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Does early tracheostomy decrease the nosocomial pneumonia incidence in cardiovascular surgery patients?

Kalp ve damar cerrahisi olgularında erken trakeostomi nozokomiyal pnömoni insidansını azaltıyor mu?

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Background: This study aims to examine the correlation between the incidence of nosocomial pneumonia and the timing of tracheostomy in our cardiovascular intensive care unit (ICU).

Methods: Between January 2008 and December 2009, 64 patients who were monitored in the cardiovascular surgery ICU and underwent tracheostomy were included in this retrospective study. The patients were divided into four groups according to their clinical pulmonary infection scores (CPIS) and the timing of tracheostomy. Group 1E (n=11): Patients with CPIS ≤5 who underwent tracheostomy within seven days of endotracheal intubation. Group 1L (n=9): Patients with CPIS ≤5 who underwent tracheostomy after seven days from endotracheal intubation. Group 2E (n=13): Patients with CPIS ≥6 who underwent tracheostomy within seven days of endotracheal intubation. Group 2L (n=31): Patients with CPIS ≥6 who underwent tracheostomy after seven days from endotracheal intubation.

Results: Comparison of the incidence of nosocomial pneumonia of the patients following tracheostomy showed no statistically significant difference between group 1E and 1L. Also, there was no significant difference between group 2E and 2L in terms of superinfection rates of the patients following tracheostomy. However, a significant difference was observed between group 1E (24.9±4.3) and group 1L (30.4±4.4) (p=0.012) in terms of APACHE II scores. Significantly lower mortality rates were observed in group 1E, compared to group 1L (p=0.043), but not between group 2E and 2L.

Conclusion: We concluded that early tracheostomy does not decrease the incidence of nosocomial pneumonia and superinfection following tracheostomy.

Key words: Early versus late tracheostomy; intensive care unit; pneumonia.

Amaç: Bu çalışmada kardiyovasküler yoğun bakım ünite (YBÜ)'mizde nozokomiyal pnömoni insidansı ile trakeostomi zamanlaması arasındaki korelasyon incelendi.

Çalışma planı: Bu retrospektif çalışmaya Ocak 2008 - Aralık 2009 tarihleri arasında kardiyovasküler cerrahi YBÜ'de takip edilen ve trakeostomi açılan 64 hasta dahil edildi. Hastalar trakeostomi öncesi klinik pulmoner enfeksiyon skoru (KPİS) ve trakeostomi zamanlamasına göre dört gruba ayrıldı. Grup 1E (n=11): KPİS ≤5 olan endotrakeal entübasyonun ilk yedi günü içinde trakeostomi açılan hastalar. Grup 1L (n=9): KPİS ≤5 olan endotrakeal entübasyonun 7. gününden sonra trakeostomi açılan hastalar. Grup 2E (n=13): KPİS ≥6 olan endotrakeal entübasyonun ilk yedi günü içinde trakeostomi açılan hastalar. Grup 2L (n=31): KPİS ≥6 olan endotrakeal entübasyonun 7. gününden sonra trakeostomi açılan hastalar.

Bulgular: Trakeostomi sonrası hastaların nozokomiyal pnömoni insidansları karşılaştırıldığında, grup 1E ile grup 1L arasında istatistiksel olarak anlamlı bir fark saptanmadı. Bununla birlikte, trakeostomi sonrası hastaların süperenfeksiyon oranları açısından da, grup 2E ve grup 2L arasında anlamlı bir farklılık gözlenmedi. Ancak grup 1E (24.9±4.3) ve grup 1L (30.4±4.4) arasında APACHE II skorları açısından anlamlı bir farklılık gözlendi (p=0.012). Grup 1E'de, grup 1L'ye kıyasla, anlamlı düzeyde düşük mortalite oranları gözlendi (p=0.043); ancak grup 2E ve grup 2L arasında bu fark gözlenmedi.

Sonuç: Erken trakeostominin trakeostomi sonrası nozokomiyal pnömoni ve süperenfeksiyon insidansını azaltmadığı sonucuna vardık.

Anahtar sözcükler: Erkene karşı geç trakeostomi; yoğun bakım ünitesi; pnömoni.

