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# Impact of tongue biofilm removal on mechanically ventilated patients

*Impacto da remoção de biofilme lingual em pacientes sob ventilação mecânica*

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This study was conducted at Hospital Santa Cruz - São Paulo (SP) and Hospital Premier - São Paulo (SP), Brazil.

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## ABSTRACT

**Objective:** To evaluate the effectiveness of a tongue cleaner in the removal of tongue biofilm in mechanically ventilated patients.

**Methods:** Tongue biofilm and tracheal secretion samples were collected from a total of 50 patients: 27 in the study group (SG) who were intubated or tracheostomized under assisted ventilation and treated with the tongue cleaner and 23 in the control group (CG) who did not undergo tongue cleaning. Oral and tracheal secretion cultures of the SG (initially and after 5 days) and the CG (at a single time-point) were performed to evaluate the changes in bacterial flora.

**Results:** The median age of the SG patients was 77 years (45-99 years), and that of the CG patients was 79 years (21-94 years). The length of hospital stay ranged from 17-1,370 days for the SG with a median stay of 425 days and from 4-240 days for the CG with a median stay of 120 days. No significant differences were found when the dental

plaque indexes were compared between the SG and the CG. There was no correlation between the index and the length of hospital stay. The same bacterial flora was found in the dental plaque of 9 of the 27 SG patients before and after the tongue scraper was used for 5 days compared with the CG ( $p=0.683$ ). Overall, 7 of the 27 SG patients had positive bacterial cultures for the same strains in both tongue biofilm and tracheal secretions compared with the CG ( $p=0.003$ ). Significant similarities in strain resistance and susceptibility of the assessed microorganisms were observed between oral and tracheal microflora in 6/23 cases in the CG ( $p=0.006$ ).

**Conclusion:** The use of a tongue cleaner is effective at reducing tongue biofilm in patients on mechanical ventilation and facilitates oral hygiene interventions performed by caregivers.

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**Keywords:** Tongue; Patient care; Respiration, artificial; Oral hygiene; Oral health

## INTRODUCTION

The risk of oral infections and their association with pneumonia in critically ill patients has been well-studied.<sup>(1-4)</sup> However, colonization of the tongue by microbiota and its effect on the overall health of individuals who are dependent on medical care has been poorly studied. Oliveira et al. evaluated biofilms that had formed on humidifier tubes in intubated patients and compared them with dental and tongue biofilms. They found a higher frequency of colonization (63%) by *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Escherichia coli* in the tongue biofilms (TBs).<sup>(1)</sup> These results support the

need for interventions to remove biofilm from the tongue.

Tongue coating, also termed tongue biofilm, is a relatively common alteration that mainly consists of food debris, desquamated cells, fungi, bacteria and active enzymes that are involved in the digestion process. Seemann et al. studied the effect of tongue cleaning to remove this coating on the levels of volatile components related to halitosis.<sup>(5)</sup> Studies conducted at universities have evaluated tongue coating removal using a toothbrush compared with a tongue cleaner and found that the toothbrush removed 0.6 g of tongue coating, whereas the tongue cleaner removed 1.3 g and caused no discomfort.<sup>(6)</sup> Another study assessed tongue coating removal using three mechanical hygiene methods (gauze, toothbrush and a tongue cleaner) and found that the tongue cleaners were the most efficient method.<sup>(7)</sup>

Based on the current knowledge of the microbiota in the tongue and its infectious impact, this study examined the presence of respiratory pathogens on the tongue surface and evaluated the efficiency of a tongue cleaner (TePe®) in removing TB based on the microbiological evaluation of biofilms. The microbiota in biofilms from patients who received tongue cleaning were compared with the microbiota in the tracheal secretions from mechanically ventilated patients.

## METHODS

A prospective, observational, nonrandomized study was performed with 50 patients who were divided into two groups: a study group (SG) that consisted of 27 patients who underwent oral hygiene procedures with a tongue cleaning device and who were admitted to hospital units specialized in palliative care and a control group (CG) that consisted of 23 patients who were sanitized according to routine nursing practices at the intensive care unit (ICU) of a general hospital. All of the patients were mechanically ventilated, hospitalized for over 72 hours and orotracheally intubated or tracheostomized.

This study was approved by the research ethics committees of the institutions that were involved in the study (Hospital Santa Cruz - SP e Hospital Premier - SP), and the study complied with the ethical principles of the Declaration of Helsinki (1964). All of the guardians of the study subjects freely signed an informed consent form.

