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Modified translaryngeal tracheostomy for ventilator-dependent cardiac patients

A pilot of nonrandomized study

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Abstract

Introduction: A significant proportion of ventilator-dependent cardiac patients need tracheostomy during intensive care unit (ICU) stay. Three different methods including traditional (surgical), percutaneous dilatation tracheostomy, translaryngeal tracheostomy (TLT), and classical Fantoni method have been developed. In this study, modified translaryngeal tracheostomy (MTLT) has been introduced to reduce and correct the technical difficulty of classical TLT through the larynx.

Materials and methods: The patients hospitalized because of cardiac diseases whose stay in ICU and coronary care unit lasted longer than 3 weeks, and were consulted and advised for elective tracheostomy. Afterwards, MTLT was performed for all patients (the new method).

Results: From the 159 patients, 64.2% were women. The mean age was 65.25 ± 14.35 years. There was no considerable hemorrhage (bleeding >5–10 mL). The mean values of arterial oxygen pressure, oxygen saturation, heart rate, systolic blood pressure, and a peak airway pressure before and after MTLT had a significant improvement ($P < .05$), which reflects a better hemodynamic state after tracheostomy. All of the tracheostomies (MTLT) were successful and without any complications. There was no considerable bleeding despite the high international normalized ratio levels.

Conclusions: Unlike the classical Fantoni method, this study indicates that using a new improved method of tracheostomy through larynx did not impose any difficulty on retrograde passage of guide wire and this procedure could be safely conducted on patients with coagulation disorders.

Abbreviations: CCU = coronary care unit, ICU = intensive care unit, INR = international normalized ratio, MTLT = modified translaryngeal tracheostomy, PDT = percutaneous dilatation tracheostomy, TLT = translaryngeal tracheostomy.

Keywords: international normalized ratio, modified translaryngeal tracheostomy, percutaneous tracheostomy, translaryngeal tracheostomy

1. Introduction

In cases in which prolonged mechanical ventilation becomes necessary or when weaning from ventilator becomes difficult and in patients who require ventilator support (e.g., chronic respiratory failure), and/or in facial major trauma, tracheostomy is needed.[1,2] Tracheostomy is conducted by using 3 different methods namely, traditional (surgical), percutaneous dilatation (PDT), and translaryngeal tracheostomy (TLT).[3–5] Complications of the surgical method are reported to be 6% to 65%, and often cause side effects such as subglottic stenosis. This technique is mostly used in cases where emergency tracheostomy is required.[6,7] TLT is an elective choice, which is performed under general anesthesia, and typically at the patient's bedside in intensive care unit (ICU), or coronary care unit (CCU). Otherwise, in the operating room, by creating an open airway with retrograde dilation of trachea through the larynx, which acts both as an expanding device and guidewire for the tracheostomy tube. Some of the indications (in addition to the cases mentioned) are the need for prolonged mechanical ventilation support, airway control (e.g., due to loss of consciousness) and respiratory toilet.[8,9]

Contraindications of TLT include emergency tracheotomy, presence of mass in the site of tracheostomy, unintubated patients, difficult access to the trachea, immobilization of the neck, restrictions on opening the mouth, and upper airway obstruction.[10] In TLT method, trauma is minimal (compared to

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Ethics approval and consent to participate: It is not required in this article. The study has been done under supervision of IRAN University of Medical Science. Written informed consent was obtained from each study participant at the beginning of the measurement. Ethical review will not always be required for the secondary use of data collected from human participants.

The authors report no conflicts of interest.

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traditional method), and dilatation is done in the anterior portion of the trachea which is an easy, safe, and reliable technique with minimum bleeding even in patients with coagulation disorders. In this technique, the patients' ventilation is continuously maintained and can be an optional method for the patients needing elective tracheostomy.[11]

In some studies, lower complication rates compared to the traditional method have been reported. In addition, due to decreased trauma to the tissue and the special techniques of the process, TLT can be performed on patients with coagulation disorders.[11,12] There are more chances of tearing in the posterior wall of the trachea in PDT which is less likely to happen in TLT method. The only technical difficulty encountered in TLT is the retrograde passage of guide wire toward larynx and 31.1% of difficulty is reported in this stage.[13]

The aim of this retrospective study was to assess the validity of the modified translaryngeal tracheostomy (MTLT) technique and reduce the difficulty associated with the retrograde passage of guide wire into the larynx and on the contrary, to perform tracheostomy more safely in patients with coagulation disorders mainly because of no incision. Especially when compared to other methods, it can be more beneficial to patients with heart and valve problems who inevitably are taking anticoagulant medication.

