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Percutaneous Dilatational Tracheostomy with Bronchoscopic Guidance in Intensive Care Unit

Yoğun Bakım Ünitesinde Bronkoskopi Kılavuzlu Perkütan Dilatasyonel Trakeostomi

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ABSTRACT

Objective: Tracheostomy is one of the most common invasive procedures in emergency rooms, intensive care units, and the bedside. In the intensive care unit, tracheostomies are most often used for prolonged mechanical ventilation, to preserve the airway and to permit pulmonary drainage. Percutaneous dilatational tracheostomy (PDT) was performed using the Seldinger method. To minimize tracheal posterior wall damage, bronchoscopy guidance was used to determine the proper spot for tracheal puncture, guide real-time needle entry into the trachea, and confirm cannula position. This study introduces bronchoscopy-guided modified mini-surgical PDT and aims to evaluate early complications with 388 case analyses.

Methods: Demographic data from patients, intensive care indications, APACHE-2 scores, duration of stay on the ventilator before tracheostomy, total duration of stay, and early complications during tracheostomy were recorded by analyzing patient files. All data from PDT patients between 2018 and 2022 were retrospectively reviewed.

Results: Of 492 tracheostomies, 388 (78.8%) were opened percutaneously. The mean and median duration of stay on the ventilator before tracheostomy were 12.95 and 12 days, respectively. The mean and median duration lengths of stay were 29.43 and 14.355 days, respectively. The most common indication for tracheostomy was chronic obstructive pulmonary disease in 70 (18%), patients. Complications related to tracheostomy were observed in 19 patients, representing a complication rate of 4.9%. Of these, 2 (0.5%) bleeds stopped with cautery, and 2 (0.5%) bronchospasms occurred during the procedure.

Conclusion: Percutaneous dilatational tracheostomy is a simple and safe tracheostomy method. Its use with bronchoscopy can facilitate the procedure and minimize the complications that may occur.

Keywords: Tracheostomy, bronchoscopy, critical care

ÖZ

Amaç: Trakeostomi acil servislerde ve yoğun bakım ünitelerinde yatak başında en sık yapılan invaziv işlemlerden biridir. Yoğun bakım ünitesinde, trakeostomi çoğunlukla uzun süreli mekanik ventilasyonda, hava yolunu korumak ve pulmoner drenaja izin vermek için kullanılır. Perkütan dilatasyonel trakeostomide (PDT), Seldinger yöntemi ile yapılır. Trakea arka duvar hasarını en aza indirmek, ponksiyon için uygun noktayı belirlemek, trakeaya gerçek zamanlı iğne girişini yönlendirmek ve kanül pozisyonunu doğrulamak için bronkoskopi kullanılır. Bu çalışma, bronkoskopi eşliğinde modifiye mini cerrahi PDT'yi tanıtmakta ve 388 vaka analizi ile erken komplikasyonları değerlendirmeyi amaçlamaktadır.

Yöntem: Hasta dosyaları incelenerek hastaların demografik verileri, yoğun bakım endikasyonları, APACHE-2 skorları, trakeostomi öncesi kalış süreleri, toplam kalış süreleri ve trakeostomi sırasındaki erken komplikasyonları kaydedildi. 2018 ve 2022 arasındaki PDT hastalarından alınan tüm veriler geriye dönük olarak incelendi.

Bulgular: Dört yüz doksan iki trakeostomiden 388'i (%78,8) perkütan açıldı. Trakeostomi öncesi ventilatörde ortalama ve medyan kalış süreleri sırasıyla 12,95 ve 12 gündü. Ortalama ve medyan hastanede kalış süreleri sırasıyla 29,43 ve 14,355 gündü. En sık trakeostomi endikasyonu 70 (%18) hastada kronik obstrüktif akciğer hastalığı idi. 19 hastada trakeostomiye bağlı komplikasyonlar gözlendi ve komplikasyon oranı %4,9'du. Bunlardan 2'si (%0,5) minimal kanama idi ve koter ile durduruldu. İşlem sırasında 2 hastada (%0,5) bronkospazm gelişti.

Sonuç: Perkütan dilatasyonel trakeostomi basit ve güvenli bir trakeostomi yöntemidir. Bronkoskopi ile birlikte kullanılması işlemi kolaylaştırabilir ve oluşabilecek komplikasyonları en aza indirebilir.

