Percutaneous tracheostomy, making it easier

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Objective Open and percutaneous tracheotomy (PT) lead to many perioperative complications. To minimize the complication and to save time and cost, certain assistive tools can be used like fiberoptic bronchoscope, ultrasound guidance and others.

Aim The aim was to compare the three procedures, blind PT, fiberoptic bronchoscopy-guided PT and open tracheostomy, regarding ease of the technique, infection rate, bleeding, and complications of the procedure.

Design A retrospective comparative trial was conducted.

Setting ICU at Dar El Shefa Hospital and respiratory ICU, Ain Shams University Hospital, were the locations for study conduction.

Patients and methods All patients required prolonged mechanical ventilation during period between August 2012 and August 2014.
They were assigned into three groups: group I underwent open tracheostomy and included 16 patients, group II underwent blind PT and included 15 patients, and group III underwent fiberoptic-guided PT and included 12 patients.

Results A total of 43 patients underwent tracheostomy during the study period. There was a statistically significant difference between the studied groups regarding neck circumference and intubation period before tracheostomy. Regarding hemodynamics, there is no statistically significant difference regarding mean heart rate, mean arterial pressure and FiO_2, pH, PaO_2, $PCaO_2$, PaO_2/FiO_2 and oxygen saturation SPO_2 before and after each procedure. Regarding complications after procedure, it shows that blind group had higher percentage of patients with no complications (86.7%) followed by fiberoptic group (75%) and open tracheostomy group (50%). It was noticed that the lowest mean of duration of the procedure was found in the blind group (15.7±5.3), followed by fiberoptic group (17.8±3.2) and lastly the open tracheostomy group (25.7±6.3).

Conclusion This study showed that PT had fewer complications than open tracheostomy, saved operating room resources as well as was more cost effective.
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Keywords: bronchoscope, mechanical ventilation, percutaneous tracheotomy

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Introduction

Percutaneous tracheotomy (PT) has become an alternative to operative tracheostomy specially in critical care unit. Performance of the bedside PT procedure is related to the experience of the operator, as it is more safe when performed by surgeons or critical care clinicians. Choosing between open or PT depends upon the availability, patient condition and institutional expertise [1]

PT has many advantages compared with operative tracheostomy: it offers less time to perform, is less expensive, is performed sooner (no need to schedule an operating room) [2], and has overall less complications when compared surgical tracheostomy, even though PT has an increased risk of false passage, anterior tracheal injury or posterior tracheal wall perforation [3].

To make PT easy and rapid procedure and decrease incident of complications, many tools have been used. These include flexible fiberoptic bronchoscopy, ultrasound guidance, and transillumination of the soft tissues of the neck [4].

The aim of this work was to compare the three procedures, blind PT, fiberoptic bronchoscopy-guided PT, and open tracheostomy, regarding ease of the technique, infection rate, bleeding, and complications of the procedure.

There are relative contraindications to PT, which include age under 15 years of age; bleeding tendency; gross disfigurements of the neck from hematoma, goiter, tumor, or scarring from previous neck surgery; infection in the soft tissues of the neck, inability for neck extension because of rheumatoid arthritis or cervical fusion/fracture; and obese and/or short neck which obscures landmarks [5].

Patients and methods

The present study was a prospective cohort analytical observational study. This study included 43 patients requiring tracheotomy. The patients were categorized into three groups according to the type of the conducted tracheostomy. All patients were selected from ICUs in Dar El Shefa and RICU Ain Shams University hospitals. All patients were selected during period from April 2012 to August 2014.

Inclusion criteria

All patients enrolled in the study had a period of prolonged mechanical ventilation with failure of their weaning or will undergo early tracheotomy owing to unsuspected early weaning.

Patients were categorized into three groups according to different consideration like the patient/relative choice, availability of bronchoscopy, which was only in the RICU, as well as the patient demographics as follows:

(1) Group I: patients in whom open tracheostomy was done.
(2) Group II: patients in whom blind PT was done.
(3) Group III: patients in whom fiberoptic bronchoscopic-guided PT was done.

Sample size estimation was as follows: minimum sample size required for the present study was calculated based on confidence level=95%, power of the study=80%, and expected no complication during and after the procedure=65%. It was estimated that 10 patients for every group would be required. Cases were increased to avoid any dropout. So, group 1 included 16 patients, group 2 included 15 patients, and group 3 included 12 patients. The patients were allocated to the different three groups of tracheostomy by using simple random technique by using table of random numbers.