2. Methods

The present study has been conducted between January 2013 and January 2016 in Shahid Rajaei Cardiovascular Medical and Research Center in Tehran, Iran. In 159 patients who intubated and hospitalized in the ICU and CCU and their mechanical ventilation lasted longer than 3 weeks, so they were consulted and advised for elective tracheostomy (see flow diagram, Fig. 1). All the tracheostomies were performed under general anesthesia. Emergent tracheotomy, presence of infection or mass in the site of tracheostomy, unintubated patients, difficult access to the trachea, immobilization of the neck, restrictions on opening of the mouth, and upper airway obstruction conditions are not included in this study. Informed consent was obtained by the use of a written consent document, which is to be signed by the participants and parents and/or legal guardians when younger than 18 years of age. So this is a retrospective study, but ethical approval was not necessary.

2.1. Techniques

The basic and classical method of TLT is referred to as the Fantoni method, in which the patient is placed under general anesthesia, endotracheal tube is drawn up to the vocal cords (where its cuff is filled so as not to slip out again), then a hole is made between the first and second or second and third tracheal cartilages with a hollow needle (available in tracheotomy set) and then a guiding wire is directed up through the hollow needle toward the mouth.

The process could be controlled by a bronchoscope with which the trachea hole and the entry of guide wire into the trachea could be observed. At this stage, the endotracheal tube cuff is deflated so that the wire could pass alongside the deflated cuff of the tube upward into the larynx and then pharynx area, and finally the guide wire is pulled out of the mouth by Magill forceps. At this moment, the patient's endotracheal tube is removed, and replaced by a smaller 5.5 tube included in the set. The new tube is guided down and cuffed just above the carina. Afterwards, the tracheotomy tube is passed over the guide wire through the larynx into the trachea.

By creating a small incision at the point of hollow needle entry (the space between the first and second or second and the third

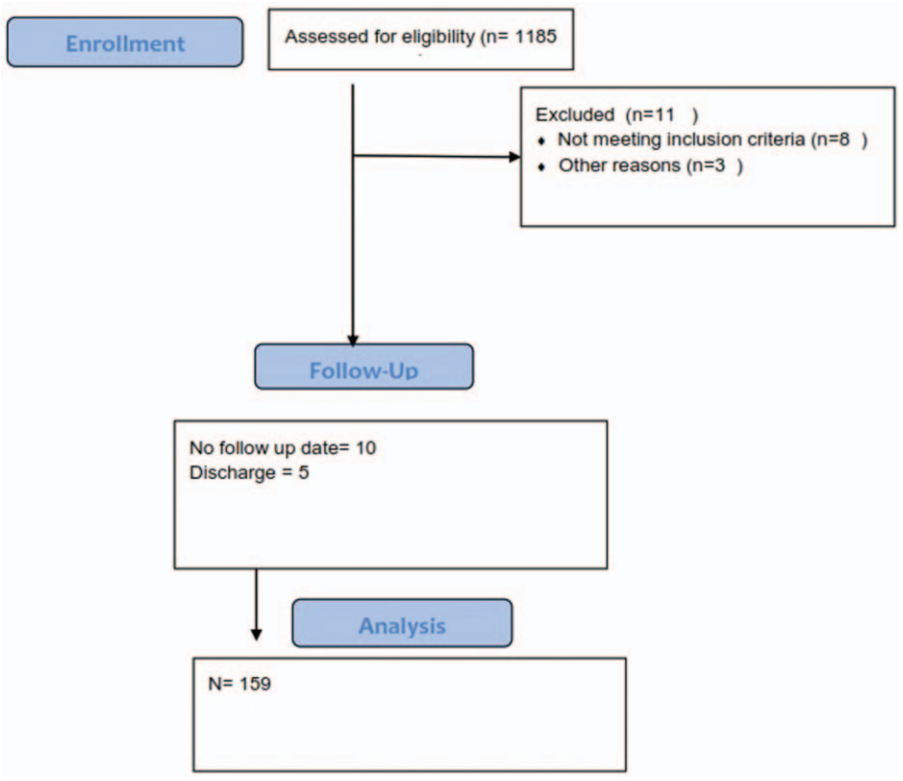

Figure 1. Flow diagram.

tracheal cartilage), the tracheostomy tube is pulled out from the incision point with a balanced and steady force while supporting the trachea with fingers. Then, after cutting the tracheostomy tube from the marked point, the tube is rotated 180°, and guided down toward the carina. Performing this classical process finishes the Fantoni procedure. At this time, bronchoscope can be used to confirm the accurate position of the tube in the trachea.

