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RESEARCH ARTICLE

Use of Endotracheal Tubes with Subglottic Drainage Reduces Ventilator-associated Pneumonia in Chronic Obstructive Pulmonary Disease Patients After Coronary Surgery

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ABSTRACT

Objectives: We investigated the effects of endotracheal tubes with subglottic drainage (SGAETT) on the incidence of ventilator-associated pneumonia (VAP) in patients with chronic obstructive pulmonary disease (COPD) undergoing coronary artery bypass grafting (CABG).

Methods: The patients were assigned to one of two groups. Group 1 patients used a SGAETT (n=94); Group 2 controls received standard endotracheal tubes (n=100). The demographic data, number of coronary bypasses performed, and cross clamp (CC) and cardiopulmonary bypass (CPB) durations were recorded. Endotracheal aspiration samples were obtained from patients with suspected VAP in the intensive care unit (ICU). Intubation time, length of ICU and hospital stays, erythrocyte transfusion volume, enteral nutrition needs, transportation needs, and reintubation and sedation needs were recorded.

Results: The VAP rate was 6.8% in Group 1 and 19% in Group 2 ($p<0.05$). Group 1 patients had lower body weight, smoking, and transportation needs; Group 1 patients also had shorter ICU and hospital stays but demonstrated a greater average body surface area, higher mean pulmonary arterial pressure, more-frequent peptic ulcers, higher mean pulmonary arterial pressure, and Group 1 patients were more likely to have ejection fractions (EFs) less than 40% ($p<0.05$). A logistic regression analyses found SGAETT independently reduced VAP independently (OR: 0.037) ($p<0.05$).

Conclusion: SGAETT reduces the incidence of VAP in patients with COPD undergoing cardiac surgery.

Keywords: Chronic obstructive pulmonary disease, coronary artery bypasses grafting, subglottic aspiration, ventilator-associated pneumonia

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Introduction

Ventilatory-associated pneumonia (VAP) is pneumonia that occurs after the first 48 h of mechanical ventilation in patients without prior pneumonia. VAP is the most frequent reason for nosocomial infections in intensive care units (ICUs), with an incidence of 10%–40% and very high mortality.[1,2]

Poor aspiration technique and exogenous airway contamination may cause VAP. Therefore, it may be possible to prevent VAP by aspirating secretions from the subglottic space.[3] VAP increases hospital mortality, prolongs mechanical ventilation and ICU stays, particularly in patients with chronic obstructive pulmonary disease (COPD). COPD is also an independent risk factor for developing VAP.[2] We investigated the effects of an endotracheal tube with subglottic drainage (SGAETT) on VAP incidence in patients with COPD undergoing coronary artery bypass grafting (CABG) surgery.

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Methods

This prospective randomized controlled study was approved by the Education Planning and Coordination Committee of our hospital (EPKK number: 2012/34.8720) and carried out according to the Declaration of Helsinki. The study participants were all adults who underwent surgery between June 2012 and October 2013 at the same center. We excluded patients with preoperative VAP diagnostic criteria, patients who underwent cardiac or vascular surgical intervention or an additional non-CABG procedure, and patients whose surgical interventions were emergent were excluded from the study. The patients were randomly assigned to one of two groups via computer algorithm. Group 1 (n=94) received the SGAETT (Shiley™ Evac Oral TrachealTube, SealGuard) and Group 2 (n=100) received conventional endotracheal tubes (SETT [Bicakcilar Cuffed Endotracheal Tube]).

An earlier study found patients who received SETT were 9.6% more likely to develop VAP than patients who received SGAETT. Based on this effect size estimate, we estimated that 95 patients would be required to detect between-group differences, assuming a two-sided α between the 95% confidence interval and 80% power.

