ORAL HEALTH STATUS IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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SUMMARY – The aim is to point to oral health status in patients suffering from chronic obstructive pulmonary disease (COPD). The study included 106 patients diagnosed with COPD who were treated at the Special Hospital for Pulmonary Diseases, Zagreb, Croatia. The World Health Organization questionnaire for oral health in adults was used as a validated measure to assess oral health. Results were compared based on the severity of the disease according to the GOLD classification, long term oxygen therapy, and their smoking habits. Most patients (61.3%) had less than 10 teeth. Also, 82.2% of the patients had problems with their oral health in the previous year. More than half of the patients (55.7%) ranked the status of their oral cavity and teeth as average or worse, whereas 58.5% of the patients ranked their gingival status as good or better. Also, 55.7% of the patients brushed their teeth once a day or less, which was more pronounced in men. The same percentage of the patients did not know whether their toothpaste contained fluoride. Sixty-seven percent of the patients were former smokers, while the rest were active smokers. Smokers reported more frequent feeling of shame and tension because of the appearance of their teeth in relation to non-smokers. Patients with advanced stages of COPD are more likely to report problems with eating and chewing food compared to patients with less advanced stages of the disease. According to the results, further systematic education of COPD patients is crucial in promoting the importance of oral health.

Key words: *Oral health; Caries; Prevention; Chronic obstructive pulmonary disease*

Introduction

Chronic obstructive pulmonary disease (COPD) is defined as a chronic inflammatory condition that is characterized with respiratory symptoms which include dyspnea and cough due to abnormalities of the airways and/or alveoli that cause persistent and in general progressive airflow obstruction. It is in direct correlation with tobacco smoking and environmental factors such as exposure to toxic particles from polluted air. There are two phenotypes of COPD, emphysema type and chronic bronchitis type. Emphysema is defined as destruction of the alveolocapillary membrane which enables respiratory gas exchange and leads to air trapping[1]. On the other hand, chronic bronchitis is defined as a productive cough during at least three months over two successive years, in which other potential causes of cough are excluded[2]. According to the Global initiative for Obstructive Lung Disease 2023 recommendations (GOLD 2023), the global prevalence of COPD is 10.3%, while the

mortality is estimated to be around three million deaths annually[3]. As the third cause of death in the world nowadays, with its progressive and irreversible nature, COPD presents a major global health problem. Oral cavity at the beginning of the respiratory tract represents the first barrier for particles that we inhale, as it is 'home' for more than 700 microorganisms that colonize it[4]. It is directly connected with the lower respiratory tract. The most common diseases of the oral cavity are caries and periodontal diseases. Dental caries, also known as tooth decay, is caused by the interaction between plaque, bacteria, and dietary sugars, leading to enamel demineralization and cavity formation[5]. On the other hand, periodontal diseases encompass gingivitis, a reversible inflammation of the gums, and periodontitis, an irreversible and more severe inflammation of the gingiva and supporting structures[6]. Research has established a clear connection between periodontitis and various systemic diseases such as cardiovascular diseases[7], diabetes[8], and respiratory infections[9]. Symptoms of periodontal diseases include red, swollen gums that bleed easily (gingivitis), and in the case of periodontitis, the gums may recede from the teeth, forming pockets that trap harmful bacteria. This can result in bone and tissue damage, eventual tooth loosening, and potential tooth loss[6]. As both COPD and periodontitis are of inflammatory origin, the same inflammatory biomarkers are involved in the pathogenesis of both conditions[5]. Several key inflammatory biomarkers are involved in both COPD and periodontitis. C-reactive protein (CRP), a marker of systemic inflammation, is consistently elevated in both conditions and has been linked to disease severity[10,11]. Interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) are proinflammatory cytokines that play pivotal roles in driving the inflammatory responses in COPD and periodontitis[12,13]. Elevated levels of these biomarkers are associated with increased disease activity and progression. Moreover, matrix metalloproteinases (MMPs), enzymes responsible for tissue remodeling, are elevated in both diseases, contributing to the breakdown of lung and periodontal tissues[14,15]. These MMPs play a central role in the destruction of extracellular matrix, resulting in the loss of connective tissues in the lungs and periodontium.

Supported with the aforementioned and other scientific publications, COPD patients with higher exacerbation rate have worse periodontal health[6].