Anahtar sözcükler: Trakeostomi, bronkoskopi, yoğun bakım

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INTRODUCTION

Tracheostomy is one of the most common procedures in emergency rooms, intensive care units (ICUs), at the bedside. It has gained popularity to facilitate the weaning of patients from the respirator, reduce pulmonary dead space, provide access to clear pulmonary secretions under various pathological conditions, and improve patient comfort (1). In ICU patients, tracheostomies are most often used for prolonged mechanical ventilation, to preserve the airway, and to permit pulmonary drainage (2). Percutaneous dilatational tracheostomy (PDT) has replaced surgical tracheostomy (ST) in adults due to its safety, ease of use, and improved aesthetic outcomes.

Percutaneous tracheostomy procedures may have substantial, even life-threatening, consequences. Therefore, any method that decreases PDT morbidity and mortality is ideal (3). To minimize tracheal posterior wall damage, bronchoscopy guidance has been used to determine the proper spot for a tracheal puncture, guide real-time needle entry into the trachea, and confirm cannula position (4). A clinician can easily detect the tracheostomy site by transilluminating the bronchoscope light within the trachea. It is becoming more apparent that PDT is associated with a substantial risk of morbidity and mortality in some individuals and is assumed to be a relative contraindication to PDT. High PEEP or FiO_2 requirements, complex anatomy (significant obesity, thick short neck, and tracheal deviation), coagulopathy, emergency operations, and hemodynamic instability are also contraindications.

Complications related to the tracheostomy procedure are bleeding, pneumothorax, injury to the posterior tracheal wall, incorrect placement of the cannula, thyroid injury, and subcutaneous emphysema. In some cases, ST is the safest procedure because of the need for a better view of the anatomy of the neck and oxygen/hemodynamic stability management. In 2015, Hashemian et al. introduced a modified mini-surgical technique (msPDT, Hashemian method) incorporating bedside and surgical experiences to overcome common PDT limitations (5). This technique makes a 2 cm vertical incision 1 cm below the cricoid cartilage. The subcutaneous tissue is separated using two hemostats. This process is repeated until the fibro-muscular tissue covering the tracheal ring is seen and PDT processes are continued (5). The modified mini-surgery PDT is like the Hashemian method. The difference is that the incision is transverse, and only one curved hemostat is used. The Griggs forceps dilation technique is used for the dilation. This study introduces bronchoscopy-guided, modified mini-surgical PDT and aims to evaluate early complications with 388 case analyses.

MATERIAL and METHODS

Erzurum Regional Education and Research Hospital Ethics Committee approval (Date: 20.06.2022 No: 2022/08-95) was obtained. All data from patients with PDT between January 2018 - January 2022 were retrospectively reviewed. Demographic data from patients, intensive care indications, APACHE II scores, duration of stay on ventilator before tracheostomy, total duration of stay, and early complications during tracheostomy were recorded by analyzing patient files.

Since 2018, in the Anesthesiology and Reanimation intensive care units of the Erzincan Binali Yıldırım University Mengucek Gazi Training and Research Hospital, all tracheostomy procedures have been performed under the guidance of bronchoscopy using the Griggs forceps dilation technique with the brand name PORTEX and a modified mini surgical method. All procedures were performed at the bedside in the ICU, and a self-screened bronchoscope was used as a guide. Attending anesthesiologists and senior anesthesia resident completed all PDT procedures.

Before the procedure, endotracheal tubes and oral aspiration were performed. The catheter mount for ventilator was attached to the endotracheal tube connector to provide ventilation during bronchoscopy, and it was checked that it did not leak air. This process prevents oxygen deprivation during the procedure and reduces aerosol leakage to the external environment in COVID-19 patients. After providing patients with adequate analgesia, sedation, and muscle relaxation, the heads of flatly lying patients were hyper-extended (unless there was cervical trauma or other restriction). The anesthesiologist was at the right side of the patient and the assistant fellow was on the left. The anterior cervical area was sterilized and covered extensively. Before incision, 2 mL local anesthetic (lidocaine 20 mg + epinephrin 12.5 µg) was used. An approximately 2 cm horizontal incision was made between the cricoid cartilage and the sternal notch.

