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# Significant pathogens in peritonsillar abscesses

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## Abstract

**Purpose:** Peritonsillar abscesses (PTA) are polymicrobial infections, with a diverse aerobic and anaerobic flora. The aim of the present study is to compare bacteriologic culture results from patients with PTA to those from patients undergoing elective tonsillectomy (clinically non-infected tonsils), to better elucidate the pathogenic significance of various isolates. **Methods:** A prospective study was conducted on 36 PTA patients undergoing acute tonsillectomy and on 80 electively tonsillectomized patients. **Results:** *Fusobacterium necrophorum* (FN) and *Streptococcus Group A* (GAS) were isolated significantly more frequently from the tonsillar cores of PTA patients, both from the abscessed ( $P=0.001$  and  $P=0.046$ , respectively) and non-abscessed side ( $P<0.001$  and  $P=0.046$ , respectively), than from the tonsillar cores of electively tonsillectomized patients.

**Conclusions:** Our findings indicate that FN and GAS are the prominent pathogens in PTA. In patients with PTA the incidence of FN and GAS isolated from the abscessed tonsil was the same as from the non-abscessed contralateral side, and the growth was comparable by a semi-quantitative approach. Our findings suggest that FN is also of pathogenic importance in acute tonsillitis, and that FN growth is not a subsequent phenomenon once an abscess has formed. Our findings further suggest that other factors influence the development of PTA.

Key words: Peritonsillar abscess; acute tonsillitis; microbiology; *Fusobacterium necrophorum*; Beta-haemolytic *Streptococci*

## 1 Introduction

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6 A peritonsillar abscess (PTA) is defined as a collection of pus between the tonsillar capsule and the  
7  
8 pharyngeal constrictor muscle. It is the most frequent complication of acute tonsillitis (AT) and the  
9  
10 prevailing cause of acute admission to the ENT-department at Aarhus University Hospital [1].  
11

12  
13 Adolescents and young adults are most commonly affected [2]. Management requires surgical  
14  
15 drainage and antimicrobial therapy.  
16

17  
18 Several studies have looked at the bacteriology of PTA aspirates [3-17]. A mixture of aerobic and  
19  
20 anaerobic bacteria is commonly isolated. As the cultures are obtained from an area normally  
21  
22 heavily colonized, the pathogenic relevance of each strain is raised.  
23

24  
25 The high incidence of Streptococcus Group A (GAS) in surface swabs from AT patients and in pus  
26  
27 aspirates from PTA patients, as well as the detection of streptococcal antibodies in these same  
28  
29 patients has established GAS as a key pathogen in AT and PTA [4-5, 11, 16, 18-19]. Large colony-  
30  
31 forming beta-haemolytic streptococci Group C and G have also been recovered from patients with  
32  
33 AT and PTA [3-5, 20-22].  
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36  
37 The importance of anaerobes in PTA formation has been suspected for decades [3-7], however, few  
38  
39 attempts have been made to explore which strains are of pathogenic importance. Immune responses  
40  
41 to *Fusobacterium nucleatum* and *Prevotella intermedia* have been detected in patients with PTA [23-  
42  
43 24], as well as in patients suffering from recurrent acute tonsillitis (RT) [25], AT [26], peritonsillar  
44  
45 cellulitis [23-24], and mononucleosis [27]. However, *Fusobacterium nucleatum* and *Prevotella*  
46  
47 *intermedia* are also commonly found in clinically non-infected tonsils [28-30].  
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54 In Denmark, PTA patients under the age of 30 years are most often treated with acute bilateral  
55  
56 tonsillectomy. To further elucidate the pathogenic significance of various bacteria associated with  
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58

1 PTA, the present study compares bacteriologic culture results from the tonsils of PTA patients with  
2  
3 results from clinically non-infected tonsils from electively tonsillectomized patients. Isolates from  
4  
5 the tonsilar surface are compared with those from the tonsillar core, and those from pus aspirates.  
6  
7 Moreover, the bacteriology of acutely infected tonsils, without abscess formation, is examined by  
8  
9 comparing growth from the abscessed side to that from the contralateral non-abscessed side.  
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## 18 **Subjects and methods**

### 19 *Patients:*

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22  
23 Patients were enrolled in the study between November, 2005 and February, 2009 at three ENT  
24  
25 Departments in Denmark. The study consisted of two patient groups: (1) 36 patients with unilateral  
26  
27 PTA undergoing acute bilateral tonsillectomy and (2) 80 patients admitted for elective tonsillectomy  
28  
29 (controls). The control patients were categorized into four subgroups according to their indication  
30  
31 for tonsillectomy: (a) recurrent tonsillitis (RT, more than five episodes within two years) (30  
32  
33 patients), (b) tonsillar hypertrophy (TH, with a history of airway obstruction) (20 patients), (c) both  
34  
35 RT and TH (20 patients), and (d) halitosis or persistant sore throat syndrome (PSTS)(10 patients).  
36  
37 Only patients between the ages of 8-30 years, without antibiotic treatment during the month  
38  
39 preceding surgery were included in the study.  
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### 50 *Specimen collection:*

