

# Association of CPAP Bacterial Colonization with Chronic Rhinosinusitis

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SCIENTIFIC INVESTIGATIONS

**Study Objective:** The purpose of our study was to investigate whether bacterial colonization of the continuous positive airway pressure (CPAP) machine reservoirs occurred, and if so, if it was related to the development of chronic rhinosinusitis (CRS).

**Design:** Prospective cohort study.

**Setting:** London Health Sciences Center (LHSC).

**Patients:** Regular CPAP users with obstructive sleep apnea (OSA).

**Interventions:** N/A.

**Measurements and Results:** Patient demographics were recorded and they were asked to fill out the chronic sinusitis survey (CSS) form. Patients then had their CPAP machines

swabbed. An ANOVA was used to determine if the presence of microbacterial colonization was related to CSS scores. In total, 72 patients were included in the study. There was no significant difference in any of the scores between the group with positive cultures and the group without positive cultures.

**Conclusions:** Having a positive culture in the CPAP reservoir does not seem to lead to an increased symptomatology of CRS: although the reservoirs often become colonized, there seems to be no clinical impact.

**Keywords:** CRS, sinusitis, CPAP, bacteria, contamination

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Chronic rhinosinusitis (CRS) refers to inflammation of the nasal mucosa and the mucosa of the paranasal sinuses. Presenting symptoms of CRS can include facial pain, headache, rhinorrhea, hyposmia, and dental pain.<sup>1</sup> Chronic rhinosinusitis is highly prevalent with an estimated 1 in 7 people affected in North America.<sup>2,3</sup> The annual cost to the American health care system is estimated at \$5.8 billion US.<sup>4</sup> CRS significantly affects patients' quality of life, as shown by a study by Macdonald et al. in which patients with CRS self-rated their health consistently worse than patients with allergies and back pain, and statistically equivalent to patients suffering from cancer and inflammatory bowel disease.<sup>3</sup>

Obstructive sleep apnea (OSA) is another highly prevalent disorder, with an estimated 3% of women and 9% of men variably affected.<sup>5</sup> Symptoms can include daytime fatigue, irritability, and personality changes.<sup>5</sup> It has also been associated with cardiopulmonary changes such as systemic hypertension, pulmonary hypertension, and heart failure, as well as motor vehicle accidents.<sup>6</sup> The mainstay of treatment for OSA is continuous positive airway pressure (CPAP), which delivers a stream of air to the patient's airway continually to splint open the airway and prevent collapse.<sup>5,7</sup>

In 2007, a study by Aydin et al. demonstrated that reusable nasal steroid spray bottles used in treatment of CRS can be positive of bacterial colonization, and that this may be associated with recalcitrant cases.<sup>8</sup> More recently, in a study by Lee et al., 50% of their samples' nasal irrigation bottles had positive microbacterial cultures.<sup>9</sup> While many viruses and bacteria have the potential to cause a simple episode of acute rhinosinusitis, there are some organisms that have been known to have devas-

## BRIEF SUMMARY

**Current Knowledge/Study Rationale:** xx.

**Study Impact:** xx.

tating effects when the nasal cavity is exposed to them. *Naegleria fowleri* is a freshwater amoeba that can lead to a rare, but nearly always fatal type of primary amoebic meningoencephalitis (PAM).<sup>10</sup> In 2011, the Louisiana Department of Health and Hospitals issued a warning about proper sterilization of water used in nasal irrigations following the death of 2 people linked to PAM who developed secondary to improperly sterilized tap water in their nasal rinses.<sup>11</sup> These cases, therefore, highlight the importance of sinonasal infections.

While nasal irrigations and their bacterial contamination has been analyzed in the CRS literature before, to our knowledge, there are no studies that look at whether contamination and colonization of CPAP machines occurs as frequently, and whether this has significant health ramifications. Since the basis of the nasal CPAP machine involves blowing humidified air into the patient's nose, it stands to reason that if bacteria were to colo-

**Table 1**—Patient demographics

	Overall	Negative Culture	Positive Culture
Sample Size	72.0	37.0	35.0
Age (years)	55.9	54.7	57.3
Males:Females	50:22 (2.3:1)	27:10 (2.7:1)	23:12 (1.9:1)
AHI (mean)	51.5	49.5	53.4