The subcutaneous tissue was separated with a curved hemostat. The procedure was continued until the subcutaneous fibromuscular tissue surrounding the trachea was observed. The bronchoscope was placed into the endotracheal tube and withdrawn until the first tracheal rings were seen. Transillumination of bronchoscope light was observed when bronchoscope and endotracheal tube levels were adjusted. The trachea was separated from the muscles, and the fibro-muscular tissue was palpated and fixed with the left hand. A 5 mL syringe with a guide wire needle was filled with 3 mL of saline. Following the advancement of the guide wire, a small diameter dilator over the guide wire was used to widen the tracheal opening. The procedure was confirmed by visualization of intratracheal air aspiration while inserted at an angle of approximately 45 degrees between the second and third rings

of the fixed trachea. Apparent accuracy was achieved with bronchoscopy. The skin and subcutaneous tissue were dilated at least twice with dilation forceps. Then, the dilation forceps were gently inserted into the trachea over the wire under the guidance of bronchoscopy, and dilation was performed. The process was repeated twice. After providing adequate potency and bleeding control, the lubricated tracheostomy cannula was placed over the wire and into the trachea. The procedure was confirmed by bronchoscopy. After the patient was observed to be ventilated, a pressure dressing was applied, and tube fixation was performed by suturing.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) for Windows was used to perform statistical analysis (SPSS, Chicago, IL, USA). Continuous data were summarized using the mean, standard deviation (SD), median, and ranges, whereas categorical variables were summarized using proportions and frequency tables. Continuously collected variables were grouped. For categorical variables Chi-square test ($\chi 2$) was used to determine the significance of the association between independent and dependent variables. The significance level was set at $p<0.05$.

RESULTS

Data from 492 patients with tracheostomy were retrospectively analyzed. Of 492 tracheostomies, 388 (78.8%) were opened percutaneously. Two hundred and eight (53.6%) of the patients were male, and 180 (46.4%) were female, with a male to female ratio of 1.15:1. The age of the patients ranged from 18 to 100 years, with a median and mean ages of 73 and 69.99, respectively. Most of the patients were in the sixth decade of life. The calculated APACHE II scores were a mean of 32.01, a median of 32.35, a minimum of 22, and a maximum of 38.

Of the patients who underwent tracheostomy, 223 died, and the other 165 survived. The mean age of the deceased was 72.25 years, and the survivors was 66.94 years. The mortality rate was higher in elderly patients ($p<0.01$). Patients with a high APACHE II score had a high mortality rate ($p<0.01$).

The mean and median duration of stay on the ventilator before tracheostomy was 12.95 and 12 days, respectively. The earliest was performed on 5 patients on their ICU admission. It was administered to 20 patients (5.2%) within the first five days after intubation. The longest treatment was performed on only one patient after 40 days of mechanical ventilation. After 30 days of mechanical ventilation, it was performed in 7 (1.8%) patients. The mean and median duration lengths of stay were 29.43 and 14.35 days, respectively. There was a statistically significant positive correlation between the duration of the tracheostomy and the length of stay in the ICU. (Correlation coefficient 0.598, $p < 0.001$).

Table I. Common Diagnosis For Elective Tracheostomy

Diagnosis	Frequency	Percentage (%)
COPD	70	18
Cerebrovascular disease	63	16.2
Cardiac arrest	43	11
Malignant disease	35	9
Intracranial hemorrhage	31	8.0
Congestive heart failure	26	6.7
Multi trauma	20	5.1
Alzheimer's disease	17	4.4
ALS	9	2.3
Sepsis	9	2.3
Chronic renal failure	9	2.3
Acute myocardial infarction	8	2.0
PTE hip fracture	7	1.8
Mesenteric artery occlusion	5	1.3
Others	36	9.2
	388	100

COPD: Chronic obstructive pulmonary disease, **ALS:** Amyotrophic lateral sclerosis, **PTE:** Pulmonary thromboembolism, **Others:** Acute renal failure, asthma, aortic aneurysm, Burger disease, cerebral palsy, Parkinson's disease, ulcerative colitis.

The most common indications for tracheostomy were chronic obstructive pulmonary disease in 70 (18%), cerebrovascular disease in 63 (16.2%), cardiac arrest in 43 (11%), and malignant disease in 32 (9%) patients (Table I).

Complications related to tracheostomy were observed in 19 (4.9%) patients. Of these, 2 (10.52%) bleeds stopped with cautery, and 2 (10.52%) bronchospasms occurred during the procedure. In the immediate postoperative period (within the first 24 hours after the procedure), 15 (78.96%) minimal bleeding episodes occurred without surgical intervention. No complications were observed in the early postoperative period (within the first week after surgery), in the late postoperative period (after one week), or in the postoperative period when the patients were in the intensive care unit (Table II).

