The Effectiveness and Impact of Preoperative Dental Hygiene Care on the Incidence of Postoperative Pneumonia after Esophagectomy: An Interventional Prospective Study

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Abstract

Background: Postoperative pneumonia is a major cause of postoperative mortality after esophagectomy. Preoperative oral hygiene care is reportedly effective to prevent pulmonary complications after esophagectomy.

Methods: Since April 2012, we have included preoperative oral hygiene in the standard perioperative care regimen for esophagectomy and have accumulated data on 188 consecutive patients undergoing esophagectomy to evaluate oral hygiene care's effectiveness. To determine basic (i.e. non-clinical) and clinical effects of preoperative oral care, we prospectively observed the incidence rate of postoperative pneumonia and accumulated perioperative culture study and oral bacteria count data on these 188 patients. One hundred five patients studied in our previous retrospective study from 2009 to 2012 were enrolled as a historical control.

Results: In the current study's patients, no significant reduction of postoperative pneumonia was observed compared to the historical control (30 out of 188 vs. 21 out of 105, P=0.423). Perioperative culture studies showed significantly decreased positivity in preoperative oral samples (11% in dental plaque and 13% in tongue coating) but no such decrease was observed in studies of postoperative gastric juice and endotracheal sputum. With the exception of postoperative endotracheal sputum, perioperative cultures had few of the pathogenic microbes identified in pneumonia patients. In the analyses of oral bacterial count, oral microbial flora were significantly decreased after oral care in both dental plaque (median ratio to before care: 1:0.13, P<0.0001) and tongue coating (median ratio: 1:0.015, P<0.0001); however, only in the dental plaque did the decrease last until the day of the operation (median ratio: 1:0.10, P=0.0008). Logistic regression analysis showed only the bacterial amount in dental plaque on the operation day (P=0.026) to be marginally correlated to the incidence of pneumonia.

Conclusions: Although perioperative oral hygiene care had a significant impact on oral bacterial load, its contribution to the prevention of postoperative pneumonia was limited.

Trial registration: This study was registered and approved by the institutional review board of The University of Tokyo Hospital: Approval number: 3383, Date: 26th November, 2011

Background

Esophagectomy is associated with high postoperative morbidity (1,2,3). Most postoperative mortality is accounted for by respiratory complications, whose incidence in the first decade of the 21st century has been reported to range from 16–27% (3,4,5). Innovations and progress have been made in surgical techniques as well as in perioperative care, and postoperative morbidity has decreased (6,7,8). Among the innovations proposed to reduce pulmonary complications after esophagectomy is perioperative oral hygiene care (9,10, 11,12).

Evidence of the effectiveness of oral hygiene care to prevent postoperative pneumonia has not been convincing, however, due to the small number of studies conducted so far. Our own previous study of 105 esophageal cancer patients suggested that pathological bacteria responsible for postoperative pneumonia were rarely detected in preoperative oro-nasal culture specimens (13). This calls into question the theory that postoperative pneumonia is caused by oral pathogenic bacteria. Both the rationale and the clinical benefit of oral hygiene care before esophagectomy required reappraisal in a prospective study.

In this study, we investigated the incidence of postoperative pneumonia in prospectively accumulated esophageal cancer patients who had received preoperative oral hygiene care by dentists before their operation. We also investigated both quantitatively and qualitatively the effect of oral hygiene care on microbes adjacent to the airway.

Methods

Patients

A consecutive series of 188 esophageal cancer patients who underwent esophagectomy from April 2012 to March 2016 in The University of Tokyo Hospital were enrolled. We previously reported the incidence of postoperative pneumonia as 20% (21 out of 105 patients) from 2009 to 2012 in a patient cohort without preoperative oral hygiene care; this cohort was used as a historical control (13). All of the current study participants received preoperative oral hygiene care from dentists and perioperative bacteriological studies were performed routinely as standard perioperative care. The clinico-pathological characteristics and the surgical procedures of the 105 previous and 188 current patients are shown in Table 1.