51  
52 For all patients after the induction of anaesthesia, coal-coated cotton swabs were rubbed thoroughly  
53  
54 on the surfaces of each of the tonsils and placed in transport media (Stuart´s medium, SSI  
55  
56 Diagnostic, Hilleröd, Denmark). In PTA patients, the abscess was punctured through the  
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1 peritonsillar mucosa, and pus was aspirated into a sterile syringe. The tonsils were removed by  
2  
3 blunt dissection, and placed in sterile containers separately. None of the patients received antibiotics  
4  
5 before collection of specimens had been completed. Tonsillar tissue, pus aspirates, and surface  
6  
7 swabs in Stuart's media were placed in a minus 80<sup>o</sup> C freezer within minutes of collection. Surface  
8  
9 swabs of three group 1 patients were lost before cultures were performed.  
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16 *Microbiological analysis:*  
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18 Microbiological analysis was carried out at the Department of Clinical Microbiology, at Aarhus  
19  
20 University Hospital. Samples were stored at minus 80<sup>o</sup> C until bacteriologic investigations were  
21  
22 performed. Specimens were processed in a class-2 laminar airflow safety cabinet by aseptic  
23  
24 technique. Tissue samples, aspirates and swabs were cultured semi-quantitative onto 5% blood agar  
25  
26 plates, chocolate agar plates and anaerobic plates (all from SSI Diagnostic, Hillerød, Denmark).  
27  
28 Semi-quantitation of growth was done by plating on the various agar plates using the dilution streak  
29  
30 technique. The first quadrant of the plate was streaked using the tissue or swab and each successive  
31  
32 quadrant was streaked using a new bacteriologic loop in order to dilute the number of bacteria in  
33  
34 each quadrant. The plates were incubated at 35<sup>o</sup>C in either a carbon dioxide (CO<sub>2</sub>) enriched  
35  
36 atmosphere for three days or anaerobically for five days using the Concept 400 anaerobic  
37  
38 workstation (Fisher Scientific, Denmark). Quantification was expressed as 1+, 2+, 3+, or 4+ based  
39  
40 on the number of quadrants that demonstrated bacterial growth. Bacterial growth limited to  
41  
42 quadrant 1 was categorized as 1+, bacterial growth limited to quadrants 1 and 2 was categorized as  
43  
44 2+, bacterial growth limited to quadrants 1, 2, and 3 was categorized as 3+, and bacterial growth  
45  
46 that extended to all 4 quadrants was categorized as 4+. Speciation for microorganisms was  
47  
48 performed by standard methods [35] or by using the VITEK 2 system. Special care was taken to  
49  
50 differentiate (small colony) beta-hemolytic group C and G streptococci (Voges-Proskauer test-  
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1 negative) from *Streptococcus anginosus* (Voges-Proskauer test-positive). Antibiotic sensitivities  
2  
3 were determined by a standard disc diffusion method using the protocol from [WWW.SRGA.ORG](http://WWW.SRGA.ORG)  
4  
5 on isosensitivity plates (Oxoid, Denmark). Organisms of the same species were deemed  
6  
7 indistinguishable if they had the same colony morphology, the same basic biochemical features and  
8  
9 an identical antibiogram.  
10

#### 11 *Statistical analysis:*

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18 The Fisher exact test (2-sided) was used for between-group comparisons of bacteriologic findings.  
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21 The Kruskal-Wallis test was used for comparison of semi-quantitative growth distributions, and  
22  
23 logistic regression analysis was used for comparison of aerobic and anaerobic detection frequencies.  
24  
25 Bacteriological data from the right tonsil (selected at random) of electively tonsillectomized patients  
26  
27 were used to compare to findings from PTA patients. The statistical differences having used the left  
28  
29 tonsil data were insignificant, as the differences between the two sides were very small. Statistical  
30  
31 significance was defined as  $p < .05$ .  
32  
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36

37 The study was approved by The Ethical Committee of Aarhus County (Number 20050034).

38  
39 Informed consent was obtained from all patients, in accordance with the guidelines set by The  
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41 Danish National Board of Health.  
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47 For the purpose of this study, “PTA side” refers to the tonsil in close relation to the abscess and “AT  
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49 side” refers to the contralateral, acutely infected tonsil (without abscess formation).  
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## 57 **Results**

