Fiberoptic-guided percutaneous dilatational tracheostomy versus surgical tracheostomy for intensive care ventilated patients

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Background and objectives
The aim of the study was to compare the safety and efficacy of fiberoptic-guided percutaneous dilatational tracheostomy (FGPDT) with surgical tracheostomy (ST) in ICU ventilated patients.
Patients and methods
A prospective randomized double-blind study was performed to compare ST and FGPDT. In the ST group (n = 20), the procedure was performed by the same surgical team, ENT consultant and his assistant in operative theater. In the FGPDT group (n = 20), the procedure was performed at the bedside in the ICU by the same team, the anesthesia consultant and his assistant. All the steps of FGPDT were performed under the visual control of the fiberoptic bronchoscope. The duration of the procedure, hemodynamics, oxygenation parameters, skin incision size, number of trials during tubal insertion, and complications and adverse events arising during the procedure, immediately postoperatively, and throughout the patients continuing care for 2 weeks were assessed and recorded by ICU doctor blinded to the study.
Results
Forty patients were enrolled into the study, 20 patients for each group. Success in tracheostomy tube placement was found in 100% of patients in both groups. Regarding the procedure details, the mean size of skin incision was 3.7 ± 1.7 and 2 ± 0.6 for groups ST and FGPDT, respectively, and it was highly statistically significant (P < 0.0001). The mean number of trials was 1.27 ± 0.46 and 1.00 ± 0.00 for groups ST and FGPDT, respectively. It was statistically higher in group ST (P = 0.016). There was a significant reduction in the incidence of minor bleeding (oozing requiring dressing change, no need for transfusion or surgical intervention) with the FGPDT technique compared with ST [one patient (5%) and six patients (30%), respectively, P < 0.005].
Conclusion
Bedside percutaneous tracheostomy with fiberoptic bronchoscopic guidance is safe and cost-effective. FGPDT reduces the overall incidence of wound infection and relevant bleeding when compared with ST. FGPDT may be considered the procedure of choice for performing elective tracheostomies in ICU ventilated patients.

Keywords:
fiberoptic bronchoscopy, ICU, percutaneous dilatational tracheostomy, ventilated patients

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Introduction

The classical method of performing tracheostomy requires transport of critically ill patients from the ICU to the operating theater, where a surgical team performs an open or surgical tracheostomy (ST). This involves a full dissection of the pretracheal tissues and insertion of the tracheostomy tube into the trachea under direct vision [1].

Percutaneous dilatational tracheostomy (PDT) was first described in 1957 [2] and became increasingly popular after the release of a commercially available kit in 1985 [3]. This technique involves the use of blunt dilatation to open the pretracheal tissue for passage of the tracheostomy tube. Proponents of PDT suggest that the limited dissection results in less tissue damage, and therefore fewer wound complications such as hemorrhage and infection [3–15]. Long-term complications, such as tracheal stenosis or scar problems, have also been reported less frequently [4–7,9,10,12].

Finally, PDT is proposed as a bedside procedure that can be performed by every physician, with less assistance and less material [3–9,11,12]. This was supposed to diminish the cost of the intervention [1,4,6].

Various modifications of PDT have evolved to aid correct needle and subsequent tube placement within the trachea. This includes visualization of the inside of the trachea by a fiberoptic bronchoscope and the use of an endotracheal ventilation catheter. This is to avoid the potential risk for unintentional extubation while sharing the airway or the impalement of the needle, to

guide wire through the endotracheal tube, and also to avoid injury to the posterior wall of trachea during the step of cannulation and dilation [11].

The aim of this study was to compare the surgical conditions and the complication rate, especially the incidence of bleeding and wound infection, of conventional surgical and percutaneous dilatational tracheostomies guided by fiberoptic bronchoscopy performed under general anesthesia for ICU ventilated patients.

Patients and methods

This randomized prospective double-blind comparative study included 40 adult patients of both sexes to compare fiberoptic-guided percutaneous dilatational tracheostomy (FGPDT) and ST. All patients were hospitalized in the ICU of New Jeddah Clinic Hospital. Approval was obtained from the hospital Ethical Research Committee; informed written consent was obtained from first-degree relatives of all patients. The indication of tracheostomy was for either airway maintenance, which was for 30% of patients in the FGPDT group and 40% of patients in the ST group, or difficult weaning with prolonged intubation, which was for 70% of patients in the FGPDT group and 60% of patients in the ST group.