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The most common indication for tracheostomy in the intensive care unit (ICU) is prolonged mechanical ventilation.[1] However, the optimum timing for performing the tracheostomy is still controversial. In the Consensus Conference on Artificial Airways held by the American College of Chest Physicians (ACCP) in 1989, it was suggested to "perform tracheostomy in patients with trans-laryngeal intubation duration of longer than 21 days." From then until now, the timing of tracheostomy has changed, with durations varying between three days and three weeks being reported.[1,2]

The decision for tracheostomy is particular to every single patient and is decided by evaluating the existing disease, expected recovery time, risks of continuous trans-laryngeal intubation, and risks of the tracheostomy procedure for the individual patient. The advantages of tracheostomy over endotracheal intubation are lower airway resistance, smaller dead space, reduced risk of mobilization of the tube in the airway, better patient comfort, and more efficient tracheal aspiration capability. Despite these advantages, there are different views regarding the effects of tracheostomy on duration of mechanical ventilation, time of stay in the hospital or the ICU, and the incidence of pneumonia.[1,2] In this study, the correlation between the risk of development of nosocomial pneumonia, superinfection rates, and the timing of tracheostomy was assessed in patients who underwent tracheostomy and were followed up in our cardiovascular surgery ICU.

PATIENTS AND METHODS

Sixty-four patients who were followed up in the cardiovascular surgery ICU between January 2008 and December 2009 following tracheostomy for mechanical ventilation were assessed retrospectively. The patients were classified into four groups according to the presence of pneumonia based on their modified clinical pulmonary infection scores (CPIS) prior to tracheostomy and timing of tracheostomy.

1. Group 1E (n=11): Patients with a CPIS of 5 or below who underwent early tracheostomy (within 7 days of endotracheal intubation).

2. Group 1L (n=9): Patients with a CPIS of 5 or below who underwent late tracheostomy (after 7 days of endotracheal intubation).

3. Group 2E (n=13): Patients with a CPIS of 6 or above who underwent early tracheostomy (within 7 days of endotracheal intubation).

4. Group 2L (n=31): Patients with a CPIS of 6 or above who underwent late tracheostomy (after 7 days of endotracheal intubation).

For all patients, age and gender along with the existence of additional diseases, preoperative ejection fractions, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, type of operation, reoperation status, postoperative complications were evaluated along with the need for postoperative dialysis, inotropic support, and an intra-aortic balloon pump (IABP). The method of tracheostomy (percutaneous/surgical), complications of tracheostomy, microorganisms isolated from deep tracheal aspirate cultures, time of stay in the ICU/hospital, and mortality rates were evaluated.

The diagnosis of nosocomial pneumonia was evaluated according to the CPIS of the patients (Table 1). A CPIS of 6 or above was accepted as nosocomial pneumonia after 48 hours of admission to the ICU. In group 1E and 1L, nosocomial infection after tracheostomy was evaluated while in group 2E and 2L, superinfection was evaluated after tracheostomy. We defined superinfection as any new infection complicating the course of antimicrobial therapy of an existing infection due to the proliferation of bacteria or fungi resistant to the drug(s) in use.

Statistical analysis

The data was presented as mean and standard deviation, along with percentage where appropriate. A chi-square

Table 1. Modified clinical pulmonary infection score (CPIS)

Parameter	0	1	2
Tracheal secretion	Rare	Abundant	Abundant + purulent
Chest X-ray infiltrasyon	Noninfiltrate	Diffused	Consolidation
Temperature	≥36.5 and ≤38.4	≥38.5 and ≤38.9	≥39 or ≤36
Leucocyte count/mm^3	≥4000 and ≤11000	<4000 and >11000	<4000 or >11000,
Band forms ≥500			
PaO_2/FIO_2	>240 or ARDS		≤240 and no evidence of ARDS
Microbiology	Negative		Positive

ARDS: Acute respiratory distress syndrome; FIO_2: Fraction of inspired oxygen; PaO_2: Partial pressure of oxygen in arterial blood.

test and Student's t-test were used to compare patient characteristics and test values. Probability *(p)* values below 0.05 were considered to be significant. Confidence intervals (CI) were calculated at the 95% level.