(Table 1 to be located here)

Study design

This was an interventional study with a prospectively accumulated cohort of esophageal cancer patients undergoing esophagectomy after preoperative oral hygiene care. The primary clinical endpoint was the incidence of postoperative pneumonia. The secondary study endpoint was the impact of oral hygiene care on bacteria in the oral cavity and other sites adjacent to the airway. Data obtained from the perioperative bacteriological cultures and oral bacterial counts were analyzed to evaluate oral hygiene care's effectiveness in both clinical and non-clinical terms.

Oral hygiene care

Patients visited dentists as outpatients and screening for dental disease was done by dental pantomography. Tooth extraction was performed when severe dental disease was noted. Buccal swab samples were retrieved for quantitative bacterial analysis as described in the subsequent section. After these steps, patients were given detailed instructions on tooth-brushing techniques and advised to perform tooth brushing at least three times a day. No subsequent care was given by dentists except on occasions such as follow-up visits after tooth extraction.

Perioperative culture studies

Culture specimens were collected at the sites and timings reported below and sent immediately to the laboratory. Bacteriological studies were performed in exactly the same way as those in our previous study (13). The culture specimens were (A) dental plaque and (B) tongue coating immediately before surgery; (C) gastric juice from the gastric conduit immediately before anastomosis; (D) sputum obtained by endotracheal suction during the operation; (E) gastric juice from the nasogastric tube on the first or the second postoperative day; (F) sputum obtained by endotracheal suction within three days after surgery.

Quantitative measurement of oral bacteria.

Quantitative measurement of oral bacteria was begun in March 2013. Buccal swabs were done with cotton swab sticks from the 5^{th} tooth (or, if missing, from any other tooth) and the tongue coating. These swab samples were processed using a Bacterial Counter (Panasonic Healthcare Co., Ltd., Tokyo, Japan) according to the manufacturer's instructions. This device measures the dielectrophoretic impedance in the aqueous medium washing the cotton swab to quantify the amount of microbes trapped in the cotton swab (14,15). If possible, this quantification of the oral cavity microbial load was repeated three times for each patient: the first and the second samples were retrieved before and immediately after oral hygiene care, and the third was retrieved in the early hours of the day the surgery was performed. (The first and the second samplings, however, had to be abandoned in January 2015 when the medical staff collecting these specimens retired.) Increases or decreases in the bacterial load detected in the three types of specimens and their association with the incidence of postoperative pneumonia were the subjects of the analysis.

Diagnostic criteria of postoperative pneumonia

The diagnosis of pneumonia was made in accordance with the Japanese Respiratory Society's Guidelines for Hospital Acquired Pneumonia in Adults. This diagnosis was contingent on the presence of pulmonary infiltrates in the standard chest radiography and at least two of the three criteria (a) pyrexia (>38.0 degrees), (b) leukocytosis (>12,000/mm3) or leukocytopenia (<4000/mm3), and (c) purulent airway exudates. All cases of pneumonia diagnosed by the above diagnostic criteria occurring within 14 days after the operation were retrospectively defined as postoperative pneumonia [16]. These criteria are identical to those of our previous study.

Statistical analysis

Proportional differences were tested by Fisher's exact test. Student's *t*-test was used to compare group differences. Association of the oral bacterial count to the incidence of pneumonia was verified by logistic regression analysis. A value of $P<0.05$ was regarded as statistically significant. All analyses were performed using JMP Pro software version 14.0.0 (SAS Institute Inc., Cary, NC, USA).

Results

Incidence of pneumonia

Diagnoses of pneumonia were made from four to fourteen days after the surgery (median: 6 days). In the current cohort, 30 out of 188 patients (16%) suffered from postoperative pneumonia; the reduction in pneumonia incidence in comparison to our previous cohort (16% vs. 20% (21/105), P = 0.423) was not considered significant.

