in the FPDT group than in the SPDT group (p<0.05).

None of the patients developed pneumothorax, subcutaneous emphysema, or oesophageal perforation. Minor and major haemorrhage rates tended to be higher in the SPDT group than in the FPDT group (p>0.05). A significant difference was observed between the groups in terms of inaccurate intubation (p<0.05). A cuff rupture was detected in 5(16.7%) patients in the SPDT group, and in no patient in the SPDT group. The total complication

rate in the SPDT group was significantly higher than that in the FPDT group (p<0.05) (Table-2).

No significant differences were observed between preoperative and postoperative 90 min pH, partial pressure of oxygen (PO_2), partial pressure of carbon dioxide (PCO_2), or saturation (SAT) values. No significant difference was observed between preoperative and postoperative PO_2 values of patients in the SPDT group. However, preoperative PO_2 values were higher than those postoperatively in the FPDT group (p<0.05). No significant difference was observed between the preoperative and postoperative PCO_2 values of patients in the FPDT group. The postoperative PCO_2 values of patients in the SPDT group were significantly higher than the postoperative ones in the SPDT group (Table-3).

Discussion

Tracheostomy is one of the most common invasive methods applied to critically ill patients in the ICU. The most common indication for tracheostomy is to reduce endotracheal intubation and mechanical ventilation complications in patients who require prolonged mechanical ventilation due to respiratory or neuromuscular diseases, and to increase patient comfort. In our study, PDT was opened for an average of 21.6 days in patients who needed prolonged mechanical ventilation or who were not expected to neurologically improve over the short term. This duration was longer than that in some previous studies.[7-10] We believe that this resulted from difficulty in receiving written consent from the relatives of patients due to their socio-cultural background.

Because of the many newly opened ICUs, tracheostomy is a widely used procedure. Despite its advantages, the procedure is associated with certain complications. Numerous studies have been conducted with the aim of reducing these complications. One study[10] compared PDT and surgical tracheostomy and reported that PDT was more advantageous in terms of haemorrhage and complications, and so was preferred over surgical tracheostomy. Another study[11] reported that the rates of complications — such as haemorrhage, pneumothorax, emphysema, tracheomalacia, and stenosis - were significantly lower with PDT than surgical tracheostomy, and that PDT was preferred for critically ill patients. As PDT was more advantageous than surgical tracheostomy[12,13] it is used frequently in ICUs. However, PDT, particularly when applied by physicians without adequate experience, can have life-threatening complications. In our study, PDT was applied by specialists who had a minimum 3-yearICU experience, who had received FOB

training, and who had previously performed PDT on a minimum of 30 patients.

Potential complications during PDT include haemorrhage, infection, accidental removal of the ET during retrieval, oesophageal perforation, trachea back-wall damage, placement of the cannula outside the trachea, subcutaneous emphysema, pneumothorax, tracheal ring rupture and tracheal stenosis.[12-14] A study[10] reported major haemorrhage in 5, inaccurate extubation in 7, and subcutaneous emphysema in 5 of 99 patients who underwent PDT. We observed no subcutaneous haemorrhage in any of our patients.

One study[15] compared the Griggs and Ciaglia methods for PDT and reported minor haemorrhage in 70% and major haemorrhage in 30% 50 patients using the Griggs method. Similar to our findings, the study observed no emphysema or pneumothorax in any patient when it used the Griggs method. A comparison of complications and complication rates in this study with those in literature cited above revealed that major complications — such as mortality, pneumothorax, and subcutaneous emphysema — were not observed in our study. In contrast, the rates of minor complications, such as local haemorrhage and inaccurate extubation were similar.

FOB has been used widely in ICUs to reduce complications. The majority of ICU specialists feel more comfortable using FOB during PDT. There is increasing evidence on the effect on complication rates of using FOB while applying PDT. FOB has been reported to reduce complication rates, but other studies have reported no effect.