Each patient's preoperative age, height, body weight, and body surface area (BSA) were recorded. History of peptic ulcers, diabetes mellitus (DM), smoking, usage of antibiotics over the preceding 3 months, prior hospitalization, prophylaxis for stress ulcer, and usage of steroids or bronchodilator medication were recorded. Preoperative left ventricular ejection fraction (EF) and mean pulmonary artery pressure (MPAP) values were recorded in the preoperative period by transthoracic echocardiography. Routine spirometric analysis and consultation from the Chest Diseases Clinic were performed for all patients to diagnose COPD and determine its severity. For standardization, anesthetic management, and surgical procedures were performed similarly for all patients.

Cephazolin-Na was administered as surgical prophylaxis to all patients for 48 h before the operation. Per perioperative data, the number of vessels bypassed, cross clamp (CC), and cardiopulmonary bypass (CPB) durations, amount of perioperative blood transfusion, and overall fluid balance at the end of the operation were recorded.

All patients were transferred to the cardiovascular ICU postoperative and ventilated with 60% oxygen. The tidal volume was 6–8 mL/kg. The fraction of inspired oxygen (FiO_2) and respiratory rate were maintained as PaO_2 >80 mmHg and $PaCO_2$: 35–45 mmHg, respectively, during routine blood gas analysis intervals. Midazolam was administered to patients whose Richmond Agitation Sedation Scale (RASS) scores were between 0 and −2. RASS was preferred because it was easy to perform and did not require advanced training.[4] All the patients' endotracheal cuff pressures were maintained at 20–30 mmHg, and the bed heads were fixed at a 45º angle. The patients' endotracheal tubes were aspirated at maximum intervals of 2 h. Patients who were hemodynamically and unremarkable blood gas analyses were extubated. Enteral nutrition was started following nasogastric tube placement 48 h postoperatively for patients who continued to require mechanical ventilation. ETA was sent from patients who could not be extubated within the first 48 postoperative hours and for whom VAP was clinically suspected. We calculated clinical pulmonary infection scores (CPISs) and those with a CPIS ≥6 were considered to demonstrate VAP.[5] We additionally recorded the following data from Group 1 and 2 patients: postoperative mechanical ventilation time, length of ICU, hospital stay (in days), amount of erythrocyte transfusion used (in units), the need for enteral nutrition by nasogastric tube, transport requirement between the clinics due to the need for imaging studies such as computerized tomography, the requirements of reintubation and sedation were recorded.

Statistical Methods

Statistical analysis was done using the Number Cruncher Statistical System (NCSS, 2007). Power Analysis and Sample Size (PASS, 2008), and "MINITAB" software. We used descriptive statistical methods (Mean, Standard Deviation, Median, Frequency, Ratio, Minimum, and Maximum) to compare quantitative data, Student's t-test for two-group comparisons of normally distributed parameters, and the Mann–Whitney U test for two-group comparisons of non-normally distributed parameters. In addition, the Pearson Chi-Square test, Fisher's exact test, and Yates' Continuity Correction test (Yates corrected Chi-Square) were used to compare qualitative data. P-values of <0.05 were considered statistically significant.

Results

There were 200 patients who were diagnosed with COPD preoperatively. After excluding six patients with missing data, 194 patients who underwent surgery between June 2012 and October 2013 at the same center were all enrolled. The sample size of our study, with 94 patients in the SGAETT group (power=0.80) and 100 patients in the SETT group (power=0.82), was sufficient and we consider our results reliable.

All patients underwent elective CABG procedures. Among the 194 patients enrolled in the study, VAP occurred in 22 (11.34%). While the BSA, EF, and forced expiratory volume in 1 second (FEV_1) values of VAP-positive and negative pa-

tients were similar (p>0.05), MPAP levels, CC, and CPB durations were significantly higher in VAP-positive patients (p<0.05) (Table 1). Six cases of VAP (6.8%) occurred in Group 1 and 16 (19%) in Group 2, indicating a statistically significant between-group difference (p<0.05) (Fig. 1). We found no significant between-group differences for age, DM, history of hospitalization, history of anti-biotherapy in the last 3 months, FEV_1 value, stress ulcer prophylaxis, the number of vessels bypassed, CC and CPB durations, the number of blood transfusions, presence of a nasogastric tube and requirement of sedation and reintubation. Group 1 demonstrated lower weight, fewer transports between hospitals; shorter intubations, and shorter ICU and hospital stays and were less likely to smoke; however, Group 1 demonstrated a higher BSA, higher MPAP values, and were more likely to have an EF <40% and a history of peptic ulcers (p<0.03) (Tables 2, 3).