Perioperative Cultures And Incidence Of Pneumonia

Positivities of the preoperative oral specimens, namely (A) and (B), were lower (11%, P = 0.018 and 13%, P = 0.0011, respectively) in the current study patients; in the intraoperative and postoperative culture studies, namely (C), (D), (E) and (F), the current and the previous studies' positivities did not differ. None of the culture studies (from (A) to (F)) showed significant associations with the incidence of pneumonia (data not shown). In 25 out of the 30 pneumonia patients, bronchoscopically suctioned sputum was collected soon after the onset of pneumonia; Table 3 shows the result of bacteriological studies performed before and after the onset of pneumonia.

(Table 3 to be located here.)

Twenty-three cases presented microbial growth in the sputum specimen after onset; species detected included *Klebsiella pneumoniae* (7 cases), *Pseudomonas aeruginosa* (5 cases), *Xanthomonas maltophilia* (8 cases), as well as other microbes in a few cases. In 10 out of the 23 cases these presumably pathogenic microbes were identified in the perioperative studies performed before the onset of pneumonia. Such identification was observed most frequently in (F) endotracheal sputum retrieved after surgery (8 out of 20); detection rates were lower in other bacteriological study categories.

Effect Of Oral Hygiene Care On Oral Bacterial Amounts

Quantitative evaluations of oral bacteria were performed using the Bacterial Counter for 129 patients; complete sets (before oral care, after oral care, on the operation day) were available from 62 patients. Histograms in Fig. 1 show rates of reduction to before-surgery levels of bacterial amounts on two occasions, soon after oral care and on the day of the operation. Bacterial amounts were significantly decreased immediately after oral hygiene care in both dental plaque (median ratio to before oral care 1:0.015, P < 0.0001) and tongue coating (median ratio to before oral care 1:0.13, P < 0.0001). The decrease on the operation day was also significant in dental plaque (median ratio 1:0.10, P = 0.0008) but not in tongue coating (median ratio 1:0.83, P = 0.2313).

Correlation Of Oral Bacterial Amounts To Incidence Of Pneumonia

We also investigated whether oral bacteria amounts were associated with the incidence of postoperative pneumonia. Table 4 summarizes the logistic regression analyses for their possible association with the incidence of postoperative pneumonia. Bacterial amount in dental plaque was the sole criterion that showed a (marginal) association.

Discussion

In this study, we investigated preoperative oral hygiene care's effectiveness in reducing the incidence of postoperative pneumonia after esophagectomy. We also analyzed oral care's basic (i.e. non-clinical) effects on microbes that might induce postoperative pneumonia. Culture studies as well as analysis of oral cavity bacterial flora showed clear effects of oral hygiene care. These effects did not, however, appear to have reduced postoperative pneumonia.

Comparison of the previous and the current cohorts might have been confounded by evolution in the types of surgical procedure employed, especially the surgical approach and the reconstruction route. The current cohort included a greater proportion of non-transthoracic approaches and posterior mediastinal route reconstruction (Table 1). When patients undergoing non-transthoracic esophagectomy were excluded from both studies, the difference in pneumonia incidence between the previous and the current cohorts was smaller (21% (21 out of 102) vs. 20% (26 out of 131 patients)). When the two cohorts' comparisons were performed separately for each of the three types of reconstruction route, no significant difference in pneumonia incidence was observed (data not shown).

Our current findings are incompatible with previous reports investigating the effectiveness of preoperative oral hygiene care for patients undergoing esophagectomy (10,11,12); evidence of its effectiveness has also been reported by several studies in fields of surgery other than esophagectomy (17,18). The discrepancy might be explained in part due to differences in preoperative intervention methods. The fact that study participants' compliance and adherence were not investigated also limits the significance of our findings. However, the intervention included in our study did reduce the rates of positive findings of oral bacteria in culture studies and also reduced bacterial amounts in dental plaque on the operation day. Postoperative culture studies, however, showed no decrease in positivity, which implies that the effect of preoperative oral hygiene care had become attenuated or limited in the meantime, and that improvement in the postoperative airway environment had no meaningful lasting effect. In patients after esophagectomy, airway contamination by regurgitated gastric contents must also be considered a significant source of pathogenic microbes responsible for postoperative pneumonia; recurrent nerve injuries as a surgical complication or clinical manifestations of lymphatic metastasis may also corrupt the airway environment. Given the existence of such adverse factors, preoperative oral hygiene interventions cannot be assured of success in improving postoperative airway bacteriological status. Preoperative oral hygiene care may therefore be less useful for patients undergoing esophagectomy than it is for patients undergoing other types of surgeries.