Ethical consideration

The patients and/or relatives of the patients gave informed consent before the procedure.

Tools of the study

All patients who underwent tracheostomy were registered using a standard form. Reason of hospitalization, duration of endotracheal intubation before tracheostomy, indication for tracheostomy, complications, and duration of the procedure were recorded. During bronchoscope-guided PT, the guide wire passage, site and level of entry were verified using the bronchoscope, which was then withdrawn. Perioperative complications are complications related to the procedure that occurred during or immediately after the procedure (within 6 h). Late complications were defined as complications occurred from 2 weeks onwards after the procedure.

Patient preparation

Open tracheostomies were done by otolaryngology specialists in operation room under general anesthesia. The PT was performed in ICU bed with good lighting and sufficient working space fullfillig infection control criteria. All equipments required for the procedure were available at the bedside. Proper oxygen 100% was applied to the patient for 10–15 min immediately before the procedure to prevent intraoperative hypoxia, and the positive end expiratory pressure on the ventilator was discontinued.

Patient positioning

The patient is placed in a supine position with the neck extended. Pillow or a rolled up towel was placed between the scapulae to improve visualization of the trachea. The endotracheal tube (ETT) is withdrawn so as the cuff would remain at or just below the vocal cords.

Anesthesia

It included premedication with propofol (2 mg/kg), fentanyl (1 μg/kg) or incremental doses of midazolam sedation and local infiltration of lidocaine. PT technique in the blind group (group II) was performed using the single graduated dilator technique, in which blunt dissection of the trachea was done using index finger, and then Seldinger-based technique included cannulation of trachea between second and third tracheal ring with a guide wire, which was followed by a single graded dilator with the insertion of a tracheotomy tube. PT technique in the bronchoscopic group (group III) was performed through the single graduated dilator technique as before, except ETT and the tracheal suctioning were done by the flexible bronchoscope (FB) (Pentax EB-1830T3 video bronchoscope 6.0 mm insertion tube, 2.6 mm working channel, 60 cm working length; Asahi Optical, Toshima suburb of Tokyo, japan). FB was used to confirm correct placement of guide wire and identify the point of needle insertion into the trachea. FB guidance minimizes the risk of complication, especially injury of posterior tracheal wall. It increase procedure costs and complexity, but proper visualization makes the procedure easy. FB was removed once the guide wire placement is confirmed to minimize the risk of volutrauma.

Postoperative care

Suctioning was done through the tracheotomy tube. Patient's position in bed should be semisetting, with fixation of neck and avoiding position change for 24 h. Humidified oxygen inhalation, regular wound care and postoperative chest radiography were performed. Any complications were recorded in all groups and divided into early and late.

Statistical analysis

Data were collected, coded, and analyzed using the SPSS 19.0 software (SPSS Inc., Chicago, Illinois, USA). Results were presented in tables and figures. Proportion, mean±SD, *t*-test, *F*-test, χ^2 linear regression, and correlation coefficient were the statistical methods used throughout the study. *P* value less than 0.05 was considered as the level of statistical significance.

Results

The general characteristics of the studied groups are shown in Table 1. There is no statistical significance difference between the studied groups regarding age and sex. However, the proportions of males among blind tracheostomy group (66.7%) and among bronchoscopic group (83.3%) were higher than found in open tracheostomy group. It was noticed that there is a statistically significant difference between the studied groups regarding neck circumference and intubation period before tracheostomy. It was found that there was no statistical significance difference between the studied groups regarding the comorbid conditions before conducting any type of the tracheostomy. It was observed that the proportions of the causes of mechanical ventilation are statistically insignificant among the studied groups.