When we applied logistic regression analysis due to the lack of between-group homogeneity, we found that high BSA and MPAP values increased VAP risk. In contrast, SGAETT independently reduced the occurrence of VAP (Table 4).

Table 1. VAP evaluations (all patients)

	VAP		p
	Positive (n=172) Mean±SD	Negative (n=22) Mean±SD	
BSA	1.9±0.1	1.8±0.2	0.449[a]
EF<%40	48±9.8	47.2±11.2	0.741[a]
MPAP (mmHg)	24.9±5.5	30±14.9	0.050*[b]
FEV_1	60.7±10.6	60.2±10.8	0.851[a]
Cross clamp time (min)	64±24	82±27.1	0.001*[b]
Cardiopulmonary bypass time (min)	97.3±29.5	109.9±23.1	0.007*[b]

*: p<0,05; [a]: Student's t-test; [b]: Mann–Whitney U test. VAP: Ventilator-associated pneumonia; SD: Standard deviation; BSA: Body surface area; EF: Ejection fraction; MPAP: Mean pulmonary artery pressure; FEV_1: Forced expiratory volume in one second

Discussion

Even when endotracheal tubes necessary for mechanical ventilation are correctly positioned and appropriate cuff pressures are maintained, there is an elevated risk of nosocomial pneumonia secondary to repeated escape of gastro-oropharyngeal secretions. These secretions contain bacteria and typically pool around the endotracheal tube's cuff. The upper respiratory tract, accepted as sterile, becomes colonized with gram-negative bacilli by mechanical ventilation.[6]

COPD is an independent risk factor for nosocomial lower respiratory tract infections. A study of patients with COPD who were mechanically ventilated using standard endotracheal tubes found COPD to be associated with higher mortality, prolonged mechanical ventilation, and longer ICU stays in patients with VAP.[7]

We tried to determine the isolated effects of endotracheal tube type on VAP incidence. Therefore, our study population included only high-risk patients with COPD and found that VAP was less frequent in patients who received a SGAETT. In addition, these patients's intubation duration, ICU stays, and hospital stays were significantly shorter.

While the standard endotracheal tube only enables aspiration of the distal part of the tracheal cuff from a central lumen, SGAETT contains an individual dorsal lumen that enables aspiration of both the lumen and the distal subglottic area.[8] The incidence of VAP is particularly high (3.2%–8.3%) in patients undergoing major cardiac surgery. Importantly, these patients enjoyed a significant decrease in VAP incidence secondary to SGAETT use.[9,10] These studies focused on patients undergoing valve surgery, heart transplantation, emergency cardiac surgery, and other, non-CABG surgeries. We focused solely on patients with COPD undergoing an isolated CABG. We found significant reductions in VAP incidence secondary to SGAETT use, similar to the studies above.

Another study sought to determine risk factors for postoperative pneumonia following surgery for lung cancer and found a higher risk in older patients, those with intraoperative erythrocyte transfusion, postoperative complications other than pneumonia, and lower FEV_1/FVC ratios.[11] In patients with end-stage COPD (particularly when the FEV_1 value was <50% of expected), there was a higher risk of gram-negative bacteria causing endogenous pneumonia through the oropharyngeal tract; this risk increased further with intubation.[12] Since our study consisted of only patients with COPD, FEV_1 ratios were similar between the groups.