Regardless of this, GOLD 23 recommendations do not include any information on oral health in these patients. The aim of our study was to determine oral health status in patients with COPD. We also had two hypotheses: 1) patients with a higher stage of COPD according to the GOLD 23 have worse oral health status than patients with milder stage of the disease; and 2) patients on long term oxygen therapy (LTOT) have worse oral health status than patients without it.

Materials and Methods

The World Health Organization (WHO) oral health questionnaire for oral health in adults was used as a validated measure of oral health[18]. All patients filled out the questionnaire during in-person visits at the Special Hospital for Pulmonary Diseases, Zagreb, Croatia, from November 2022 until March 2023, under physician's supervision. The study included 106 adult patients diagnosed with COPD. The only inclusion criterion was the diagnosis of COPD, which was defined as spirometry confirmed airflow obstruction with forced expiratory volume in one second/forced vital capacity (FEV1/FVC) ratio <0.70 after negative bronchodilation test in patients with prior long term cigarette smoking history. Exclusion criteria were patients diagnosed with asthma/COPD overlap and patients diagnosed with COPD diagnosis but were non-smokers. The study was approved by the Ethics Committee of the Special Hospital for Respiratory Diseases, Zagreb, Croatia (no.: 02-17/2023) and all participants signed the informed consent form before being enrolled in the study. The WHO oral health questionnaire consisted of sixteen questions that included participant`s personal information (sex, age and education) and their subjective opinion on their oral health status and daily oral care routine. There were questions if the patient had dentures, their tooth brushing habits, eating habits, smoking status, and their general knowledge and attitude on oral health and its importance. We found the questionnaire very helpful in our study since it answered all our initial dilemmas and proved our hypotheses. We used the GOLD 2023 classification to divide patients into groups according to the lung function status and rate of exacerbations. The GOLD 2023 classification divides patients into four groups (1, 2, 3 and 4) according to their initial FEV1 values. GOLD 1 patients have a post bronchodilation (post BD) FEV1 >80%, GOLD

2 have post BD FEV1 50%-79%, GOLD 3 have post BD FEV1 30%-49%, and GOLD 4 patients have post BD FEV1 <30%. There are also three subgroups (A, B and E) according to severity of their symptoms and exacerbation rate. Group A patients had zero to one moderate exacerbation in the current disease and have dyspnea status according to the modified Medical Research Council (mMRC) scale 0-1 or COPD assessment test (CAT) scale <10, group B had the same exacerbation status but dyspnea status according to mMRC >2 or >10 according to CAT while GOLD E had more than two moderate exacerbations or one leading to hospitalization with dyspnea status the same as group B patients[3]. This scoring system gives physician information about the severity and stage of patient`s disease.

Statistical analysis

Statistical analysis was conducted using SPSS Statistics software, version 29.0.1.0 (IBM, New York, NY, USA). To summarize data, descriptive statistics such as frequencies and proportions were employed. Continuous data, with age being a confounding factor, were compared using the t-test. For comparison of categorical data, the χ^2-test, Fisher exact test, and Cramer's V test were utilized to evaluate associations and differences between groups. The level of statistical significance was set at $p<0.05$.

Results

This study included 106 patients with COPD, of whom 61 (57.5%) were male and 45 (42.5%) were female. The median age of the subjects was 69 years, and there was no statistically significant gender difference (p=0.506, t-test). Most of the respondents (56.6%) had only completed secondary school. Most patients (61.3%) had less than 10 teeth and had not experienced any pain or discomfort in the oral cavity in the last year (82.2%). Almost one-fifth (17.9%) of the subjects had partial denture, 39.6% had full upper and 35.8% full lower denture. The patients mostly described the condition of their teeth as average or worse (55.7%), while they described the condition of their gingiva as good or better than that (58.5%). The patients generally brushed their teeth less frequently than once a day (55.7%); better oral hygiene was reported by women who brushed their teeth two or more times a day in 66.7% of cases, whereas males did so in only 27.9% of cases (p<0.001). Most patients did not know whether the toothpaste they used contained fluoride (55.7%), whereas more women used fluoride toothpaste (46.7% *vs*. 23%, p=0.03). Most patients (42.2%) reported that their last dental appointment was 5 years or more before. When it comes to smoking habits, the majority of patients (67%) were former smokers, while the rest were active smokers, each of them smoking every day. According to the GOLD classification, 36.8% of study patients were in group 4, 32.1% in group 3, and less than one-third in group 1 or 2. When it comes to subgroups, the majority of patients (55.7%) were in subgroup E, 29.2% in subgroup A, and 15.1% in subgroup B. Also, 25.5% of COPD patients were on LTOT. Most patients (70.4%) on LTOT had not visited a dentist for more than 5 years and reported more problems on biting and chewing food compared to patients that were not treated with LTOT (Table 1). Only nine patients had completed college, whereas the rest of them (83.4%) had completed elementary and secondary school.