RESULTS

No significant difference was detected between the groups regarding age, gender, tracheostomy technique, number of reintubations, readmission to the ICU, mortality, APACHE II scores, or time of stay in the ICU/hospital (Table 2).

We also compared the groups by their accompanying diseases. While there was no significant difference between the groups in terms of diabetes mellitus, chronic obstructive pulmonary disease (COPD), type of operation, postoperative mesenteric ischemia, postoperative IABP, postoperative need for inotropic drugs, complications of tracheostomy, or preoperative ejection fraction, significant differences were established in terms of preoperative chronic renal failure and postoperative cerebrovascular incidents, which were higher in group 2L than in the other groups (Table 3).

When the nosocomial pneumonia rates of the patients after tracheostomy were compared, it was observed that there were no statistically significant differences between groups 1E and 1L. We also observed that there were no differences between groups 1E and 1L regarding the type of microorganisms isolated from deep tracheal aspirate cultures (Table 4).

We also investigated and compared the groups in terms of infecting microorganisms before and after tracheostomy. *Escherichia coli* was the leading cause of pneumonia in group 2E while *Acinetobacter baumanii* was the primary microorganism in group 2L. Also, when the superinfection rates of the patients after tracheostomy were compared, it was observed that there were no statistically significant differences between groups 2E and 2L. *Acinetobacter baumanii* was the prominent microorganism which caused superinfection in both groups (Table 5).

When the APACHE II scores were compared, statistically significant differences were observed between group 1E (24.9±4.3) and group 1L (30.4±4.4) (p=0.012). However, no statistically significant difference was found between groups 2E and 2L.

When the mortality rates of the patients were assessed, it was observed that a statistically significant lower mortality rate was present in group 1E than in group 1L (p=0.043) while no statistically significant difference was observed between groups 2E and 2L.

DISCUSSION

In patients with a need for long-term mechanical ventilation, the maintenance of the airway through tracheostomy is a preferred application. There is no

Table 2. Demographic data of groups

Parameter	Group 1				Group 2			
	Group 1E (55.0%) (n=11)	Group 1L (45.0%) (n=9)	*p*	*Total*	Group 2E (29.5%) (n=13)	Group 2L (70.5%) (n=31)	*p*	*Total*
Age	67.2±7.5	59.7±17.8	0.222	63.9±13.3	69.3±9.4	67.5±10.0	0.584	68.1±9.8
Gender								
Male	27.3 (3)	11.1 (1)	0.369	20.0 (4)	84.6 (11)	58.1 (18)	0.090	65.9 (29)
Female	72.7 (8)	88.9 (8)		80.0 (16)	15.4 (2)	41.9 (13)		34.1 (15)
Technique								
Percutaneous tracheostomy	90.9 (10)	44.4 (4)	0.024	70.0 (14)	69.2 (9)	77.4 (24)	0.567	75.0 (33)
Surgical tracheostomy	9.1 (1)	55.6 (5)		30.0 (6)	30.8 (4)	22.6 (7)		25.0 (11)
# of re-entubations	1.0±0.7	0.8±0.9	0.586	1.0±0.7	1.1±0.8	1.3±1.1	0.583	1.3±1.0
# of ICU re-admissions	0.6±0.9	0.4±0.7	0.618	0.5±0.8	0.6±0.7	0.5±0.9	0.750	0.5±0.9
Mortality	63.6 (7)	100.0 (9)	0.043	80.0 (16)	92.30 (12)	77.4 (24)	0.243	81.8 (36)
APACHE II	24.9±4.3	30.4±4.4	0.012		28.5±5.9	26.5±4.5		
Positive culture after tracheostomy	90.9 (10)	55.6 (5)	0.069	75.0 (15)	76.9 (10)	51.6 (16)	0.119	59.1 (26)
Post-tracheostomy ICU stay (days)	44.9±41.0	27.1±40.1	0.343	36.9±40.5	36.2±31.1	37.8±36.8	0.891	37.3±34.8
Length of hospitalization after tracheostomy (days)	49.2±40.3	27.1±40.1	0.236	39.3±40.7	37.3±32.1	40.5±36.9	0.787	39.5±35.2

APACHE II: Acute Physiology and Chronic Health Evaluation; ICU: Intensive care unit; #: Number of patients who are re-intubated and re-admitted to intensive care unit.