Patient vital data and oxygenation are compared in Table 2. Mean heart rate, mean arterial pressure (MAP) and FiO_2 are not statistically significantly different regarding before and after conducting each of the three methods of tracheostomy. Moreover, there was no statistical significance difference between the means of heart rate, MAP, and FiO_2 among the three conducted methods of tracheostomy after conducting

Table 1 General characteristics of the studied groups

General characteristics	Open trachestomy group (*N*=16)	Blind PT group (*N*=15)	Fiberopticbronchoscopic-guided PT group (*N*=12)	Test of significance
Age				
Range (years)	45–69	33–67	20–70	*F*=0.07 *P*=0.9
Mean±SD (years)	56.0±7.05	54.6±10.8	55.7±14.05	
Sex [*n* (%)]				
Male	7 (43.75)	10 (66.7)	10 (83.3)	χ^2=4.7 *P*=0.09
Female	9 (56.25)	5 (33.3)	2 (16.7)	
Neck circumference				
Range (cm)	40–48.5	40–46.5	39–45.8	*F*=3.9 *P*=0.02*
Mean±SD (cm)	45.2±2.3	43.5±2.3	42.8±2.5	
Intubation period before tracheostomy				
Range (days)	13–20	7–15	13–16	*F*=7.7 *P*=0.001*
Mean±SD (days)	16.4±2.6	13.5±2.03	14.8±1.03	
Comorbid condition [*n* (%)]				
Heart disease	3 (18.75)	1 (6.7)	5 (41.7)	χ^2=13.6 *P*=0.2
Hypertension	3 (18.75)	4 (26.7)	1 (8.3)	
Heart disease and hypertension	3 (18.75)	2 (13.3)	0 (0.0)	
Heart disease, hypertension and diabetes	3 (18.75)	1 (6.7)	1 (25)	
Hypertension and diabetes mellitus	2 (12.5)	3 (20.0)	0 (0.0)	
Diabetes mellitus	0 (0.0)	1 (6.7)	0 (0.0)	
Cause of mechanical ventilation [*n* (%)]				
COPD	2 (12.5)	0 (0.0)	7 (58.3)	χ^2=20.4 *P*=0.009*
Obesity hypoventilation	5 (31.25)	1 (6.7)	1 (8.3)	
Abdominal surgery/sepsis	2 (12.5)	2 (13.3)	0 (0.0)	
Postcardiac arrest	2 (12.5)	5 (33.3)	1 (16.7)	
Neurological/neurosurgical	5 (31.25)	7 (46.7)	2 (16.7)	

COPD, chronic obstructive pulmonary disease; PT, percutaneous tracheotomy. *Significant.

Table 2 Mean heart rate, mean arterial pressure, FiO_2, and mean parameters of blood gases before and after the different procedures among the studied groups

	Open tracheostomy group (*N*=16)	Blind PT group (*N*=15)	Fiberoptic bronchoscopic-guided PT group (*N*=12)	*F*-test (*P* value)
Mean heart rate (beats/min)				
Before procedure	88.9±10.4	88.9±10.5	93.08±12.9	1.05 (0.4)
After procedure	87.2±9.3	86.6±10.04	92.08±12.6	
t-test	0.5	0.08	0.2	
P value	0.6	0.9	0.8	
Mean MAP (mmHg)				
Before procedure	77.7±7.6	85.4± 11.3	86.7±8.8	**4.8 (0.01)***
After procedure	77.9±5.9	85.5±11.2	86.8±7.3	
t-test	0.08	0.02	0.03	
P value	0.9	0.9	0.9	
Mean FiO_2				
Before procedure	0.4±0.04	0.4±0.05	0.4±0.03	0.0 (1.0)
After procedure	0.4±0.07	0.4±0.04	0.4±0.04	
t-test	0.0	0.0	0.0	
P value	0.9	0.9	0.9	
Mean PaO_2/FiO_2 (mmHg)				
Before procedure	195.03±33.3	187.9±37.8	200.7±37.4	0.7 (0.5)
After procedure	188.5±38.9	190.0±34.5	204.7±35.9	
t-test	0.5	0.1	0.3	
P value	0.6	0.9	0.8	
Mean pH				
Before procedure	7.40±0.03	7.4±0.06	7.4±0.06	**223.0 (0.0)***
After procedure	7.40±0.06	7.4±0.05	7.4±0.05	
t-Test	0.0	0.0	0.0	
P value	0.9	0.9	0.9	
Mean PaO_2 (mmHg)				
Before procedure	76.1±11.2	74.3±11.2	76.8±7.1	**9.1 (0.0005)***
After procedure	75.7±8.03	76.3±9.2	78.8±6.8	
t-Test	0.1	0.5	0.7	
P value	0.9	0,6	0.5	
Mean $PCaO_2$ (mmHg)				
Before procedure	44.1±6.6	44.4±5.05	43.9±4.4	0.02 (0.9)
After procedure	43.5±4.7	43.7±4.8	43.3±4.1	
t-test	0.3	0.4	0.3	
P value	0.8	0.7	0.7	
Mean oxygen saturation				
Before procedure	96.9±1.6	95.9±2.4	96.7±1.7	1.03 (0.4)
After procedure	96.7±1.8	96.0±2.6	97.1±1.4	
t-test	0.3	0.1	0.6	
P value	0.7	0.9	0.5	