Evaluation of complications showed that bleeding complications that could be stopped during the procedure with cautery occurred in relatively young and male patients (mean age=46.5) ($p<0.05$). The incidence of bronchospasm during the procedure was significantly higher in patients with a low APACHE II score ($p<0.01$). The duration of MV before tracheostomy and the length of stay in the ICU were not associated with complications.

Table II. Tracheostomy Complications

Period	Complication	Frequency	Percentage (%)
Intraoperative	The bleeding stopped with cautery during the procedure	2	10.52
	Bronchospasm during the procedure	2	10.52
Immediate complication	Minimal bleeding without surgical interventions	15	78.96
Early complication	No complication		
Late complication	Not observed while in ICU		
		19	100

ICU: Intensive Care Unit.

DISCUSSION

Although tracheostomy is subject to various changes during the process, it is one of the most commonly performed invasive procedures in the ICU. The process, which began with an open surgical tracheostomy, has become more visible in recent years with the addition of bronchoscopy to the procedure.

Because the percutaneous procedure is performed at the patient's bedside, it is more commonly recommended in ICU. The percentage of percutaneous tracheostomy opening was 77.2% in the study by Mirski et al.; in the international multicenter study by Vargas et al., the percutaneous tracheostomy was 75.9% (6,7). Similar to these results, the percutaneous method was chosen for our study.

In other studies, 60% of patients undergoing PDT were male, and 40% were female. The mean age of the patients was 66 years. In our study, 53.6% of the patients were male, 46.4% were female, and the mean age was 73 years (8, 9). Compared to similar studies, we had an older patient group.

This study retrospectively examined a cohort of patients who received bronchoscopy-assisted PDT. Patients were evaluated according to age, APACHE II, the indication of admission to the ICU, duration on a mechanical ventilator before tracheostomy, complications, and length of stay. The primary outcome of this study was tracheostomy-related complications which were low.

In the study by Antonelli et al., the expected mortality rate according to the SAPS II score of the patients was approximately 34%. In the study by Destegul et al., the expected mortality rate according to the APACHE II score was approximately 95% (10, 11). In our study, the mean expected mortality rate was 73% according to the APACHE II score.

Complications related to PDT vary in severity, from mild tissue damage to airway loss. Tracheoesophageal fistula, posterior tracheal wall perforation, laryngotracheal stenosis, and pneumothorax are possible consequences. Complications range from 4% to 13%, depending on the physician's experience performing the PDT (12). A study found a major complication rate of 0.38%, and another found a major complication rate of 0.04% (11). The most common complications of the percutaneous technique are bleeding, emphysema, placement of the cannula outside the trachea, injury to the posterior tracheal wall and esophagus, and infection. The most important complication is hypoxia and death from airway failure. In particular, perioperative complications, such as lack of airway, cardiac arrest, and death, have been reported to be more common with the percutaneous technique (13). Our study showed no major complications. Minor complications were 4.9% (19/388) in our study. This rate is lower than in the previous series, in which rates of 63% and 14.8% were reported (7,14).

In the literature, some authors recommend using bronchoscopy to determine the correct position of the guide wire and the tracheal cannula during the procedure to avoid misplacement and tracheal injury (15). Using bronchoscopy during tracheostomy is helpful to show the physician that the cannula is in the correct area and to avoid contact with the posterior wall during dilation. It is recommended to use bronchoscopy because it provides a clear image during the procedure (16). We believe that the common complications of tracheostomy (such as cannula failure, airway loss, hypoxemia, and cannula displacement) are not observed because of bronchoscopy guidance. In the study by Yesiler and Sendur, percutaneous tracheostomy was performed in 90% of cases with bronchoscopy (17). In the study that conducted in Turkey, PDT was opened in a similar proportion of patients. The study found that the proportion of bronchoscopy use was 100%.

Our research has several limitations. Because it is a retrospective case series, it entirely depends on the quality of hospital records. Because the data could not be recovered after patient discharge, we could not search for association with late structural problems such as tracheal stenosis, found in 30% of patients (although it was symptomatic in only 6%) (18). As a result, late complications were not evaluated. The study involved a series of patients in a single institution. Another limitation in its application is the involvement of the

author (A.K.), who was present in most operations. Similar multidisciplinary models in which various seniors are present have been safe and economically efficient (6).