The choice of tracheostomy technique was randomized using a computer-generated random numbers table. The procedure was performed either in the operating room for ST or at the bedside in the ICU for FGPDT. All patients were intubated during the procedure, which was performed under general anesthesia.

Exclusion criteria included children below 16 years of age, enlarged thyroid gland, previous tracheostomy, unstable cervical spine fracture, pre-existing infection at the tracheostomy site, and evidence of coagulopathy defined as platelet count less than 100 000 ml or prothrombin time greater than 1.5 times as compared with control.

Patients randomized to conventional tracheostomy (the ST group = 20) underwent general anesthesia in the operating room. The procedure was performed by the same surgical team, the ENT consultant and his assistant. The choice of anesthetic agent depends upon the attending anesthesiologist, which was a combination of inhaled and intravenous agents, such as propofol, fentanyl, and atracurium with sevoflurane, according to patient's general condition and his hemodynamics.

The FGPDT group of patients (n = 20) underwent this procedure in the ICU under propofol, fentanyl induction followed by propofol infusion. Injection of atracurium was used as muscle relaxant. The procedure was performed by the same team, anesthesia consultant and his assistant. The procedure was performed using 'Portex Percutaneous Dilation Tracheostomy Kit' (Smiths Medical International Ltd, Kent, UK). Following induction and maintenance of general anesthesia using intravenous agents, the patient was positioned in the ICU bed with the head extended and the operative area prepared. The patient's lungs were ventilated with 100% oxygen. A special rubber connector was used between the endotracheal tube and ventilator tubes to allow easy passage of fiberoptic bronchoscope (Pentax Ltd, Slough, UK.) through the endotracheal tube with minimal ventilation leak, then the endotracheal tube was withdrawn under direct vision until the cuff was located just below the vocal cords; this is to avoid the potential risk for unintentional extubation while sharing the airway or the impalement of the needle and to guide wire through the endotracheal tube. The skin and the underlying tissues were infiltrated with local anesthetic solution (2% lidocaine) containing 1 : 100 000 epinephrine as a vasoconstrictor to minimize bleeding at the site of the incision. After making a 1 cm vertical incision in the midline halfway between the thyroid cartilage and the suprasternal notch, the needle and cannula were inserted between the second and third tracheal rings. The tracheal rings were identified by palpating below the cricoid cartilage and by the light of bronchoscopy. Correct positioning was confirmed by easy aspiration of air and a fluid-filled syringe that allowed visualization of withdrawn air bubbles and by direct visualization through bronchoscopy. The guide wire was inserted and then the single-stage dilator was used and passed over the guide wire until it reached the safety stop. After dilation, the tracheostomy tube was mounted on a specially designed obturator and advanced over the guide wire into the trachea. The obturator and guide wire were removed and tracheal suction of blood and secretions was carried out. Cuff inflation and connection to the ventilator were confirmed by capnography and auscultation of breath sounds in both sides. All the steps were performed under the visual control of the fiberoptic bronchoscope to avoid any structural injury and to confirm the position of tracheostomy tube. The endotracheal tube over the bronchoscope was removed after confirmation of its correct site under vision, and then the tracheostomy was stitched and tied in place with tapes.

All patients had chest radiography performed 1 h postoperatively and after 24 h. These were reviewed by radiologist blinded to the study and compared with the preoperative chest radiograph. The duration of the

procedure was timed starting with the skin opening and ending when the cannula was inserted; hemodynamics, oxygenation parameters, skin incision size, number of trials during tubal insertion, and complications and adverse events arising during the procedure, immediately postoperatively, and throughout the patients continuing care for 2 weeks were assessed and recorded by ICU doctor blinded to the study.

Statistical analysis

On the basis of previous studies [16], the incidence of minimal bleeding is reported to be 30%; we hypothesized that decreasing this percentage to 15% – that is, 50% reduction with a power of 80% and α error of 5% – will require 18 patients per group. A total of 10% were recruited to compensate for dropouts.

Data were analyzed using SPSS software package version 18.0 (SPSS, Chicago, Illinois, USA). Quantitative data were expressed using mean, SD, median, and inspector qualification program (IQP), whereas qualitative data were expressed in frequency and percent. Qualitative data were analyzed using the Fisher exact and Monte Carlo test to compare different groups. Not normally distributed quantitative data were analyzed using the Mann–Whitney test for comparing two groups. The unpaired Student *t*-test was used for continuous values (age, APACHE II, days intubated). All data were reported as mean ± SD. Statistical significance was accepted at *P*-value less than 0.05.