Table 3. Existence of additional diseases, type of the operation, postoperative and tracheostomy complications of groups

Parameter	Group 1E (17.2%) (n=11)	Group 1L (14.1%) (n=9)	Group 2E (20.3%) (n=13)	Group 2L (48.4%) (n=31)	*p*	*Total* (100%) (n=64)
Diabetes mellitus	63.6 (7)	55.6 (5)	69.2 (9)	41.9 (13)	0.331	53.1 (34)
Chronic renal failure	18.2 (2)	0	30.8 (4)	3.2 (1)	0.032	10.9 (7)
Chronic obstructive pulmonary disease	63.6 (7)	22.2 (2)	69.2 (9)	61.3 (19)	0.128	57.8 (37)
Hypertension	90.9 (10)	77.8 (7)	92.3 (12)	83.9 (26)	0.737	85.9 (55)
Ejection fraction (%)	44.7±8.7	43.5±8.4	41.5±7.6	44.2±8.9	0.797	44.4±8.7
Operations						
Coronary artery bypass graft	72.7 (8)	33.3 (3)	46.2 (6)	45.2 (14)	0.305	48.4 (31)
CABG + carotid endarterectomy	9.1 (1)	0	23.1 (3)	3.2 (1)	0.305	7.8 (5)
CABG + valve replacement	9.1 (1)	11.1 (1)	0	3.2 (1)	0.305	4.7 (3)
Valve replacement	9.1 (1)	22.2 (2)	0	19.4 (6)	0.305	14.1 (9)
Carotid endarterectomy	0	0	7.7 (1)	0	0.305	1.6 (1)
Aortic surgery	0	33.3 (3)	0	25.8	0.305	21.9 (14)
Congenital operations	0	0	0	3.2 (1)	0.305	1.6 (1)
Re-do surgery	0	0	15.4 (2)	6.5 (2)	0.364	6.3 (4)
Postoperative complications						
Cerebrovascular event	18.2 (2)	22.2 (2)	15.4 (2)	51.6 (16)	0.045	34.4 (22)
Acute renal failure	72.7(8)	55.6 (5)	53.8 (7)	29.0 (9)	0.060	45.3 (29)
Mesenteric ischemia	0	0	0	6.5 (2)	0.532	3.1 (2)
Intra-aortic balloon pump	27.3 (3)	22.2 (2)	15.4 (2)	9.7 (3)	0.550	15.6 (10)
Hemodialysis	72.7 (8)	66.7 (6)	76.9 (10)	45.2 (14)	0.153	59.4 (38)
Inotropy	100.0 (11)	100.0 (9)	100.0 (13)	96.8 (30)	0.782	98.4 (63)
Tracheostomy complications						
Minor	9.1 (1)	0	7.7 (1)	9.7 (3)	0.869	7.8 (5)
Major	0	0	7.7 (1)	6.5 (2)	0.869	4.7 (3)

CABG: Coronary artery bypass graft.

consensus about the timing of tracheostomy in these patients. In current studies, answers to four fundamental questions are being investigated regarding the early performance of tracheostomy: *(i)* What is the effect of early tracheostomy on mortality? *(ii)* Who are the patients that benefit from early tracheostomy? *(iii)* Does early tracheostomy shorten the duration of stay on a mechanical ventilator or length of time spent in the ICU? *(iv)* Does early tracheostomy reduce the incidence of pneumonia?[1,2]