Smokers reported more frequent feelings of shame and tension because of the appearance of their teeth in relation to non-smokers. They also consumed more alcohol than non-smokers (Table 2). Patients with advanced stages of COPD (GOLD classification, stages B and E) were more likely to report problems with eating and chewing food compared to patients with less advanced stages of the disease (GOLD A). Patients with end-stage GOLD classification (GOLD E) most commonly reported symptoms of xerostomia/subjective dry mouth (Table 3).

Table 1. Difference according to visiting a dentist, difficulties in food biting and difficulties in food chewing between patients on LTOT and those not on LTOT

Question	Answer	DLO$_2$/LTOT Yes	DLO$_2$/LTOT No	p value
How long has it been since you visited a dentist?	Less than 6 months	1 (3.7%)	12 (15.2%)	**0.014**** Cramer's V 0.343
	6-12 months	0 (0.0%)	10 (12.7%)	
	1-2 years	3 (11.1%)	13 (16.5%)	
	2 years or more but less than 5 years	4 (14.8%)	17 (21.5%)	
	5 years or more	19 (70.4%)	27 (34.2%)	
Difficulty biting food	Very often	7 (25.9%)	6 (7.6%)	**0.036*** Cramer's V 0.284
	Fairly often	2 (7.4%)	10 (12.7%)	
	Sometimes	2 (7.4%)	18 (22.8%)	
	No	16 (59.3%)	45 (57.0%)	
Difficulty chewing food	Very often	7 (25.9%)	6 (7.6%)	**0.027*** Cramer's V 0.295
	Fairly often	2 (7.4%)	10 (12.7%)	
	Sometimes	2 (7.4%)	20 (25.3%)	
	No	16 (59.3%)	43 (54.4%)	

*Pearson's χ^2-test; **Fisher exact test; LTOT = long term oxygen therapy; DLO$_2$ = diffusing capacity of the lung for O$_2$

Table 2. Difference in self-opinion about their oral health between smokers and ex-smokers

Question	Answer	Smoker	Ex-smoker	p value
Feeling of embarrassment because of your teeth	Very often	5 (15.2%)	2 (2.8%)	**0.006*** Cramer's V 0.292
	Fairly often	4 (12.1%)	7 (9.9%)	
	Sometimes	1 (3.0%)	2 (2.8%)	
	No	23 (69.7%)	60 (84.5%)	
Feeling of tension because of your teeth	Very often	3 (9.1%)	2 (2.8%)	**<0.001**** Cramer's V 0.377
	Fairly often	6 (18.2%)	6 (8.5%)	
	Sometimes	0 (0.0%)	1 (1.4%)	
	No	24 (72.7%)	62 (87.3%)	
Alcohol consumption in last month	Less than 1 drink	2 (6.1%)	1 (1.4%)	**<0.001**** Cramer's V 0.359
	1 drink	4 (12.1%)	2 (2.8%)	
	5 or more drinks	4 (12.1%)	0 (0.0%)	
	None	23 (69.7%)	68 (95.8%)	

*Pearson's χ^2-test; **Fisher exact test; non-smokers (n=2) excluded

Table 3. Difference in biting and chewing food and mouth dryness among patients classified as GOLD A, B and E

Question	Answer	GOLD A	GOLD B	GOLD E	p value
Difficulty biting food	Very often	0 (0.0%)	4 (25.0%)	9 (15.3%)	**0.013**** Cramer's V 0.276
	Fairly often	1 (3.2%)	3 (18.8%)	8 (13.6%)	
	Sometimes	11 (35.5%)	1 (6.3%)	8 (13.6%)	
	No	19 (61.3%)	8 (50.0%)	34 (57.6%)	
Difficulty chewing food	Very often	0 (0.0%)	4 (25.0%)	9 (15.3%)	**0.022**** Cramer's V 0.264
	Fairly often	1 (3.2%)	3 (18.8%)	8 (13.6%)	
	Sometimes	11 (35.5%)	1 (6.3%)	10 (16.9%)	
	No	19 (61.3%)	8 (50.0%)	32 (54.2%)	
Dry mouth	Very often	3 (9.7%)	2 (12.5%)	12 (11.5%)	**0.042*** Cramer's V 0.250
	Fairly often	6 (19.4%)	1 (6.3%)	22 (21.2%)	
	Sometimes	5 (16.1%)	4 (25.0%)	24 (40.7%)	
	No	17 (54.8%)	9 (56.25%)	13 (22.0%)	