Results

The two studied groups were homogenous for their main diagnosis; there was no statistically significant difference between them (Table 1). Tracheostomies were performed successfully in all studied patients.

There were no statistically significant difference between the two groups with respect to age, sex, duration of intubation before tracheostomy, and 3-month survival rate after tracheostomy. The mean age of the percutaneous tracheostomy group was 53.3 years with a mean APACHE II score of 16.5. The mean age of the surgical group was 52.2 years with a mean APACHE II score of 17.5 (Table 2). There were no statistically significant difference between the two groups with respect to hemodynamics, but there was difference before and after the procedure and during the procedure itself in both groups, and it was due to sympathetic stimulation during skin incision and manipulation of the trachea.

In the FGPDT group, the mean oxygen saturation (SaO_2) was 98.33 ± 0.82, 97.47 ± 0.92, 94.80 ± 1.86, and 96.87 ± 1.36 at the baseline, after induction, during tracheostomy, and after tracheostomy, respectively. In the ST group, the mean SaO_2 was 98.00 ± 1.36, 96.80 ± 1.57, 93.40 ± 1.68, and 97.13 ± 1.41 at the baseline, after induction, during tracheostomy, and after tracheostomy, respectively.

Although oxygen saturation significantly decreased after induction and during the procedure in both groups, there was no statistically significant difference between both of them regarding oxygen saturation at different times; most probably it was due to the time taken during insertion and suction from the tube (Table 3).

In the FGPDT group, the mean partial arterial carbon dioxide tension ($PaCO_2$) was 38.53 ± 4.22 and 39.13 ± 4.32 at baseline and after tracheostomy, respectively (Table 3).

In the ST group, the mean $PaCO_2$ was 43.93 ± 7.57 and 44.67 ± 7.45 at baseline and after tracheostomy, respectively.

It is noteworthy that group II $PaCO_2$ values were significantly higher than group I values ($P = 0.011$ and 0.010, respectively).

Regarding the procedure details (Table 4), the mean size of skin incision was 3.7 ± 1.7 and 2 ± 0.6 for groups ST and FGPDT, respectively, and it was highly statistically significant ($P < 0.0001$).

The mean number of trials was 1.27 ± 0.46 and 1.00 ± 0.00 for groups ST and FGPDT, respectively. It was statistically higher in group ST ($P = 0.016$).

Table 1 Comparison between the two studied groups regarding main diagnosis

Main diagnosis	FGPDT group (*n* = 20)	ST group (*n* = 20)
Pulmonary	6 (30)	5 (25)
Neurological	7 (35)	8 (40)
Cardiovascular	3 (15)	4 (20)
Multiple trauma	4 (20)	2 (10)
Gastrointestinal	0 (0)	1 (5)

Data are represented as *n* (%). FGPDT, fiberoptic-guided percutaneous dilatational tracheostomy; ST, surgical tracheostomy.

Table 2 Demographics profile of the patients

Main diagnosis	FGPDT group (*n* = 20)	ST group (*n* = 20)	*P*-value
Age (years)	53.3 (± 14.4)	52.2 (± 15.3)	>0.05
Sex (M/F)	11/9	9/11	>0.05
Days intubated	9.5 (± 6.3)	10.5 (± 5.0)	>0.05
APACHE II score	16.5 (± 6.3)	17.0 (± 5.1)	>0.05
Three-month survival [*n* (%)]	17.0 (68)	14.0 (50)	>0.05

APACHE, acute physiology and chronic health evaluation; F, female; FGPDT, fiberoptic-guided percutaneous dilatational tracheostomy; M, male; ST, surgical tracheostomy.

Table 3 Mean arterial pressure, heart rate, oxygen saturation, and partial arterial carbon dioxide tension in the two groups of the study