We observed that the mortality rate was significantly lower in patients with early tracheostomy without nosocomial pneumonia. In a study assessing the timing of tracheostomy in terms of mortality and stay in the hospital/ICU after cardiovascular surgery, the authors established that early tracheostomy markedly reduces the mortality rate.[3] Rumbak et al.[4] reported that in 120 medical ICU patients, the performance of tracheostomy in the first two days improved mortality rates, lessened the development of pneumonia, decreased the stay in the ICU, and reduced the time spent on a mechanical ventilator compared with the performance of tracheostomy after 10-14 days. They attributed these findings to the APACHE II scores of all patients being >25, to the fact that they were COPD patients getting high doses of vasopressor agents, and to good pulmonary care being provided to the patients when tracheostomy was performed in the first two days of intubation without development of associated pneumonia. One important factor in the relationship between the mortality rate and the timing of tracheostomy may be the characteristics of the patient groups. Therefore, we evaluated whether any difference existed between the groups in terms of the type of operation, postoperative pneumonia development rate, cerebrovascular event, acute renal failure, mesenteric ischemia, need for an IABP, need for hemodialysis, use of postoperative inotropic drugs, and complications of tracheostomy. However, another important criterion for mortality is the APACHE II score. In our study, there was a significant difference between the subjects without nosocomial pneumonia before tracheostomy and the patients who had undergone early tracheostomy and late tracheostomy with regard to their APACHE II scores. These scores

Table 4. Microorganisms isolated from deep tracheal aspirate in group 1 after tracheostomy

Organisms	Group 1E (55.0%; n=11)		Group 1L (45.0%; n=9)			*Total*	
	n	%	n	%	*p*	n	%
After tracheostomy							
Escherichia coli	0	0	1	11.1	0.257	1	5.0
Klebsiella pneumonia	0	0	0	0	–	0	0
Acinetobacter baumannii	8	72.7	5	55.6	0.423	13	65.0
Methicillin-resistant *Staphylococcus aureus*	1	9.1	0	0	0.353	1	5.0
Candida	1	9.1	0	0	0.353	1	5.0
Enterobacter aerogenes	0	0	0	0	–	0	0
Klebsiella oxytoca	0	0	0	0	–	0	0
Serratia marcescens	1	9.1	0	0	0.353	1	5.0
Enterobacter aerogenes	0	0	0	0	–	0	0
Burcoliholderia cepecia	0	0	0	0	–	0	0
Pseudomonas auroginosa	0	0	0	0	–	0	0
Enterobacter faecium	0	0	0	0	–	0	0
Extended-spectrum beta-lactamase	0	0	1	11.1	0.257	1	5.0
Streptomonas maltophilia	0	0	0	0	–	0	0

were significantly lower in group 1E. Therefore, we believe that both the positive effects of early tracheostomy on mortality in this group and the lower APACHE II scores of these patients played vital roles.

Nosocomial pneumonia is a common infection in the ICU. It generally develops in 28% of mechanical ventilation patients and is known as ventilator-associated pneumonia.[5] There is controversy concerning whether or not early tracheostomy reduces the incidence of pneumonia development in patients under mechanical ventilation with no onset of pneumonia. In our evaluation regarding early or late performance of tracheostomy in patients without nosocomial pneumonia, we observed that there was no significant difference between the groups (1E and 1L) in terms of the development of pneumonia after tracheostomy. In the study by Rodriguez et al.[6] which evaluated 106 surgery patients with tracheostomy by comparing the timing of tracheostomy (earlier then 7 days or later), it was demonstrated that there was no significant difference between the two groups in terms of the stay in the ICU or hospital, the number of days on mechanical ventilator, or the risk of development of pneumonia. Sugerman et al.[7] in a study of 127 trauma and surgery patients found no significant difference between patients who underwent tracheostomy within the first three to five days and those who underwent tracheostomy later with regard to the time of stay in the ICU, the risk of pneumonia development, and mortality.

In the study by Saffle et al.,[8] no significant differences in the number of days on mechanical ventilator, stay in the ICU, rates of pneumonia development, or mortality could be shown in 44 burn patients on whom tracheostomy was performed within the first four days or those on whom it was perfomed after four days,. Bouderka et al.[9] established that in 62 patients with head trauma, patients who underwent tracheostomy within the first five to six days had shorter times of stay in the ICU compared with those who underwent tracheostomy after six days, but no significant difference was found in terms of mortality or risk of development of pneumonia. In these subjects, the need for ventilator support continued after tracheostomy. Therefore, the risk of ventilator-associated pneumonia also continued.[10,11] Although it does not reduce the risk of pneumonia development, tracheostomy improves the quality of care. Pulmonary secretions can be removed more easily. It also allows for oral feeding, and patients may be mobilized more easily. With these advantages and appropriate antibiotic treatment, it may be possible to treat pneumonia effectively.