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3 The mean and median ages of PTA patients were 18.3 and 17.0 years. Controls had mean and  
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5  
6 median ages of 19.4 and 19.0 years.  
7

8 Three of the PTA patients had a history of RT. Within the two years preceding admission, a history  
9  
10 of AT was noted in eight of the PTA patients: four had one case of AT, one had two cases, and three  
11  
12 had three cases of AT. None of the patients had bilateral PTA.  
13  
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16  
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18 In PTA patients, three or more bacterial strains were isolated from all tonsillar surface swabs, two or  
19  
20 more were isolated from all tonsillar core tissue specimens, and at least one from each pus aspirate.  
21

22 Mixed aerobic and anaerobic flora was present in all but two surface swabs and in all but one core  
23  
24 tissue specimen. In pus aspirates, mixed aerobes and anaerobes were detected in 29 patients, while  
25  
26 four cultures yielded anaerobes only and three aspirates contained aerobes only.  
27  
28

29 An average of 5.1 isolates (3.7 aerobes and 1.4 anaerobes) was detected in surface swabs, 5.8  
30  
31 isolates (3.8 aerobes and 2.1 anaerobes) were grown in core tissues, and 3.7 isolates (2.2 aerobes  
32  
33 and 1.5 anaerobes) were found in pus aspirates.  
34  
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36  
37 The aerobic bacteria most frequently isolated from both surface swabs and core tissues, obtained  
38  
39 from PTA patients, were Viridans streptococci, Neisseria species, Corynebacterium species, and  
40  
41 Staphylococcus aureus (Table 1). The predominant anaerobic bacteria at both the surface and in the  
42  
43 core were Prevotella species, Fusobacterium necrophorum, and other Fusobacterium species (Table  
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47 1).  
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52 *Tonsillar core isolates: PTA side vs. controls:*  
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54 Compared to core tissue of clinically non-infected tonsils, FN and GAS were detected significantly  
55  
56 more frequently in core tissue from the PTA side (P=.001 and P=.046, respectively; Fisher exact  
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1 test). In contrast, *Fusobacterium* species and *Staphylococcus aureus* were isolated significantly less  
2 frequently ( $P < .001$  and  $P = .028$ , respectively) (Table 1) in core tissue from the PTA side. A semi-  
3 quantitative analysis revealed also significantly lighter growth of *Staphylococcus aureus* ( $P < .001$ ,  
4 Kruskal-Wallis test), *Prevotella* species ( $P = .002$ ) and *Fusobacterium* species ( $P = .023$ ) in the  
5 cultures from the PTA side cores than from control cores.  
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16 *Tonsillar core isolates: AT side vs. controls:*  
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18 Similar to culture results from the PTA side core, FN and GAS were detected significantly more  
19 frequently in the core of the AT side ( $P < .001$  and  $P = .046$ , respectively) than in the core of control  
20 tonsils. In contrast, *Fusobacterium* species was isolated significantly less frequently from the AT  
21 side core ( $P < .001$ ; Fisher exact test) compared to the control core (Table 1). Significantly lighter  
22 growth of *Staphylococcus aureus* ( $P < .001$ ), *Prevotella* species ( $P < .001$ ), *Fusobacterium* species  
23 ( $P = .026$ ), and *Viridans streptococci* ( $P = .006$ ) was obtained in cultures from the AT side core than  
24 from control cores.  
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37 *Core isolates from the PTA side vs. isolates from pus aspirates:*  
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39 Nearly all bacterial strains isolated from aspirates were also grown from the PTA side core (Table  
40 2). Three patients had pure growth of one bacterial strain from aspirated pus: FN was detected in  
41 two of these patients and in one patient GAS was isolated. The semi-quantitative analysis revealed  
42 significantly lighter growth of *Neisseria* species ( $P = .034$ ) in pus than PTA side core.  
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52 *PTA side vs. AT side:*  
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54 Isolation rates from the PTA side compared to the AT side were not significantly different, neither  
55 from the core nor from the surface, for all of the detected bacterial strains (Table 1).  
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1 Eighty five percent of aerobic isolates and 84% of anaerobic isolates were common to both the PTA  
2  
3 side core and the AT side core (Table 3). Beta-haemolytic streptococci (BHS) concordance was 87%  
4  
5 and FN concordance was 95% (Table 3). Results were similar for PTA vs. AT side surface (Table 3).  
6  
7 No significant semi-quantitative differences between the PTA and AT side core were found.  
8  
9 Nineteen of 27 BHS recovered from cores were isolated as heavy growth (4+), seven as moderate  
10  
11 growth (3+), and one as sparse growth (2+). Similarly, 33 of 41 FN recovered from cores were  
12  
13 isolated as heavy growth (4+) and eight as moderate growth (3+).  
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20 *Isolates from the core vs. from the surface for PTA side, AT side, and controls:*