Patients who were fully or partly dependent on medical care, defined as patients who could not perform oral hygiene alone and depended on a healthcare staff member, were included in the study.

Patients were evaluated by two dentists who used

the clinical criteria for the presence or absence of TB in an oral evaluation.<sup>(8)</sup> TB swabs were collected at the first time-point for the SG sample collection using a sterile TePe® tongue cleaner and sterile gloves. Swabbing was performed using sterile materials and methods; the harvested material was placed in Stuart transport medium (4 mL). Culture tests and antibiograms were performed on all of the tracheal and oral secretion samples from the SG and the CG. All of the samples of the collected material were taken to the laboratory within 4 hours. The caregiver kept the scraper and was instructed to use it daily as an oral hygiene accessory and ensure that the scraper was properly rinsed under running water, dried and stored in a dry and clean environment. The second sample collection of tongue coating, termed oral secretion culture 2 (OSC2), and a sample collection of tracheal secretions, termed tracheal secretion culture (TSC), were performed 1 week after the first sample collection, termed oral secretion culture (OSC). The same TB and tracheal secretion sample collection procedures were performed for the CG at a single time-point after 72 hours of hospitalization and mechanical ventilation.

The Simplified Oral Hygiene Index (SOHI, Greene and Vermillion, 1964)<sup>(9)</sup> was used to clinically evaluate the amount of dental biofilm in the SG at days 1 and 5 and in the CG at a single time-point.

Personal protective equipment, including a mask, safety goggles, hand sanitation and sterile gloves, was used when collecting the tracheal secretions. A 12-gauge sterile suction catheter, which was connected to the sterile collection tube, was introduced, and the secretions (a 5-mL minimum volume) were collected. When the secretions were thick and did not reach the required volume, 0.9% saline was instilled.

The microbiology laboratory of Diagnósticos da América S.A. (DASA), which is located in São Paulo (SP), assisted in the qualitative evaluation of the sample materials using standardized culture tests and antibiograms.

The analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 18.0. The  $\chi_2$  test, Fisher's exact test and McNemar's test were used to compare the qualitative variables, which were expressed as frequencies and ratios. The normality of the quantitative variables was assessed using the Shapiro-Wilk test, and the Mann-Whitney test was used to compare the quantitative variables between both groups. The correlation between the SOHI and the days of hospitalization was assessed using Spearman's test. The value of statistical significance was set at 5% or  $p < 0.05$ .

## RESULTS

The results indicated that the median age of the SG patients was 77 years (45-99 years) and that of the CG patients was 79 years (21-94 years). The median length of hospital stay was 425 days in the SG and 120 days in the CG (Table 1). The following SOHI results were found: value 0 in 21 patients, value 1 in 10 patients, value 2 in 12 patients and value 3 in 6 patients. The SOHI was not correlated with the length of hospital stay in the total

**Table 1** - General characteristics of the patients (N=50)

Sample characteristics (N=50)	Control group (N=23)	Study group (N=27)	p value
Age (median)	79	77	0.6401
IQR	17	27	
Gender (%)			
Female	12 (52)	14 (52)	
Male	11 (48)	13 (48)	
IQR	1	1	
Primary diagnosis (%)			
Neurological diseases (stroke, Alzheimer's)	5 (22)	18 (67)	0.9898
Infectious diseases (lung diseases, sepsis)	17 (74)	7 (26)	0.7788
Cancer	1 (4)	2 (7)	0.6531
Days of hospitalization	32	331	<0.00001
Days of orotracheal intubation	12	331	<0.00001
IQR	19	509	

IQR - interquartile range.

sample ( $r=0.210$  and  $p=0.146$ ).

Only 9 of the 27 patients had positive microbial cultures before and after using the tongue scraper (at OSC and OSC2). There were no significant differences between the SG and the CG when these findings were compared using McNemar's test ( $p=0.683$ ). The microorganisms detected in the SG were *Citrobacter koseri*, *Klebsiella ESBL*, *Providencia spp.*, *P. aeruginosa*, *Pseudomonas fluorescens*, *Serratia marcescens* and coagulase-negative *Staphylococcus*. The TB culture (OSC2) and TSC results in the SG revealed several shared bacterial strains: *C. koseri*, *Proteus mirabilis*, *P. aeruginosa* and *P. fluorescens*. Overall, 7 of the 27 subjects had both a positive OSC2 and positive TSC results, which was significantly different from the results for the CG ( $p=0.003$ ). There were no similarities between the strains of microorganisms that were found at the two study centers (Table 2), and there was no consistency in antibiotic resistance (data not shown).