2.2. Advantages of MTLT

In the modified TLT procedure which will be introduced in this study, instead of pulling the endotracheal tube upward, it is driven down close to the bifurcation of the trachea (carina). Subsequently, at a point between the cartilage 1 and 2 or 2 and 3, the trachea and the tube are pierced by a hollow needle. In fact, hollow needle enters into the endotracheal tube (Fig. 2A) then the guide wire is passed through the hollow needle into the endotracheal tube until it exits from its proximal end (Fig. 2B). Ultimately, both endotracheal tube and guide wire is pulled out from the trachea together. The distal end of the guide wire is clamped to prevent from entering into the trachea (Fig. 2C). Then, the previous tracheal tube is replaced by the new, narrower, and longer tube in the tracheostomy set (Fig. 2D). As a result, the difficulty of this stage (31%–34%) is almost overcome. The new tube is guided down and cuffed just above the carina; afterwards the tracheotomy tube is passed over the guide wire through the larynx into the trachea (Fig. 2E).

2.3. Postoperative Evaluation and Follow-up

All patients with chest x-rays and bronchoscopy were observed on day 1 to evaluate the tracheobronchial tree status. Demographic characteristics of patients, duration of tracheostomy, and the values of variables such as oxygen pressure, oxygen saturation, hemoglobin, the maximum trachea air pressure, heart rate, blood pressure (systolic and diastolic), and international normalized ratio (INR) were checked before and after the tracheostomy.

2.4. Statistical Analysis

We analyzed INR, complications, preoperative and postoperative pulmonary arterial pressure. The data were analyzed by SPSS software (version 16; SPSS Inc, Chicago, IL) and the results were expressed as mean ± SD. For all statistical tests, P value $<.05$ was considered as significant. Paired statistical t test was used for numerical variables.

3. Results

Among the 159 patients, 64.2% were women. The mean age was 65.25 ± 14.35 years (Table 1), with a minimum age of 24 years and the maximum age of 94 years. The mean time of tracheostomy (from the start of guiding the endotracheal tube downward to just above the carina to complete the installation of the tracheostomy tube) was 11.81 ± 3.31 minutes. The minimum

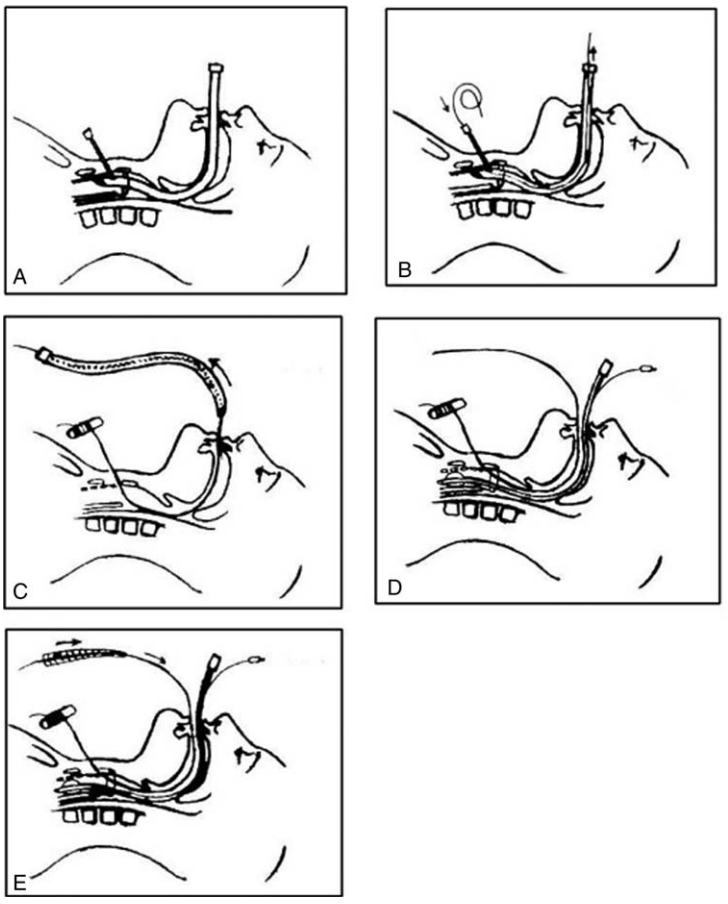

Figure 2. Classical method of translaryngeal tracheostomy (TLT).