Regarding the timing of tracheostomy, it has been reported in the meta-analyses, that early tracheostomy has different consequences in different patient groups, but does not have any useful effect on mortality. The time of stay on a mechanical ventilator and length of time spent in ICU are not shortened, except in a small number of studies, and the timing of tracheostomy does not reduce the incidence of pneumonia.[12-16] In our study, we also observed that the early performance of tracheostomy does not reduce the development of the pneumonia. We observed that the mortality rate was

Table 5. Microorganisms isolated from deep tracheal aspirate in group 2, before/after tracheostomy

Organisms	Group 2E (29.5%; n=13)		Group 2L (70.5%; n=31)			*Total*	
	n	%	n	%	*p*	n	%
Before tracheostomy							
Escherichia coli	4	30.8	2	6.5	0.032	6	13.6
Klebsiella pneumoniae	1	7.7	1	3.2	0.516	2	4.5
Acinetobacter baumannii	2	15.4	17	54.8	0.016	19	43.2
Methicillin-resistant *Staphylococcus aureus*	0	0	2	6.5	0.349	2	4.5
Candida	2	15.4	7	22.6	0.589	9	20.5
Enterobacter aerogenes	2	15.4	3	9.7	0.586	5	11.4
Klebsiella oxytoca	2	15.4	2	6.5	0.347	4	9.1
Serratia marcescens	0	0	1	3.2	0.512	1	2.3
Enterobacter aerogenes	0	0	0	0	–	0	0
Burcoliholderia cepecia	1	7.7	0	0	0.118	1	2.3
Pseudomonas aeruginosa	1	7.7	3	9.7	0.834	4	9.1
Enterobacter faecium	0	0	0	0	–	0	0
Extended-spectrum beta-lactamase	1	7.7	2	6.5	0.882	3	6.8
Streptomonas maltophilia	1	7.7	1	3.2	0.516	2	4.5
After tracheostomy							
Escherichia coli	1	7.7	2	6.5	0.882	3	6.8
Klebsiella pneumoniae	1	7.7	1	3.2	0.516	2	4.5
Acinetobacter baumannii	6	46.2	12	38.7	0.647	18	40.9
Methicillin-resistant *Staphylococcus aureus*	1	7.7	2	6.5	0.882	3	6.8
Candida	1	7.7	0	0	0.118	1	2.3
Enterobacter aerogenes	0	0	0	0	–	0	0
Klebsiella oxytoca	0	0	1	3.2	0.512	1	2.3
Serratia marcescens	0	0	0	0	–	0	0
Enterobacter aerogenes	0	0	0	0	–	0	0
Burcoliholderia cepecia	0	0	1	3.2	0.512	1	2.3
Pseudomonas auroginosa	1	7.7	5	16.1	0.457	6	13.6
Enterobacter faecium	0	0	0	0	–	0	0
Extended-spectrum beta-lactamase	1	7.7	3	9.7	0.834	4	9.1
Streptomonas maltophilia	0	0	0	0	–	0	0

lower in patients without nosocomial pneumonia prior to undergoing tracheostomy and with patients who had APACHE II scores of <25. However, our statistical results do not provide enough proof to declare that early tracheostomy decreases overall mortality rates in postoperative cardiovascular surgery patients. In post-cardiac surgery patients, mortality is a multifactorial event; therefore, we think that tracheostomy may increase the pulmonary care and comfort of patients, but the change in mortality rates is not attributable to the timing of tracheostomy alone.

Our results show that early tracheostomy does not decrease the incidence of nosocomial pneumonia or superinfection rates. In cardiovascular surgery patients, it may be useful to assess the respiratory functions on a daily basis and to perform tracheostomy accordingly due to its other significant advantages.

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