*Pearson's χ^2-test; **Fisher exact test

Discussion

The aim of the study hypotheses was to evaluate oral health status in patients with COPD and get information on this patient group subjective opinion about their oral health. Its importance lies in the fact that this topic has not been thoroughly investigated in prior available studies, and to our knowledge, this is the first study where the survey was used to evaluate oral health as a validated measure. COPD is an inflammatory condition which is believed to be connected with oxidative stress and protease-antiprotease imbalances. In general, neutrophils and macrophages mediate inflammation. As a reaction to inflammation, bronchial walls may thicken and cause irreversible obstruction of small airways, and in progressive disease of large airways. It reflects on lung function by decreasing FEV1 at first, and in some advanced forms of the disease decreasing other lung function variables. Clinically, patients complain mostly of dyspnea and cough. In comparison, periodontal disease has a similar pathophysiological sequence. The same inflammatory cells (neutrophils, macrophages) constantly and proactively circle in the periodontium in response to antigen. Also, smoking is cited as the main environmental trigger for both COPD and periodontal disease. There are multiple epidemiological studies that investigated periodontal health in COPD patients. These studies were based on the fact that the same group of pathogens and cytokines, such as CRP, IL-8, TNF-α, and MMPs are associated with periodontal diseases also induce inflammatory response in epithelium of the alveolar wall and promote inflammation in COPD patients[19,20]. Ledić *et al.* compared COPD patients with the healthy population in terms of their periodontal status. It showed that COPD patients had a statistically significantly poorer periodontal health and fewer remaining teeth[21]. In comparison, 59.98% of our study patients did not have any or only had up to nine teeth. A study by Bakdash *et al.* also supports our findings, concluding that the cause of tooth loss in COPD patients were deeper periodontal pockets, thus leading to more clinical attachment loss than in the population without COPD[22,23]. The higher the stage of the disease, the worse is periodontal status. The fact that 7% of our patients never brushed their teeth supports this

conclusion. As mentioned above, the same pathogens found in dental plaque can cause respiratory infections. Dental plaque is mainly colonized with *Staphylococcus aureus*, gram-negative bacilli and *Pseudomonas aeruginosa*[24]. These pathogens, when aspirated, cause severe respiratory infections, which in COPD patients who are considered immunocompromised, may lead to more severe clinical presentation and worse outcomes. In addition, it is worth mentioning that saliva with its composition plays an important role in regulating oral cavity microbiota and degree of its microbiological equilibrium. It plays a major role in physicochemical defense of the teeth by forming an acquired pellicle, a thin layer of salivary proteins with calcium chloride that helps contain homeostasis of dental plaque. It also helps in healing of mouth ulcers and wounds[25,26]. Xerostomia is considered as an abnormal subjective feeling of dry mouth and is a quite common symptom and/or side effect in various diseases and drug therapies. It promotes imbalance of oral microflora and might initiate the pathologies such as caries and periodontal diseases. Evidence shows that oral and systemic inflammation underlying periodontal diseases may trigger neuroinflammatory processes and contribute to further neurodegeneration in some diseases, such as Parkinson's disease[27]. Having this in mind and the fact that COPD patients often complain of dry mouth, it could be explained by the usage of long-acting muscarinic or LTOT. COPD medications work by blocking the action of acetylcholine, a neurotransmitter that can cause airway muscles to constrict. While these drugs can be effective in managing COPD symptoms, they can also have side effects, one of which is dry mouth. The reason for this side effect lies in the broader role of acetylcholine in the body. Acetylcholine not only affects airway muscles but also plays a role in stimulating salivary glands to produce saliva. Also, dry air delivered through oxygen masks or nasal cannulas during LTOT can dry out mucous membranes of the mouth and throat, potentially leading to a sensation of dry mouth. Additionally, when patients breathe in oxygen through their mouth, it can bypass the nasal passages which usually help humidify and warm the air. This direct exposure of oral tissues to dry oxygen can contribute to the development of xerostomia. This may neutralize positive effects of the saliva in tooth protection[28]. Therefore, patients undergoing LTOT should be advised to stay hydrated and practice good oral hygiene to mitigate the risk of developing severe xerostomia. Furthermore, patients in a more advanced stage of the disease experience greater difficulties with chewing or biting in daily life (p<0.036). Similarly, patients receiving LTOT report these issues more frequently (p<0.027) compared to patients not on LTOT, establishing a direct link between LTOT and dental health, which supports our hypothesis. Patients classified as subgroup GOLD A had more teeth than those in subgroup GOLD E, but the difference did not reach statistical significance. This also proved our primary hypothesis. Socioeconomic status of an individual in terms of ethnicity and level of education is a relevant factor for developing some form of periodontal disease and worse oral health[29,30]. In our study, 83.4% of the subjects finished elementary or secondary education, whereas only nine individuals finished college. Another contradictory fact was that more than half of our patients (58.5%) described their gingival status as good or better, whereas 55.7% stated that they brushed their teeth less frequently than once a day. Fluoride is an essential microelement in the human body with its anti caries effect by promoting remineralization of the enamel and inhibiting the growth of bacteria[31]. Fluoride is not recognized as an important mineral for dental health as more than half of our patients did not know whether their toothpaste contained it. Maybe this could be a surprising fact, however, the Chinese Report of the Fourth National Oral Health Survey that included a healthy population had similar conclusion[32]. COPD patients are not aware of their oral health and its importance. Taking that into consideration, more active campaigns rising awareness are needed to change the people's perspective on the importance of daily oral hygiene and habits. A similar conclusion applies to patients on dialysis treatment[33]. Our study confirmed the hypotheses set at the beginning completely. The limitation of our study was that all patients were recruited from one institution and that answers given in the questionnaire were self-reported opinions of study patients.