A retrospective study on trauma patients[16] suggested that bedside PDT is a highly reliable method even in obese patients; therefore, routine bronchoscopy is unnecessary. We applied bedside PDT due to its lower complication rate and many advantages. However, the fact that PDT applied with FOB had lower complication rates suggests its necessity.

A retrospective study[17] used FOB in 32% of trauma patients in whom PDT was applied. It observed 16 complications: 11 in the groups without FOB and 5 in the groups with FOB. The rate of haemorrhage was 3% in the FOB group and 4% in the other groups (p>0.05). It concluded that routine use of FOB is unnecessary but it would be beneficial for obese patients and those with difficult neck anatomy. However, in our prospective study, total complications were 4 in the FPDT group and 18 in the SPDT group (p<0.05). Similar to our study, although the rates of minor haemorrhage were similar in both

groups, the rate of major haemorrhage was 6.7% in the SPDT group and 3.3% in the FPDT group (p<0.05). We believe that this difference resulted from the uneven distribution of patient numbers between the groups in the earlier study.[17]

Previous clinical studies suggest that the frequency of complications such as pneumothorax, passage of a dilatator, a tracheostomy cannula outside of the trachea, and tracheal back-wall damage can be considerably reduced by PDT applied with bronchoscopy.[4,18,19] In our study, tracheal back-wall damage was observed in 2 patients in the SPDT group and none in the FOB group. The airway must be assessed by bronchoscopy during and after the procedure to evaluate tracheal back-wall damage. In the current study, the airway was assessed by FOB during and after the procedure. Previous research suggests that complications such as placement of tracheostomy cannula outside of the trachea, oesophageal perforation, tracheal back-wall injury, vertical movement of the guidewire, pneumothorax, and subcutaneous emphysema can be reduced by application of PDT with FOB.[3,18,20] A study of 71 ICU patients recommended the use of endoscopic guidance to enhance tracheal puncture and dilatation safety.[3]

One study[21] reported that the use of routine bronchoscopy prevents complications related to ET malposition. The use of FOB assists in the prevention of accidental extubation of a patient during withdrawal of the ET or insertion of the guidewire through Murphy's eye. In our study, inaccurate extubation during withdrawal of the ET occurred in six patients in the SPDT group. The patients who were inaccurately extubated were re-intubated and ventilated. These procedures increased the number of needle interventions applied to our patients. The number of needle interventions in the SPDT group was significantly higher than that in the FPDT group. We believe that the large number of needle interventions in the SPDT group may have caused higher rates of haemorrhage.

A study[22] reported that the procedure duration on patients in whom PDT was applied with FOB was significantly longer than that in those who underwent PDT without FOB. Mean procedure durations of PDT with FOB were 9.3 min in one study[23] and 21.6 min in another. In our study, the mean procedure durations were 7.3 min (median 7) for SPDT and 13.67 min (median 14) for FPDT. The variations are likely due to differences in clinical experience. One study[8] concluded that the use of FOB decreases the rate of complications, though it extends procedural duration. In our study, although the procedure duration was longer in the FPDT group, but the rate of complications in this group was significantly lower.

No significant difference was observed in the preoperative and postoperative arterial blood gas values between the groups. An intra group comparison of SPDT showed that the postoperative PCO_2 value was higher. This was likely due to the high rate of inaccurate extubation and secretions passing through the trachea due to haemorrhage in the SPDT group.

A retrospective study[24] reported that there are no large randomised controlled studies depicting direct comparison with or without bronchoscopy and concluded that Griggs PDT can be safely performed without bronchoscopy guidance. Our study was a randomised controlled study and, according to our results, we believe that SPDT is a successful method, but because of the lower incidence of complications in FPDT, PDT with FOB makes the procedure safer.

Conclusion

PDT procedures were successful with both techniques. Although PDT applied with FOB was of longer duration, but it caused no major complications and significantly reduced the rate of minor complications. As such, routine use of FOB for PDT will enhance the reliability of the procedure.

Acknowledgements

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