Main diagnosis	FGPDT group (n = 20)	ST group (n = 20)	P-value
HR			
Baseline	84.87 ± 16.47	84.27 ± 13.67	>0.05
After induction	79.47 ± 15.81	80.53 ± 11.58	>0.05
During tracheostomy	100.47 ± 16.66	100.67 ± 11.31	>0.05
After tracheostomy	87.33 ± 13.39	90.07 ± 12.21	>0.05
MAP			
Baseline	61.20 ± 7.69	59.47 ± 5.91	>0.05
After induction	59.33 ± 6.54	57.87 ± 6.24	>0.05
During tracheostomy	67.40 ± 7.62	65.20 ± 6.39	>0.05
During tracheostomy	62.13 ± 6.61	62.00 ± 5.36	>0.05
SaO_2			
Baseline	98.33 ± 0.82	98.00 ± 1.36	>0.05
After induction	97.47 ± 0.92	96.80 ± 1.57	>0.05
During tracheostomy	94.80 ± 1.86	93.40 ± 1.68	>0.05
After tracheostomy	96.87 ± 1.36	97.13 ± 1.41	>0.05
$PaCO_2$			
Baseline	38.53 ± 4.22	43.93 ± 7.57	<0.011*
After tracheostomy	39.13 ± 4.32	44.67 ± 7.45	<0.010*

Data are expressed as mean ± SD. FGPDT, fiberoptic-guided percutaneous dilatational tracheostomy; HR, heart rate; MAP, mean arterial pressure; $PaCO_2$, partial arterial carbon dioxide tension; SaO_2, oxygen saturation; ST, surgical tracheostomy.
*P-value is significant.

Table 4 Comparison between the two studied groups regarding procedural details

Main diagnosis	FGPDT group (n = 20)	ST group (n = 20)	P-value
Skin incision size (cm)	2 ± 0.6	3.7 ± 1.7	0.001*
Number of trials	1.1 ± 0.50	2.1 ± 0.46	0.016*
Duration of procedure (min)	7.5 ± 3.9	15.5 ± 2.9	0.005*

Data are expressed as mean ± SD. FGPDT, fiberoptic-guided percutaneous dilatational tracheostomy; ST, surgical tracheostomy.
*P-value is significant.

The mean time of the procedure was 15.5 ± 2.9 and 7.5 ± 3.9 for groups ST and FGPDT, respectively; it was highly significant (P < 0.005) (Table 4).

There was a significant reduction in the incidence of minor bleeding (oozing requiring dressing change, no need for transfusion or surgical intervention) with the FGPDT technique compared with ST [one patient (5%) and six patients (30%), respectively, P < 0.005].

There was a statistically significant difference in the wound infection when the tracheostomy was performed using the FGPDT compared with the ST technique [PDT = 0 patient (0%), ST = 4 patients (20%), respectively, P < 0.005].

Subcutaneous emphysema occurred in one patient in each group (5%), whereas neither pneumothorax nor pneumomediastinum was encountered in any of the patients of both groups.

Tracheal wall affection was found in one patient (5%) in the ST group and none in the FGPDT group; there was no statistically significant difference in-between (P = 0.578).

There were no deaths directly related to the procedure of tracheostomy performed by either technique. No patient suffered major bleeding requiring blood transfusion or surgical intervention.

Discussion

The FGPDT technique was associated with a shorter procedure time and a significantly fewer morbidity in comparison with the standard ST technique; it is a safe technique for tracheostomy with a low complication rate.

There are hazards in transporting critically ill patients with the associated risks for accidental disconnection of the breathing circuit or extubation as well as reduced monitoring during transfer. Additional benefits of a bedside procedure in the ICU are the avoidance of operating room delays and surgery being performed late in the day.

Despite the long experience with ST, the technique still has many complications with an overall incidence of 6–66%, including pneumothorax or subcutaneous emphysema (4–17%), tube dislodgement (0–7%), local hemorrhage (3–37%), stomal infection (17–36%), and a mortality rate of 0–5.3% [17,18].

FGPDT, in contrast, requires only a small skin incision, minimal blunt dissection of the anterior tracheal structures, takes only 1–10 min to perform, and is commonly performed at bedside [7].

The primary outcome of the study was the difference between the two groups in the incidence of bleeding, which occurred in six patients (30%) in the ST group versus one patient (5%) in the FGPDT group. In all patients, bleeding was minor and required no more than brief compression with statistically significant difference between both groups.

There was statistically significant difference between the two groups with respect to procedural time, which was defined as the time from skin incision to successful placement of the tube. In the FGPDT group, the mean time was 7.5 ± 3.9 min, whereas in the ST group the mean time was 15.5 ± 2.9 min. In the literature, PDT required 21.5 ± 4.90 min. In comparison, Fikkers *et al.* [19] reported 9.1 ± 8.3 min for the blind Grigg's technique, whereas Kost [20] reported 17.3 ± 1.9 min for the bronchoscopic technique and Ambesh

et al. [17] reported 6.5 min. Variability in time between the present study and the previous studies is attributed to different experience gained by the workers from performing more tracheostomies.