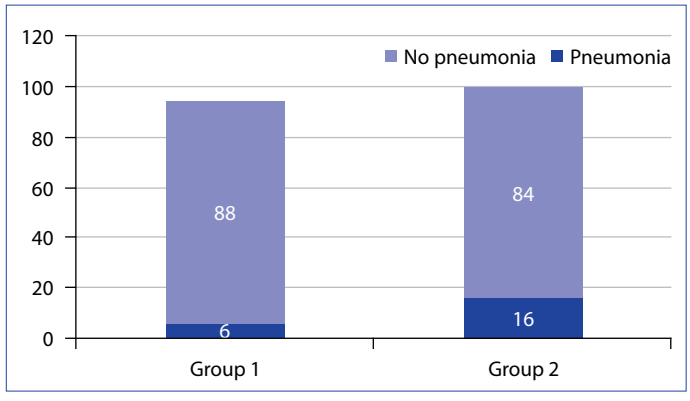

Figure 1. VAP rates for Groups 1 (SGAETT) and 2 (control).
VAP: Ventilator-associated pneumonia; SGAETT: Endotracheal tube with subglottic drainage.

Table 2. Perioperative variables for groups 1 (SGAETT) and 2 (control)

	Group 1 (n=94) Mean±SD		Group 2 (n=100) Mean±SD		p
	n	%	n	%	
Age (years)	63.7±9.3		64.3±10.1		0.683[a]
Weight (kg)	76.4±10		79.6±11.7		0.044*[a]
BSA	1.95±0.18		1.84±0.15		0.001**[a]
Use of nasogastric cannula	6	6.4	12	12.0	0.271[b]
The number of vessels bypassed	2.7±0.6		2.8±0.7		0.528[a]
MPAP (mmHg)	26.7±9.8		24.4±3.5		0.034*[b]
FEV_1 (%)	59.9±11.2		61.4±10		0.329[b]
Cross clamp time (min)	68.6±25.1		63.6±24.7		0.159[b]
Cardiopulmonary bypass time (min)	101±2.9		96.6±29.2		0.424[a]
Blood transfusion (units)	2.7±3.7		2.1±2.3		0.371[a]
Diabetes mellitus	41	43.6	32	32.0	0.095[c]
Smoking history	53	56.4	72	72.0	0.023*[c]
Hospitalization history	51	54.3	44	44.0	0.153[c]
EF ≥%40	61	64.9	88	88	0.001**[c]
<%40	33	35.1	12	12	
Peptic ulcers	28	29.8	12	12	0.004**[c]
Use of antibiotics in the last 3 months	8	8.5	12	12	0.574[c]
Prophylaxis for stress ulcer	26	27.7	16	16	0.072[c]
Blood transfusion <4 unit	39	66.1	40	66 7	0.948[d]
≥ 5 Unit	20	33.9	20	33.3	

*: p<0,05; **: p>0.05; [a]: Student's t-test; [b]: Mann–Whitney U Test; [c]: Pearson Chi-Square; [d]: Pearson Chi-Square. SGAETT: Endotracheal tube with subglottic drainage; SD: Standard deviation; BSA: Body surface area; MPAP: Mean pulmonary artery pressure; FEV_1: Forced expiratory volume in one second; EF: Ejection Fraction

Table 3. Postoperative variables for Groups 1 (SGAETT) and 2 (control)

	Group 1 (n=94) Mean±SD		Group 2 (n=100) Mean±SD		p
	n	%	n	%	
Intubation time (hour)	11±24.1		16.3±42.2		0.001[a]
Extubation time					
<48 h	84	89.4	80	80.0	0.109[c]
≥48 h	10	10.6	20	20.0	
The length of stay in the ICU (days)	2±3.2		3.5±5		0.001*[b]
The length of hospital stay (days)	7.7±2.1		11.4±5.5		0.044*[b]
The requirement for sedation	6	6.4	12	12	0.271[b]
Reintubation	6	6.4	12	12	0.271[b]
CPIS score (>6)	6	6.4	16	16	0.035*[c]
Intubated patient transport between clinics	4	4.3	16	16	0.014*[b]