In our attempt to identify quantifiable factors associated with the frequency of pneumonia, only bacterial amounts in preoperative dental plaque appeared to have (marginal) significance. Preoperatively reduced bacterial amounts can be interpreted as a sign of successful oral hygiene care; in those patients whose adherence to oral hygiene care was exceptionally good, postoperative pneumonia may well have been prevented effectively through these measures. Preoperative oral hygiene care may also have different effects in individuals with varying compliance, dental disease, and susceptibility to pneumonia.

In sum, the oral hygiene care investigated in our study showed significant effects on the oral bacterial studies' findings, but those effects were insufficient to reduce the incidence of postoperative pneumonia after esophagectomy. Preoperative reduction of oral bacteria as a preemptive measure to prevent postoperative pneumonia awaits continued re-evaluation through further prospective studies or more powerful oral hygiene interventions.

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board of The University of Tokyo Hospital (No.3383). All participating patients gave written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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None to be declared.

Authors' contributions

KM: Writing the manuscript; Study design; Statistical analyses.

Acknowledgment

Not applicable.

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Tables

Table 1. Clinico-pathological characteristics of patients.

	Previous cohort n=105	Current cohort n=188	P value*
Gender (male/female)	91/14	152/36	0.257
Median age (range)	66 (41-86)	66 (39-92)	0.315
Median body mass index (range)	20.9 (13.4-31.4)	21.8 (13.4-33.4)	0.157
Pathological stage† (I/II/III/IV)	12/21/38/25/9	17/42/63/51/15	0.908
Smoker (yes/no)	80/25	156/32	0.169
Type of operation (thoracic one-stage/ non-transthoracic one-stage/ two-stage)	85/3/17	121/57/10	<0.0001
Conduit (stomach/other)	91/14	180/8	0.575
Reconstruction route (posterior mediastinum/retrosternal/subcutaneous)	76/5/24	175/2/11	<0.0001
Operation time (minutes)	380 (190-712)	393 (169-827)	0.0433
Estimated blood loss (ml)	460 (50-2810)	420 (20-3810)	0.159

† Staged defined according to the Japanese Classification of Esophgaeal Cancer, 11th Edition

* Fisher's exact test for proportional differences and Student's *T*-test for average differences

Table 2. Positivities of culture studies in previous and current study

Timing of retrieval	Culture specimen	Previous study	Current study	P value*
Before surgery	A) Dental plaque	13/54 (24%)	20/178 (11%)	0.018
	B) Tongue coating	19/55 (35%)	24/179 (13%)	0.0011
During surgery	C) Gastric juice	14/82 (17%)	19/174 (11%)	0.23
	D) Endotracheal sputum	11/89 (12%)	16/168 (10%)	0.52
After surgery	E) Gastric juice	38/56 (68%)	71/136 (52%)	0.55
	F) Endotracheal sputum	51/92 (55%)	80/156 (51%)	0.60

* Fisher's exact test

Table 3. Bronchial microbes detected after the onset of pneumonia and perioperative bacteriological study findings†.