The reduction in TB and halitosis in the SG patients who were clinically assessed at the OSC and OSC2 time-points was significant according to the patient caregivers.

## DISCUSSION

Most critically ill patients who are hospitalized lack proper oral hygiene, most likely due to the lack of

**Table 2** - Distribution of the microorganism strains found at different sample collection time-points

Microorganism	Control group (N=23)		Resistance to antibiotics	Study group (N=27)			Resistance to antibiotics
	OSC	TSC		OSC	OSC2	TSC	
<i>Acinetobacter baumannii</i>	2	2	Oxacillin, vancomycin, carbapenems	--	--	--	--
<i>Acinetobacter ssp.</i>	1	--	--	--	1	--	--
<i>Candida albicans</i>	2	2	--	--	--	--	--
<i>Citrobacter koseri</i>	--	--	--	1	1	1	Ampicillin, subactam, ciprofloxacin
<i>Enterococcus spp.</i>	1	--	--	--	--	--	--
<i>Escherichia coli</i>	--	--	--	--	1	--	--
<i>Klebsiella spp.</i>	--	1	--	--	--	--	--
<i>Klebsiella ESBL</i>	--	--	--	2	1	--	--
<i>Proteus mirabilis</i>	3	2	--	--	1	1	Ampicillin, cephalothin,
<i>Providencia spp.</i>	--	--	--	1	1	--	Cefotaxime, ciprofloxacin, gentamicin
<i>Providencia stuartii</i>	--	--	--	--	--	2	--
<i>Pseudomonas aeruginosa</i>	2	2	Ampicillin, cephalothin	2	3	2	--
<i>Pseudomonas fluorescens</i>	--	--	--	1	2	1	--
<i>Pseudomonas spp.</i>	1	--	--	--	--	--	--
<i>Streptococcus aureus</i>	1	--	--	--	--	--	--
<i>Serratia marcescens</i>	--	--	--	1	1	0	Ampicillin, subactam, ceftazidime, ciprofloxacin, gentamicin
<i>Staphylococcus spp.</i>	1	--	--	--	--	--	--
Coagulase-negative <i>Staphylococcus</i>	1	--	--	2	3	--	--

OSC - oral secretion culture; TSC - tracheal secretion culture.

knowledge regarding adequate techniques by intensive care teams and regarding the inter-professional relationship between dentistry and nursing.<sup>(10)</sup> Several studies have demonstrated the correlation between poor oral hygiene and nosocomial pneumonia; however, the need for well-designed studies persists.<sup>(11-15)</sup>

The length of hospital stay was not correlated with the amount of TB according to the SOHIs in either group when the clinical and microbiological effectiveness of TB removal and bacterial colonization in the tracheal secretions from mechanically ventilated patients were analyzed. This finding suggests that oral hygiene must be maintained with a tongue scraper, a set of interventions that will remove dental biofilm and antimicrobial solutions. The length of hospital stay varied between the SG (425 days) and the CG (120 days) due to the contrasting profiles of the inpatient units at the institutions that participated in the study. TB removal is necessary to reduce the incidence of nosocomial pneumonia<sup>(1)</sup> and halitosis. TB removal is an easy and effective oral hygiene method,<sup>(7,16)</sup> which can improve the motor function of the tongue.<sup>(17)</sup> This study found a high rate of culture positivity in the oral and tracheal secretions from the SG even after the TB was removed. This finding suggests that oral flora mobility may result from established oral care practices, which has been previously reported by several authors.<sup>(1,13,15)</sup> In this study, strain resistance was assessed by antibiograms to identify pathogenic microorganisms in the oral flora that may be involved in oral infections and trigger ventilator-associated pneumonia (VAP). Resistance was found only in the CG despite the short length of hospital stay in this group, which supports this correlation. However, studies with larger sample sizes are needed to irrefutably establish a correlation between oral microbiota and pneumonia.<sup>(18)</sup>

Halitosis is a condition that limits or hinders interventions by caregivers and the effectiveness of oral hygiene. In addition, this condition is an important clinical indication of TB accumulation.<sup>(5-7)</sup> The caregivers frequently stated that oral hygiene was easier to perform after using the tongue scraper, which consequently reduced halitosis in the patients, who were monitored by dentists in this study.