*: p<0,05; [a]: Mann–Whitney U Test; [b]: Student's t-test; [c]: Yate's continuity correction. SGAETT: Endotracheal tube with subglottic drainage; SD: Standard deviation; ICU: Intensive care unit; CPIS: Clinical pulmonary infection score

In patients undergoing CABG, stress ulcer prophylaxis increases the VAP risk. Moreover, postoperative pneumonia was more common in patients administered proton pump inhibitors compared to those treated with H2-receptor blockers.[13] Interestingly, while all our Group 1 patients demonstrated a lower incidence of VAP, more patients in this group demonstrated peptic ulcer histories. Application of subglottic aspiration-even in high-risk patients-may prevent VAP.

Another study, which included all cardiac surgical procedures and recurrent surgical interventions, found a statisti-

Table 4. Logistic regression analysis of variables that affected VAP incidence

	p	Odds ratio
Use of SGETT	0.01*	0.037
Age	0.679	1.019
Weight	0.286	1.052
BSA	0.014*	0.001
Operation type	0.103	0.236
EF (%40)	0.264	1.054
MPAP	0.001*	1.475
FEV_1 (%)	0.814	1.008
Smoking	0.198	3.311
Use of antibiotics in the last 3 months	0.998	0.001

VAP: Ventilator-associated pneumonia; SGETT: Subglottic endotracheal tube; BSA: Body surface area; EF: Ejection fraction; MPAP: Mean pulmonary artery pressure, FEV_1: Forced expiratory volume in one second

cally significant relationship between prolonged CC and CPB durations and the incidence of pulmonary infections. The same study found a significant relationship between severe pulmonary hypertension and the incidence of pulmonary infections.[12] While the CC and CPB durations were similar in our study, CC and CPB durations were longer for patients with VAP. Furthermore, estimated MPAP values with preoperative transthoracic echocardiography in patients with VAP were higher than those without. Although there were, coincidentally, more patients in Group 1 with higher MPAP values and more patients with EF values lower than 40%, the lower incidence of VAP in Group 1 suggests that the application of SGAETT reduced the incidence of VAP, particularly in high-risk patients with cardiovascular disease.

Transporting mechanically ventilated patients between different hospital units for treatment or examination was also reported as an effective factor for VAP.[13] On the other hand, it was also mentioned that the patients who required in-hospital transfer demonstrated more-severe disease and had longer intensive care unit and hospital stays. These are well-known risk factors for VAP.[14,15] In contrast to our study, the patient groups in these studies included hospitalizations for all reasons, including trauma. We only enrolled patients with known preoperative risk factors who were followed up postoperatively while in the ICU. The patient transfer requirements were for brief, advanced examinations, most of which were imaging studies. The in-hospital transfer rate was significantly lower among patients who received SGAETT.[16] It is possible that complications that would require a patient to transfer to another facility were less-common in patients who received SGAETT; thus, these patients might be less likely to need in-hospital transfer.

In three studies that investigated the incidence of VAP and nosocomial pneumonia and associated factors in isolated cardiac surgery patients, reintubation was found to be an independent risk factor for pneumonia.[6–8] In our study, the reintubation rate in patients who underwent subglottic aspiration was lower than the rest, even though this finding was not statistically significant.

The most important limitation of our study was that we only examined patients presenting for isolated primary CABG to determine the effect of endotracheal tube type on VAP occurrence. However, our inclusion and exclusion criteria also controlled for other factors that could have affected VAP incidence. To our best knowledge, this is the first study to demonstrate a reduced risk of VAP and shorter ICU and hospital stays in patients with COPD undergoing CABG, who received SGAETT rather than typical (i.e., non-aspirated) endotracheal tubes.

Disclosures

Ethics Committee Approval: The study was approved by The Kocaeli University Non-Invasive Clinical Research Ethics Committee (Date: 27/12/2017, No: KÜ GOKAEK 2017/18.16).

Informed Consent: Written informed consent was obtained from all patients.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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