		Before surgery		During surgery		After surgery	
Case	Bronchial microbes after pneumonia	A) Dental plaque	B) Tongue coating	C) Gastric juice	D) Endo-tracheal sputum	E) Gastric juice	F) Endo-tracheal sputum
1	*K. pneumoniae*	No growth	No growth	*K. pneumoniae*/ *C. albicans*	*C. albicans*	*C. albicans*	No growth
2	*K. pneumoniae*	*C. albicans*	*C. albicans*	*C. freundii*	No growth	*E. cloacae*/ *C. freundii*	*C. freundii*
3	*K. pneumoniae*	No growth	No growth	No growth	No growth	No growth	No growth
4	*K. pneumoniae*/*X. maltophilia*	No growth	No growth	No growth	No growth	***K. pneumoniae***	***K. pneumoniae***
5	*K. pneumoniae*/*X. maltophilia*	*S. aureus*	No growth	No growth	No growth	*E. cloacae*	*S. aureus*
6	*K. pneumoniae*/*K. oxytoca* / *C. albicans*/*S. marcescens*	No growth	*S. agalactiae*	No growth	***K. oxytoca*/ *S. marcescens*/** *E. aerogenes*	No growth	N/A
7	*K. pneumoniae*/*P. aeruginosa*	No growth	No growth	No growth	No growth	*P. vulgaris*	***K. pneumoniae***/ *E. cloacae*/ *Neisseria*
8	*P. aeruginosa*	No growth	No growth	***P. aeruginosa***	No growth	N/A	***P. aeruginosa***
9	*P. aeruginosa*	***P. aeruginosa***/ *E. cloacae*	***P.aeruginosa***/ *E. Cloacae*	No growth	N/A	N/A	***P. aeruginosa***
10	*P. aeruginosa*	No growth	No growth	***P. aeruginosa***	N/A	***P. aeruginosa***	***P. aeruginosa***
11	*P. aeruginosa*/*X. maltophilia*	No growth	No growth	No growth	*C. albicans*	*E. coli*	*Acinetobacter*
12	*X. maltophilia*	No growth	No growth	N/A	N/A	N/A	N/A
13	*X. maltophilia*	No growth	No growth	No growth	No growth	No growth	No growth
14	*X. maltophilia*	No growth	No growth	No growth	No growth	No growth	No growth
15	*X. maltophilia*/*C. albicans*	N/A	N/A	N/A	N/A	N/A	*S. pneumoniae*
16	*E. coli* /*X. maltophilia*	*E. cloacae*/ *S. marcescens*	*E. cloacae*/ *S. marcescens*	*E. cloacae*	N/A	*E. cloacae*	*E. cloacae*/ *S. marcescens*
17	MRSA	No growth	No growth	No growth	No growth	N/A	*E. cloacae*
18	MRSA	No growth	No growth	No growth	No growth	N/A	**MRSA**
19	MRSA	No growth	No growth	No growth	N/A	No growth	N/A
20	*S. pneumoniae*	No growth	No growth	No growth	No growth	*E. cloacae*	*E. cloacae*
21	*Acinetobacter*	N/A	No growth	No growth	No growth	No growth	No growth
22	*C. albicans*	***C. albicans***	***C. albicans***	N/A	***C. albicans***	No growth	***C. albicans***
23	*C. albicans*	No growth	No growth	No growth	No growth	***C. albicans***	***C. albicans***
24	No growth	No growth	No growth	No growth	No growth	No growth	*X. maltophilia*
25	No growth	No growth	No growth	N/A	No growth	N/A	No growth
Detection in total		2/21	2/22	3/20	2/17	3/17	8/20

Bold lettered bacteria species were also detected in the endotracheal sputum after pneumonia. †Abbreviations; *K. pneumoniae*: *Klebsiella pneumoniae*, *C. albicans*: *Candida albicans*, *C. freundii*: *Citrobacter freundii*, *E. cloacae*: *Enterobacter cloacae*, *X. maltophilia*: *Xanthomonas maltophilia*, *S. aureus*: *Staphylococcus aureus*, *K. oxytoca*: *Klebsiella oxytoca*, *S. marcescens*: *Serratia marcescens*, *S. agalactiae*: *Streptococcus agalactiae*, *E. aerogenes*: *Enterobacter aerogenes*, *P. aeruginosa*: *Pseudomonas aeruginosa*, *P. vulgaris*: *Proteus vulgaris*, *S. pneumoniae*: *Streptococcus pneumoniae*, *E. coli*: *Escherichia coli*, MRSA: Methicillin-resistant *Staphylococcus aureus*, N/A: not available