PT, percutaneous tracheotomy; MAP, mean arterial pressure. *Significant.

the three procedures, except for the mean of MAP, which shows higher mean in the group of fiberoptic, with statistically significant difference. Moreover, the means of pH, PaO_2, $PCaO_2$, PaO_2/FiO_2, and oxygen saturation were not statistically significantly different before and after each of the three conducted methods of tracheostomy. Moreover, the means of pH, PaO_2, $PCaO_2$, PaO_2/FiO_2, and oxygen saturation after conducting the three procedures show no statistically significant difference, except for the mean PaO_2 ($P<0.05$).

The data for duration of the procedures and complications during and after the different

Table 3 Duration of the procedures and complications during and after the different procedures among the studied groups

Duration of the procedure and complications during and after the different procedures	Open tracheostomy group (*N*=16)	Blind PT group (*N*=15)	Fiberoptic bronchoscopic-guided PT group (*N*=12)	Test of significance
Duration of procedure				
Range (min)	15–35	10–25	10–20	F=15.5 (P=0.0)*
Mean±SD (min)	25.7±6.3	15.7±5.3	17.8±3.2	
Complication during procedure [*n* (%)]				
Nothing	13 (81.25)	13 (86.7)	12 (100)	χ^2=2.4 (P=0.3)
Tube misplacement	0 (0.0)	2 (13.3)	0 (0.0)	
Subcutaneous emphysema	1 (6.25)	0 (0.0)	0 (0.0)	
Minor bleeding	2 (12.50)	0 (0.0)	0 (0.0)	
Complication after procedure [*n* (%)]				
No complication	8 (50.0)	13 (86.7)	9 (75.0)	χ^2=5.1 (P=0.07) χ^2 =1.4 (P=0.5)
Stomal infection and/or inflammation	5 (31.25)	2 (13.3)	3 (25.0)	
Pneumomediastinum	1 (6.25)	0 (0.0)	0 (0.0)	
Tube displacement	2 (12.50)	0 (0.0)	0 (0.0)	

PT, percutaneous tracheotomy. *Significance.

procedures among the studied groups are shown in Table 3.There were no complications at all during the fiberoptic procedure, whereas only 13.3% among cases of blind group experienced tube misplacement, but in the group of open tracheostomy, 6.25 and 12.5% of cases had subcutaneous emphysema and minor bleeding, respectively. Regarding the complications after each procedure, it shows that blind group had higher number of patients with no complications (86.7%) followed by fiberoptic group (75%) and open tracheostomy group (50%). It was noticed that the lowest mean of duration of the procedure was found in the blind group (15.7±5.3), followed by fiberoptic group (17.8±3.2) and lastly the open tracheostomy group (25.7±6.3). However, there was a statistically significance difference.

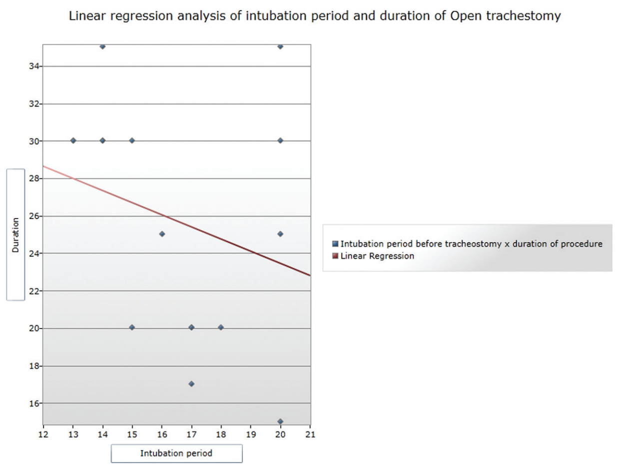
Figure 1 shows the linear regression analysis and correlation coefficient of intubation period and duration of the open tracheostomy. It showed little correlation (r^2=0.11).