**Table 2**—Microbacterial organisms found in the reservoirs, masks, and tubing systems

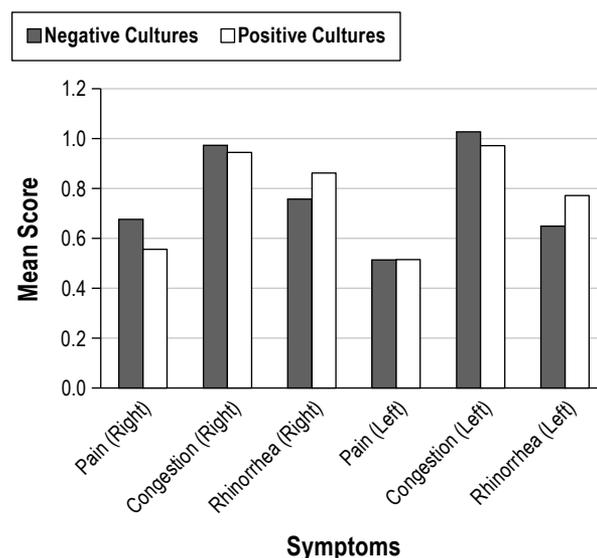
Organism	Positive Cultures in Reservoir (%)	Positive Cultures in Mask (%)	Positive Cultures in Tubing (%)
Gram-negative rods	32	4	15
Coagulase-negative <i>Staphylococcus</i>	23	68	36
Bacillus Sp.	14	0	0
Diphtheroids Sp.	11	6	9
<i>Pseudomonas</i>	6	1	9
Gram-positive rods	1	0	0
Yeast	1	6	12
<i>Staphylococcus aureus</i>	1	9	0
Other	11	5	18

nize the CPAP machine, bacterial seeding of the nasal mucosa could occur as a result of the CPAP usage. The goal of our study was to investigate whether bacterial colonization of the CPAP reservoirs occurred, and if so, if it was related to CRS.

## METHODS

The Western University research ethics board approved this study. Patients were recruited from both a tertiary care Otolaryngology-Head and Neck Surgery practice as well as a Respiriology practice with a focus on Sleep Medicine. Inclusion criteria were that of any patient who was a regular CPAP user for obstructive sleep apnea purposes. Patients with a known history of CRS, known nasal allergies, used nasal sprays/rinses regularly, were smokers, or who had any prior nasal surgery, were excluded from the study. After informed consent, patient demographics were recorded and they were asked to fill out the chronic sinusitis survey (CSS) form.<sup>12</sup> The CSS is a validated tool that has good test-retest reliability and is frequently used as a screen to assess patients' quality of life as related to potential CRS. Specifically, the CSS consists of 2 parts. The first part asks the patient to rate the severity of their symptoms (divided into left and right side), while the second part asks about duration of symptoms, as well as duration of medical therapy they have received recently. Patients then had their CPAP machines swabbed in 3 locations: the mask, the tubing of the machine, and the reservoir.

Patients had their average score on the CSS form calculated for both the symptoms and duration parts of the survey. Once this was completed, the microbacterial cultures were checked, to see whether there was evidence of bacterial or fungal growth. Positive cultures (of any bacteria or fungi) were assigned a value of 1, while those swabs that failed to grow anything were as-

**Figure 1**—Mean scores of part 1 of the CSS divided by culture status

signed a value of 0. In this way, the patients were separated into 2 groups, and an ANOVA test was used to compare the groups (with *p* set at 0.05 *a priori*) to analyze whether the presence of bacteria was related to the CSS scores. Data analysis was completed using PASW Statistics 18.

## RESULTS

Eighty patients were recruited into the study (8 from the Otolaryngology-Head and Neck Surgery clinic and 72 from the Respiriology clinic). Of those patients, 8 were excluded because they had incompletely completed surveys or because their microbacterial cultures were never reported, leaving 72 patients for the final study population. AHI ranged from 51.5+/-25, with a minimum of 5 and maximum of 104. Overall CPAP compliance in the study population was 85.8% ± 17.1% (~3.3 ± 0.7 h per night), with no difference between groups. Demographic details are found in **Table 1**. A breakdown of the various microbacterial organisms that were grown can be seen in **Table 2**.

While we initially planned to analyze the 3 sub-sites of the CPAP system (mask, tubing, reservoir), we found that the reservoir generated by far the widest variety of microorganisms when compared to the mask and tubing. In fact, in the mask, over 90% of the cultures were coagulase-negative staphylococci, which is not surprising given the contact the mask makes with the skin. We therefore focused our analysis exclusively on the reservoirs.

The patients were divided into 2 groups—those who had positive cultures in their reservoir and those who did not. In total, 35 patients had positive cultures (48.6%). The average scores for the various parts of the CSS can be seen in **Figures 1** and **2**. There was no significant difference for any of the scores between the group with positive cultures and the group without positive cultures.

Next, the average scores for Part 1 (symptoms) of the CSS were calculated. In this part of the survey, patients were asked

to rank how bad their symptoms were (pain, congestion, and rhinorrhea) on the left side and right side of their face. The scoring system sets 0 as “No Symptoms” and 4 as “Severe.” All symptoms had overall average scores  $\leq 1.0$ , which indicates mild symptoms.