Table 1

Patients' demographic and background characteristics.

Variable		Descriptive result
Sex	Male	57 (35.8%)
	Female	102 (64.2%)
Age, y	≤50	24 (15.1%)
	51–60	33 (20.8%)
	61–70	30 (18.9%)
	≥70	72 (45.3%)
	Mean ± SD	65.25 ± 14.35
INR	≤1.8	75 (47.2%)
	1.8–3.4	84 (52.8%)
	Mean ± SD	1.97 ± 0.65
Causes for hospitalization	Coronary artery disease	51 (27.4%)
	Heart valve disease	33 (17.7%)
	Heart failure	3 (1.6%)
	Cerebrovascular accidents	6 (3.2%)
	Diabetes	6 (3.2%)
	Pneumonia	15 (8.1%)
	Other	72 (38.7%)

INR = international normalized ratio.

time was 9 minutes, and the maximum time was 30 minutes. The minimum value for INR was 1, and the maximum value was 3.4, with an average of 1.97 ± 0.65 (Table 1).

The lowest hemoglobin level in patients in the study was 6 mg/dL, and the maximum amount equaled to 13.8, there was no difference between hemoglobin in the day before and the day after tracheostomy, and no considerable hemorrhage (bleeding >5–10 mL) occurred. The mean values of arterial oxygen pressure, oxygen saturation, heart rate, systolic blood pressure, and a peak airway pressure before and after tracheotomy had a significant improvement ($P < .05$), which reflects a better hemodynamic state after tracheostomy (Table 2). All of the tracheostomies were performed using the new method (modified TLT) and they were successful without any complications.

4. Discussion

Our study shows the technical validity of MTLT because of its reduced tracheal stenosis and trauma is minimal and with minimum bleeding, even in patients with coagulation disorders. In this technique, the patients' ventilation is continuously maintained, and can be a method of choice for the patients needing elective tracheostomy. These methods also minimize the difficulty of this procedure.

Table 2

Comparison of the mean for study endpoints before and after the modified translaryngeal tracheostomy.

Variable	Before	After	*P*
PaO_2, mm Hg	91.7 ± 33.44	102.8 ± 36.35	<.001
SpO_2	94.7 ± 5.7	95.9 ± 3.6	<.001
HR	85.5 ± 11.97	82.9 ± 11.6	<.001
SBP, mm Hg	119.5 ± 21.4	110.3 ± 15.6	<.001
DBP, mm Hg	65.8 ± 15.01	64.6 ± 14.6	.085
PAP, mm Hg	28.8 ± 8.1	27.5 ± 5.8	<.001
Hb, mg/100	9.59 ± 1.75	9.58 ± 1.75	.123

DBP = diastolic blood pressure, HB = hemoglobin, HR = hear rate, PAP = pulmonary arterial pressure, PaO_2 = partial pressure of oxygen, SBP = systolic blood pressure, SpO_2 = atrial oxygen saturation.

4.1. Technique

We applied 2 modifications to the original techniques: first, instead of pulling the endotracheal tube upward, it is driven down close to the bifurcation of the trachea. Second, the difficulty of this procedure (31%–34%) is almost overcome. The new tube is guided down and cuffed just above the carina. Afterwards the tracheotomy tube is passed over the guide wire through the larynx into the trachea.

In our study, the mean time of tracheostomy (from the start of guiding the endotracheal tube downward to just above the carina to complete installation of the tracheostomy tube) was 11.81 ± 3.31 minutes. An average value for INR was 1.97 ± 0.65 (Table 1). In previous studies, the highest reported value for INR was 2.80, with 1.2 ± 0.3 on the average.[11] In a study which is conducted by MacCallum et al[11] during a 26-month period in 2 ICUs in Canada, TLT was performed on 111 patients with Fantoni method under general anesthesia at bedside. In their study, the average duration of each operation was 28 ± 1 minutes, the average reported arterial oxygen saturation was 98% ± 3%; the lowest reported oxygen saturation was 81% (20 patients confronted a slight percentage drop in blood saturation of short-term duration without any complications). Average arterial pressure of patients was 77 ± 26. No considerable bleeding (<5 mL) was observed. Mean INR was 1.2 ± 0.3 (minimum was 0.9 and maximum 2.8). In addition, pneumothorax occurred in only 1 patient. Results obtained from this study were as follows: TLT is an easy and reliable method even in patients with coagulation disorders. Moreover, based on the results of our study, we recommend that the future researches can be conducted on elective patients.