Figure 2 shows the linear regression analysis and correlation coefficient of neck circumference and duration of the open tracheostomy. It showed no correlation (r^2=0.01).

Figure 3 shows the linear regression analysis and correlation coefficient of age and duration of the open tracheostomy. It showed no correlation (r^2=0.0).

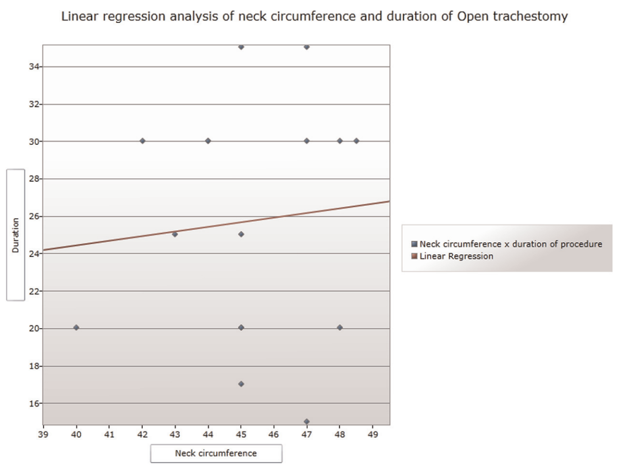
Figure 4 shows the linear regression analysis and correlation coefficient of age and duration of the blind tracheostomy. It showed no correlation (r^2=0.01).

Figure 1



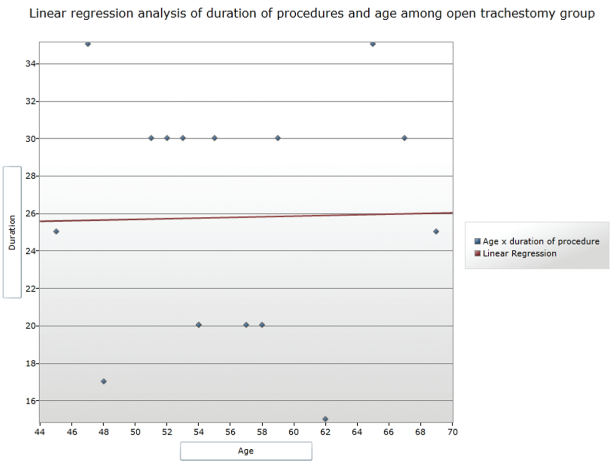
The linear regression analysis of intubation period and duration of the open tracheostomy. There was an inverse correlation.

Figure 2



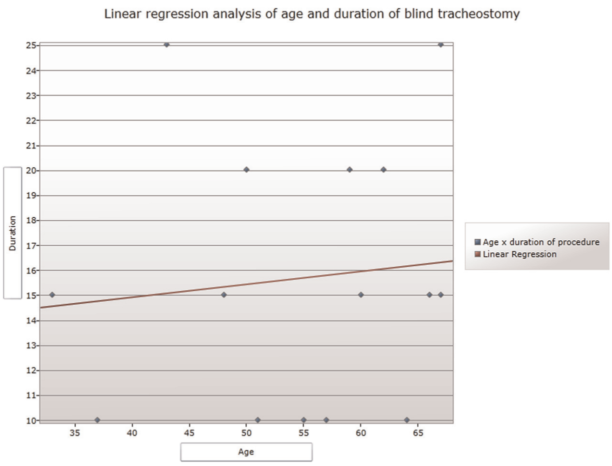
The linear regression analysis of intubation period and duration of the blind tracheostomy. There was an inverse correlation.

Figure 3



The linear regression analysis of intubation period and duration of the fibroptic tracheostomy. There was a positive correlation.

Figure 4



The linear regression analysis of neck circumference and duration of the open tracheostomy. There was a positive correlation.