Then the average scores for Part 2 (duration) of the CSS were determined. This part of the survey asks patients in the past 8 weeks, how often they have had symptoms (headache, rhinorrhea, or congestion) or taken medications (antibiotics, nasal sprays, or pills [decongestants or antihistamines]). The average scores for symptoms all fell between 1 and 2 (indicating symptoms present just 1-2 weeks of the previous 8 weeks), and for medications the average was  $< 1$ .

## DISCUSSION

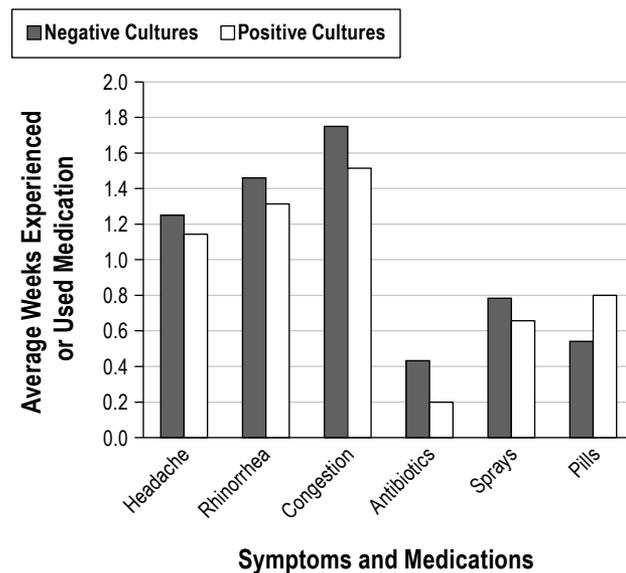
In our study, we hypothesized that those patients who had positive microbacterial cultures in their CPAP reservoir would have symptomatology of CRS more frequently than those who did not, as a result of the humidified air “seeding” the nasal cavity and sinuses with the microbes present in the reservoir. However, the study results did not support this hypothesis—CRS symptoms were mild in all patients (whether CPAP culture positive or negative), and despite demonstration of some unusual flora in the CPAP reservoir, there did not appear to be an association between CPAP microbiology and CRS symptoms. Having a positive culture in the CPAP reservoir does not seem to lead to an increased symptomatology of CRS. This could be interpreted that although the reservoirs often become colonized, there seems to be no clinical impact.

Our findings were similar to the findings of a previous study,<sup>9</sup> in that the patients with a positive culture in their reservoir did not have an increased chance of developing symptomatic CRS. While it is generally advised that the reservoirs should only be used with sterile water, a review of the literature did not demonstrate any evidence to support this recommendation at this time. Furthermore, in a 2012 Cochrane Review, Fernandez et al. found that there was no difference in infection rates of acute wounds when tap water was used as compared to sterile water.<sup>13</sup> It would seem then that further investigation regarding whether water from a non-sterile source (for example, tap water) has detrimental effects is warranted.

A wide variety of microorganisms were cultured in this study. This ranged from yeast to Enterococci to *Pseudomonas* and Gram-negative rods. While certain pathogens, like the previously mentioned *Naegleria fowleri*, can have devastating clinical effects, in our study the patients with positive cultures did not seem to have any adverse clinical effects.

Likely, the reason that our patients did not develop clinically significant disease is multifactorial and can in part probably be related to our study design and its limitations. First, although the reservoir was cultured positive, this did not necessarily translate to these same microorganisms making their way through the CPAP tubing to reach the patients sinuses. Perhaps the degree of inoculation was not sufficient to cause any serious health effects. As well, just one swab was taken for each patient’s reservoir. It is possible that through sampling error, those patients who had a “negative culture” actually had other areas of the reservoir that were in fact positive. More compre-

**Figure 2**—Mean durations of part 2 of the CSS divided by culture status



hensive swabbing of the reservoirs could potentially address this issue. Another reason why the microorganisms may not have caused adverse events is that of biofilms. Perhaps the bacteria in the reservoir had created biofilms that not only ensured their survival in the reservoir, but also prevented the bacteria from being distributed throughout the CPAP system. Lastly, the compliance rate of CPAP can be variable,<sup>14</sup> and although in our study there was no difference in compliance between groups, it could be that a larger population might show a difference in that regard.

In summary, in our study population, there was no association seen between floral colonization of CPAP machine and symptoms of chronic rhinosinusitis.

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## DISCLOSURE STATEMENT

This was not an industry supported study. The authors have indicated no financial conflicts of interest.