In another study by Velmahos et al which was performed on 100 patients in the ear, nose, and throat wards of a select few hospitals in Ontario, Canada, and London in 2000, the 3 methods of tracheotomy: traditional surgical, PDT, and translaryngeal tracheotomy (TLT) were compared. In this study, traditional surgical tracheotomy was conducted on 50 patients. A case of tension pneumothorax occurred, and 15 more developed complications, including 1 patient started bleeding and lost >2 L of blood during the first 24 hours. TLT was performed on 37 patients, of which 20 had coagulation disorders. The reported complications after 2 weeks were accidental decannulation during surgery, and an abscess formation was observed around tracheotomy incision. PDT method was performed on 13 patients, and no major complications were found. It is concluded that, in addition to the fact that TLT and PDT methods are cost-effective, these methods can also cause fewer complications when compared to traditional method of surgical tracheostomy. In addition, TLT is the most beneficial method for patients with coagulation disorders.[12] The value of hemoglobin for the day before and after tracheotomy indicates no statistically significant change, which reflects no considerable bleeding. According to Table 2, the lowest amount of INR was 1, the highest amount was equal to 3.4. Therefore, tracheostomy through the larynx with the new techniques (MTLT) could be safely conducted in patients with coagulation disorders, and in cardiac patients who requires a continuous use of anticoagulation drugs with an ultimate result of having a high INR, without any considerable bleeding (>5–10 mL).

In the present study, and according to Table 2, using paired *t* test, it is indicated that the percentage of oxygen saturation after conducting the MTLT had a significant increase ($P = .0001$), which implies improved condition; heart rate and systolic blood pressure stayed within limits; there was no statistically

significant change in diastolic blood pressure after tracheotomy; and peak airway pressure had a significant decrease ($P < .0001$), which reflects a better hemodynamics after tracheotomy. In a study Westphal et al published in the journal of *Anesthesia and Analgesia*, a clinical comparison was made between the 2 TLT and PDT methods. This study was performed on 90 patients for elective TLT and PDT tracheotomy who were hospitalized in ICU ward of Frankfurt university hospital in Germany. It was reported that 11.1% of patients (5 cases) in PDT group had complications, of which 4 cases were due to blood aspiration, and 1 case was due to extensive bleeding, which resulted in surgery. In TLT group, 31.1% of the problems were due to passing the retrograde guide wire from trachea to larynx (14 cases), and of which, in 1 case the anesthesiologist was forced to stop TLT, and changed it to PDT method. There were no other complications observed in TLT group. The ratio of arterial blood oxygen pressure, to the percentage of inhalation oxygen in PDT method after the operation was remarkably less than TLT ($P < .05$), whereas this ratio was not significant before the operation. However, during TLT operation arterial carbon dioxide pressure was significantly increased, whereas nothing happened in the PDT group. There were no infections in any of the groups, and for this reason, the PDT and TLT are considered as a suitable method when compared to traditional surgical tracheostomy to be used for elective patients.[13]

In another study by Byhahn et al, an attempt was made to invent a new tool (direct cannula instead of curved one). In addition, they used the improved and modified technical methods compared to classical Fantoni procedure, which could possibly shorten the operation time for TLT; however, they were not able to completely solve the retrograde passage problem.[14]

5. Conclusions

Based on this study, it can be concluded that firstly, the use of MTLT method in addition to solving the problem of passing the guide wire alongside the endotracheal tube (which presents a prevalence of 31.1% difficulty in classic Fantoni method) also shortens the operation time. Secondly, the new method presented in this study can be safely used in patients with coagulation disorders who are the candidates for elective tracheostomy and even MTLT can be the preferred method for such patients.

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Author contributions

A.S. provided the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article, revised it critically for important intellectual content, and final approval of the version to be submitted. J.M. supplied the acquisition of data, drafting of manuscript. M.A. supplied the design of study, analysis, and interpretation. S.S. supplied the acquisition of data and all of authors' provided the revised the article critically for important intellectual content and gave final approval of the version to be submitted.

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