CONCLUSION

Tracheostomy is a procedure that increases the comfort of patients who require mechanical ventilation for prolonged periods. The use of PDT, which is a simple and safe tracheostomy method, under the guidance of bronchoscopy may facilitate the procedure and minimize the complications that may occur.

AUTHOR CONTRIBUTIONS

Conception or design of the work: AK

Data collection: AK

Data analysis and interpretation: AK

Drafting the article: AK

Critical revision of the article: AK

Other (study supervision, fundings, materials, etc): AK

All author (AK) reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Chavan RP, Ingole SM, Mane B, Kalekar TM, Birajdar SN. Tracheostomy: Experience at Tertiary Hospital. Indian J Otolaryngol Head Neck Surg 2019;71(1):580-4.
2. Shelden CH, Pudenz RH, Tichy FY. Percutaneous tracheotomy. J Am Med Assoc 1957;165(16):2068-70.
3. Karimpour H, Vafaii K, Chalechale M, Mohammadi S, Kaviannezhad R. Percutaneous dilatational tracheostomy via griggs technique. Arch Iran Med 2017;20(1):49-54.
4. Gobatto ALN, Besen BAMP, Tierno PFGMM, et al. Ultrasound-guided percutaneous dilational tracheostomy versus bronchoscopy-guided percutaneous dilational tracheostomy in critically ill patients (TRACHUS): A randomized noninferiority controlled trial. Intensive Care Med 2016;42(3):342-51.
5. Hashemian SMR, Digaleh H, Massih Daneshvari Hospital Group. A prospective randomized study comparing mini-surgical percutaneous dilatational tracheostomy with surgical and classical percutaneous tracheostomy: A new method beyond contraindications. Medicine 2015;94(47):e2015.
6. Mirski MA, Pandian V, Bhatti N, et al. Safety, efficiency, and cost-effectiveness of a multidisciplinary percutaneous tracheostomy program. Crit Care Med 2012;40(6):1827-34.
7. Vargas M, Sutherasan Y, Antonelli M, et al. Tracheostomy procedures in the intensive care unit: An international survey. Crit Care 2015;19(1):291.
8. Karasu D, Yılmaz C, Baytar Ç, Korfalı G. Retrospective analysis of percutaneous tracheostomi cases in intensive care unit. Turk J Intensive Care 2018;16(3):83-7.
9. Atlas A, Altay N. Our percutaneous tracheostomy experience in our intensive care unit: A retrospective analysis. Harran Univ Tıp Fak Derg 2021;18(1):104-8.
10. Antonelli M, Michetti V, Di Palma A, et al. Percutaneous translaryngeal versus surgical tracheostomy: A randomized trial with 1-yr double-blind follow-up. Crit Care Med 2005;33(5):1015-20.
11. Destegül D, Kocaöz FŞ, Özkan Kuşcu Ö. Yoğun bakımda perkütan ve cerrahi trakeostomi deneyimlerimiz. Kırıkkale Üni Tıp Derg 2020;22(2):192-8.
12. Tabaee A, Geng E, Lin J, et al. Impact of neck length on the safety of percutaneous and surgical tracheotomy: A prospective, randomized study. Laryngoscope 2005;115(9):1685-90.
13. Koçyiğit F, Bayındır S. Yoğun bakım trakeostomi deneyimlerimiz; 103 olgu. J Contemp Med 2018;8(3):197-200.
14. Cohen O, Shnipper R, Yosef L, et al. Bedside percutaneous dilatational tracheostomy in patients outside the ICU: A single-center experience. J Crit Care 2018;47:127-32.
15. Polderman KH, Spijkstra JJ, de Bree R, et al. Percutaneous dilatational tracheostomy in the ICU: Optimal organization, low complication rates, and description of a new complication. Chest 2003;123(5):1595-602.
16. Peris A, Linden M, Pellegrini G, Anichini V, Di Filippo A. Percutaneous dilatational tracheostomy: A self-drive control technique with video fiberoptic bronchoscopy reduces perioperative complications. Minerva Anestesiol 2009;75(1-2):21-5.
17. Yeşiler Fİ, Şendur ÜG. Yoğun bakım ünitesinde trakeostomi deneyimlerimiz. Aegean J Med Sci 2018;1(3):106-10.
18. Norwood S, Vallina VL, Short K, Saigusa M, Fernandez LG, McLarty JW. Incidence of tracheal stenosis and other late complications after percutaneous tracheostomy. Ann Surg 2000;232(2):233-41.