The cost of treating infections in inpatients is high because of increased therapeutic demand (spending on antibiotics), longer hospital stays and increased morbimortality.<sup>(19)</sup> The following types of costs have been classified by the Health Ministry: direct costs, which are closely related to patient expenditure on

nosocomial infections; indirect costs, which result from morbidity, including sick leave, sequelae from a disease or death; and unattainable costs, which cannot be measured economically because they include disturbances caused by pain, discomfort, isolation, distress and suffering experienced by the patient in the hospital setting.<sup>(19,20)</sup>

The implementation of oral health protocols to treat patients who are hospitalized, elderly, physically or mentally disabled or admitted to nursing homes incurs few expenses because these protocols consist of simple and inexpensive procedures that provide great benefits to patients.<sup>(18)</sup> Hospitals currently use several strategies to reduce the amount of oropharyngeal bacteria in patients, which is a leading cause of hospital respiratory infections. These strategies include respiratory physical therapy, oxygen therapy and topical administration of antibiotics. However, antibiotics are associated with adverse effects because of an increased risk of resistance to microorganisms, and all of these preventative measures are more expensive than oral hygiene practices.<sup>(12,21)</sup>

This study has several significant limitations. First, the study was not randomized or blinded. The sample size was not assessed. The SG was enrolled from a palliative care hospital for chronic patients with long hospital stays. The CG was enrolled from a general ICU with a high turnover of patients, which included clinical and surgical patients; therefore, we could not determine whether the strains that were isolated from the oral cultures were the same as those in the tracheal secretion cultures.

VAP is associated with high morbidity, a prolonged ICU stay and increased mortality rates in mechanically ventilated patients. The colonization of the aerodigestive tract by bacteria is primarily involved in VAP pathogenesis; therefore, performing preventive actions is important.<sup>(22)</sup> Oral hygiene methods that can mechanically reduce oral biofilm, including TB, as demonstrated in this study, and topical antibiotics and antiseptics<sup>(23)</sup> are effective at reducing the incidence of VAP in the ICU.

## CONCLUSIONS

The use of tongue cleaners is effective at reducing TB when these devices are used concomitantly with other oral hygiene devices. The tongue cleaners improved the quality of oral health in the patients, and the devices were easily used by the patient caregivers when they performed oral hygiene interventions.

## RESUMO

**Objetivo:** Avaliar a eficiência de limpador de língua para remoção do biofilme lingual em pacientes sob ventilação mecânica.

**Métodos:** Foram coletadas amostras de biofilme lingual e de secreção traqueal de 50 pacientes intubados ou traqueostomizados sob ventilação assistida em grupo de estudo (GE - uso de limpador lingual) e grupo controle (GC - sem higienização da língua). Foi realizada cultura de secreção oral e traqueal do GE (inicialmente e após 5 dias) e do GC (em momento único) para avaliar as modificações na flora bacteriana.

**Resultados:** Os pacientes do GE tinham mediana de idade de 77 (45 - 99 anos), e os do GC de 79 (21 -94) anos. O período de internação dos pacientes do GE oscilou entre 17 e 1.370 dias, com mediana de 425 dias, e do GC, entre 4 e 240 dias, com mediana de 120 dias. Na comparação do índice de placa bacteriana bucal entre os grupos de estudo e controle, não foram encontradas diferenças significantes. Não houve correlação entre esse índice e o

tempo de internação. A mesma flora bacteriana foi encontrada na placa bacteriana bucal antes e após 5 dias de uso do raspador lingual no GE, somente em 9 dos 27 casos em relação ao encontrado no GC ( $p=0,683$ ). Em 7 dos 27 pacientes do GE houve positividade de culturas bacterianas com as mesmas cepas tanto para biofilme lingual quanto para secreção traqueal ( $p=0,003$  em relação ao GC). A similaridade na resistência e na sensibilidade das cepas dos micro-organismos encontrados, com o objetivo de associar a flora do biofilme lingual com a da secreção traqueal, mostrou significância em 6/23 casos somente no GC ( $p=0,006$ ).

**Conclusão:** O uso do limpador de língua é um mecanismo efetivo na redução do biofilme lingual em pacientes sob ventilação mecânica, além de facilitar a ação dos cuidadores para ações de higiene bucal.

*Clinical Trial Registry* NCT01294943

**Descritores:** Língua; Assistência ao paciente; Respiração artificial; Higiene bucal; Saúde bucal

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