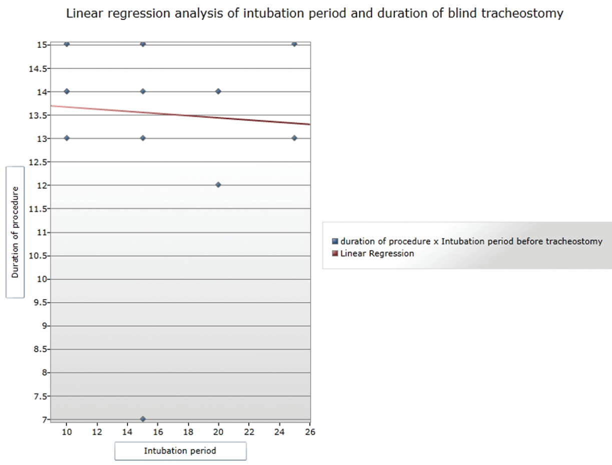
Figure 5 shows the linear regression analysis and correlation coefficient of intubation period and duration of the blind tracheostomy. It showed no correlation (r^2=0.0).

Figure 6 shows the linear regression analysis and correlation coefficient of neck circumference and duration of the blind tracheostomy. It showed no correlation (r^2=0.0).

Figure 7 shows the linear regression analysis and correlation coefficient of age and duration of the fibroptic tracheostomy. It showed no correlation (r^2=0.0).

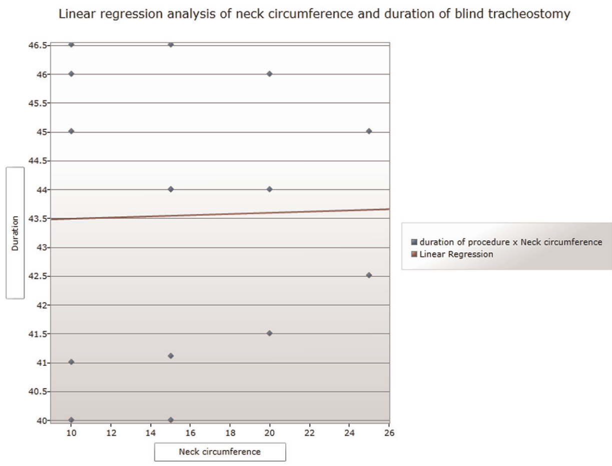
Figure 8 shows the linear regression analysis and correlation coefficient of intubation period and

Figure 5



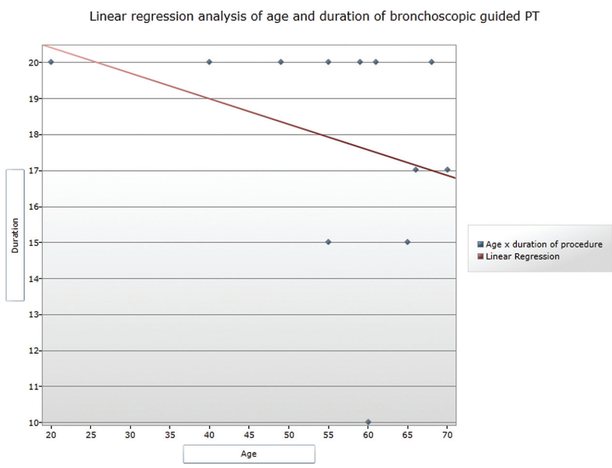
The linear regression analysis of neck circumference and duration of the blind tracheostomy. There was a weak positive correlation.

Figure 6



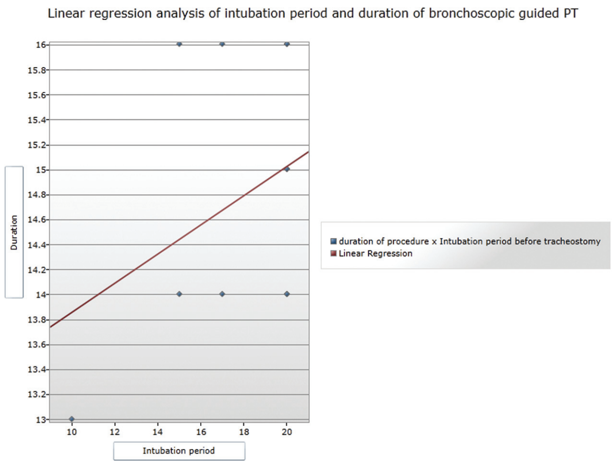
The linear regression analysis of neck circumference and duration of the fibroptic tracheostomy. There was a positive correlation.