Heart rate and mean arterial pressure values were elevated in comparison with the pretracheostomy values in both groups. These changes were of short duration and returned to near baseline immediately after the procedure was completed in the two groups.

These changes happened provided that all patients received general and local anesthesia. This could be due to severe stress initiated by dilation using initial dilator and forceps that was not ameliorated by limitation of narcotic used in critically ill patients with compromised hemodynamics. However, there was no statistical significance between the two groups with respect to heart rate and mean arterial pressure. Fikkers *et al.* [19] found the incidence of hypotension to be 0.6%, whereas Kost [20] reported it to be 2.6%. These results should be taken with some caution recognizing the marked difference in the number of patients recruited in each study, being 171 in the former study and 38 in the latter one. However, Ambesh *et al.* [17] did not encounter any cases of hemodynamic instability in his Griggs' method patients. None of the previously mentioned studies reported cardiac arrhythmias as a result of complication whether PDT or ST.

Regarding complications during procedure, bleeding occurred in five patients (25%) in the ST group versus one patient (5%) in the FGPDT group. In all patients, bleeding was minor and required no more than brief compression with statistically significant difference between both groups. Dulguerov *et al.* [21] experienced 143 patients with bleeding of the 1871 (7.8%). Friedman *et al.* [12] experienced minor bleeding in 13%. Ambesh *et al.* [22] graded bleeding in five patients of their 50 patients (who were subjected to flexible bronchoscopic-guided Griggs' technique) as grade III (blood loss 11–50 ml). These variable results may be attributed to the unavailability of a standard classification of the amount of bleeding, making the issue judged by personal experience.

Wound infection was encountered in four patients (20%) in the ST group and in none in the FGPDT group. Fikkers *et al.* [19] reported wound infection in 2.4% of patients, whereas Kost [20] did not report any patient with wound infection. Ambesh *et al.* [17] encountered this complication in 2/30 of patients (6.7%). Highly variable size of the sample in each study is suggested to be the only possible explanation for these contradictory results. Wound infection may be attributed to traumas from repeated punctures and associated bleeding producing more local inflammatory reaction, which may invite infection later on. It had been suggested that the low incidence of bleeding and stomal infection associated with percutaneous tracheostomy may be due to the small incision and tight fit of the cannula. This results in tamponed of bleeding sites and decrease in size of the tract for entry of bacteria.

In our study, it was better and one of our recommendations is to perform PDT under vision by fiberoptic bronchoscope to decrease the incidence of trauma to the posterior tracheal wall, upward migration of the guide wire, and false passage of the tracheostomy tube. It was consistent with the study by Sally *et al.* [23]; in their study a comparison of percutaneous and operative tracheostomies was performed in intensive care patients [23].

The PDT was performed only in elective patients. It is not recommended in emergencies, in enlarged thyroid glands, in marked obesity, in children, and whenever the cricoid cartilage cannot be definitely palpated. The perioperative complications are few and minor. PDTs, however, have significant advantages when compared with the standard techniques of tracheostomy (ST) [22,24].

Escarment *et al.* [25] reported that two to three forceps dilatations were required in two-third of patients to achieve successful insertion of the tracheostomy tube, and they found that insertion of a tracheostomy tube is rarely achieved on the first attempt with Griggs' guide wire dilating forceps [21]. In contrast, our study had only three patients from the FGPDT group who required a second dilatation and none required a third dilatation before successful insertion of the tracheostomy tube.

An important issue in the development of the PDT technique is the question of who should perform percutaneous tracheostomy.

Leinhardt *et al.* [26] recommended to keep this technique in the domain of surgery. He also pointed out that some doctors in nonsurgical specialties, such as intensive care and anesthesia, have already been skilled in vascular access using the Seldinger technique; they could also be trained to perform percutaneous tracheostomy. In our study, all PDTs were performed by the same anesthesia intensivist and were carried out at bedside in the ICU. The success of the PDT technique has caused gradual replacement of the ST in adult ICU patients.

Conclusion

Bedside PDT with fiberoptic bronchoscopic guidance is safer and less costly than ST with less incidence of postoperative complication. It reduces the overall incidence of wound infection and relevant bleeding and mortality when compared with ST. PDT may be considered the procedure of choice for performing elective tracheostomies in critically ill adult patients.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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