Conclusion

To conclude, taking all the above mentioned in consideration, we proved our two hypotheses; first, that patients classified as group GOLD E have worse oral health than those classified as GOLD A, and second,

that patients on LTOT have more oral health problems than those without it. Considering the increasing incidence of oral diseases and problems within the oral cavity from the standpoint of a physician, it is necessary to promote dental appointments more often for patients with COPD. Only by doing that, we can influence quite unsatisfactory results recorded in this study.

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Sažetak

STATUS ORALNOG ZDRAVLJA KOD BOLESNIKA S KRONIČNOM OPSTRUKTIVNOM PLUĆNOM BOLESTI

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Cilj je prikazati status oralnog zdravlja kod bolesnika s kroničnom opstruktivnom plućnom bolesti (KOPB). Istraživanje je obuhvatilo 106 bolesnika s dijagnozom KOPB-a koji se liječe u Specijalnoj bolnici za plućne bolesti, Zagreb, Hrvatska. Primijenjen je upitnik Svjetske zdravstvene organizacije o oralnom zdravlju odraslih kao validirana mjera procjene zdravlja usne šupljine. Rezultati su uspoređeni s obzirom na težinu bolesti prema klasifikaciji GOLD, domicilnoj oksigenoterapiji bolesnika te s obzirom na naviku pušenja. Većina ispitanika, njih 61,3%, imalo je manje od 10 zuba. Također 82,2% ispitanika je unazad godinu dana imalo problem ili osjetilo bol u usnoj šupljini. Više od polovine ispitanika (55,7%) ocjenjuje zdravlje svojih zubiju kao prosječno ili lošije, dok ih 58,5% status gingive ocjenjuje kao dobar ili bolji od toga. Također 55,7% ispitanika pere zube jedanput na dan ili čak manje, što je izraženije u muškaraca. Uz navedeno isti postotak ispitanika ne zna sadrži li zubna pasta koju rabe dodatak fluorida. Također 67% ispitanika su bivši pušači, dok su preostali aktivni. Pušači češće prijavljuju osjećaj srama i napetosti zbog izgleda svojih zubi u usporedbi s nepušačima. Bolesnici u naprednim fazama KOPB-a češće navode probleme s jedenjem i žvakanjem hrane u usporedbi s bolesnicima u manje naprednim fazama bolesti. S obzirom na rezultate provedenog istraživanja potrebna je daljnja poduka bolesnika s KOPB-om od strane medicinskog osoblja uz mjere promicanja važnosti oralnog zdravlja.

Ključne riječi: *Oralno zdravlje; Karijes; Prevencija; Kronična opstruktivna plućna bolest*