Figure 7



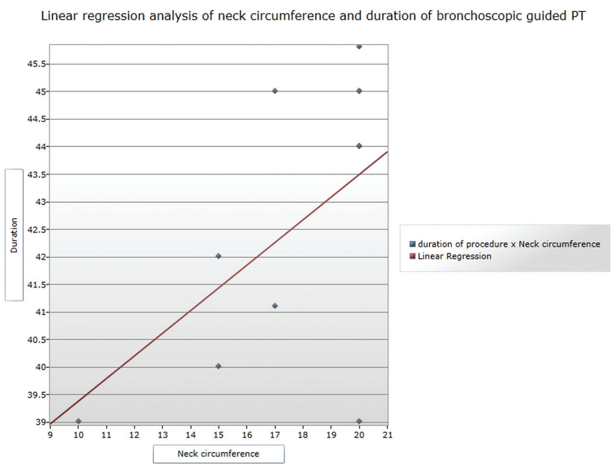
The linear regression analysis of age and duration of the open tracheostomy. There was a weak positive correlation.

Figure 8



The linear regression analysis of age and duration of the blind tracheostomy. There was a positive correlation.

Figure 9



The linear regression analysis of age and duration of the fibroptic tracheostomy. There was an inverse correlation.

duration of the fibroptic tracheostomy. It showed little correlation (r^2=0.19).

Figure 9 shows the linear regression analysis and correlation coefficient of neck circumference and duration of the fibroptic tracheostomy. It showed fair correlation (r^2=0.4).

Discussion

PT was first introduced by Ciaglia *et al.* in 1985 [6]. IN certain circumstances when the anatomical land marks are difficult to be identified, PT is contraindicated or otherwise will carry a huge risk of complications (palpalable midline structure like thyroid cartilage , cricoid cartilage and sternal notch), so the operator/ surgent will choose open surgical trachestomy. Therefore, bronchoscopy was introduced as a good method of monitoring and visualization of airway during PT.

Bronchoscopy carries the advantages of decreasing the risk for accidental loss of airway, pneumothorax or pneumomediastinum, posterior tracheal wall injury, false passage of wire or dilator and bleeding. It also facilitates teaching and supervision. However, it has the disadvantage of partially occluding the ETT, which leads to carbon dioxide retention and/or hypoxia. It also increase the cost and complexity of operation [2].

From our experience, we tried to fairly compare between the open tracheostomy, blind PT and bronchoscopy-guided PT in a retrograde study.

The choice of technique was influenced by patient demographics, so it was found that group I included patient with unfavorable anatomy, obese and wide neck circumference.

Regarding the patient characteristics, the age limit ranged between 20 and 70 years. All younger patients were excluded from the study because of high complication rate like pneumothorax and weak tracheal ring, as mention by Fowler *et al.* [7,8].

The predominance of males especially in nonsurgical groups can be explained by the ease to identified landmarks among males rather than females.

Neck circumference gives an indication about obesity status of the patient [9], as well as the intubation difficulties [5]. There is a statistically significant difference between the studied groups regarding neck circumference. Moreover, there was a positive linear regression correlation between neck circumference and duration of tracheostomy.

The causes of mechanical ventilation are statistically insignificant among the studied groups, although the most common cause of mechanical ventilation was neurological and neurosurgical diseases in both groups I and II, followed by chronic obstructive pulmonary disease cases in group III (owing to availability of bronchoscopy in the respiratory care unit). Hassanin *et al.* [10] reported cerebrovascular stroke as the most common diagnosis in their study on PT, whereas Hazzard *et al.* [11] reported that respiratory failure secondary to lung diseases was the most common diagnosis for PT.There is a statistically significance difference between the studied groups regarding intubation period before tracheostomy, which ranged between 7 and 20 days, based on patient conscious level, hope of weaning and obtaining the approval consent from family members. Anon *et al*. [12] and Fikkers *et al*. [13] reported intubation period before tracheostomy of 17.3 and 16.9 days, respectively.

Conclusion

This study has shown that PT had fewer complications than open tracheostomy, saves operating room resources and is more cost effective. Introducing bronchoscopy to the procedure allows nonsurgeons to learn and perform the PT safely, though it took longer time and more personnel, yet it decreased unnecessary complications.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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