21  
22 Eighty five percent of aerobes and 65% of anaerobes isolated from the PTA side core were also  
23  
24 detected from swabs of the PTA side surface (Table 4). For BHS and FN respectively, 86% and 56%  
25  
26 of core isolates were also detected on the surface. Similarly, 84% of aerobes and 55% of anaerobes  
27  
28 isolated from the AT side core were detected also at the AT side surface. Aerobes were predominant  
29  
30 on the tonsillar surface compared to anaerobes, both on the PTA side and the AT side (P=.005,  
31  
32 logistic regression analysis).  
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42 **Discussion**

43  
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47 Within the past five years, there has been an emerging focus on *Fusobacterium necrophorum* (FN)  
48  
49 as a pathogen in AT [32-34]. Furthermore, in a retrospective study of 847 PTA patients treated at our  
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51 department from 2001 to 2006, we found FN to be the most prevalent bacterial strain in pus  
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53 specimens. Patients infected with this bacterium displayed significantly higher neutrophil counts  
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1 and CRP values than patients infected with other bacteria, indicating a larger immune response and  
2  
3 suggesting that FN is of pathogenic importance in PTA [2].  
4

5  
6 In the current study, FN was a frequent finding in PTA. We recovered FN from 60% of all  
7  
8 aspirates. Of note, FN was isolated significantly more frequently from the cores of abscessed  
9  
10 tonsils than from the cores of clinically non-infected tonsils from electively tonsillectomized  
11  
12 patients (Table 1), thus supporting a pathogenic role for FN in PTA. These findings confirm the  
13  
14 results of our retrospective study [2] and emphasize that FN is a very prominent pathogen in PTA -  
15  
16 at least in Denmark.  
17  
18

19  
20 When FN was present at the abscessed site we were able to recover it in nearly all cases from both  
21  
22 the abscess aspirate, as well as the tonsillar core. However, swabs of the abscessed tonsil yielded  
23  
24 FN much less frequently (56% incidence in cores of abscessed tonsils vs. 27% in surface swabs  
25  
26 from the same tonsils) indicating that swabs are not a reliable clinical tool for detecting the  
27  
28 organism, or that our method of collection of the swabs was not optimal for culturing FN  
29  
30 downstream.  
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33  
34 FN, an obligate, anaerobic, Gram-negative rod, is most commonly associated with Lemierre's  
35  
36 Syndrome. However, unlike in Lemierre's Syndrome, most FN infections remain localised [35]. In  
37  
38 contrast to FN, Fusobacterium species are not considered of pathogenic importance in ENT  
39  
40 infections.  
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42

43  
44 In Finland, Jousimies-Somer et al. detected FN in 38% of PTA aspirates and found an association to  
45  
46 previous tonsillar / peritonsillar infections and previous use of antimicrobial therapy [4]. We did not  
47  
48 find an association between incidence of FN and previous events of AT. Brook [14] and Jokipii et  
49  
50 al [3] also detected FN in 13% and 7% of PTA aspirates, respectively.  
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53  
54 As expected, GAS was also detected significantly more frequently from the cores of the PTA side  
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56 than from the control cores confirming the well-documented role of GAS in PTA. In our study,  
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1 GAS was isolated in 19% of PTA patients, which is less than reported by some studies [4, 10, 15]  
2  
3 and similar to the findings of other studies [3, 8, 9, 11-14].  
4

5  
6 Fusobacterium species and Staphylococcus aureus were isolated significantly less frequently and in  
7  
8 significantly lighter growth from PTA side cores than control cores. We interpret these findings as  
9  
10 signs of overgrowth by the pathogens described above. It stresses the belief that Staphylococcus  
11  
12 aureus does not exert a pathogenic role in PTA.  
13

14  
15 By comparing the bacteriology from the PTA side and the non-abscessed, but acutely inflamed,  
16  
17 contralateral tonsil, we conclude that the core bacteriology was almost identical between the PTA  
18  
19 side and AT side (Table 3). This suggests that other factors are of major importance in the  
20  
21 development of PTA. It also indicates that growth of FN is not a subsequent overgrowth  
22  
23 phenomenon once an abscess is formed, but that FN is a primary pathogen with importance not only  
24  
25 in the pathogenesis of PTA, but also in severe, non-abscessed AT. This is in agreement with recent  
26  
27 studies suggesting FN could be involved in AT [32-34, 36]. Batty et al. found FN in 10% of all  
28  
29 throat swabs and a clinical diagnosis of tonsillitis was equally likely to be associated with GAS or  
30  
31 FN infection [36]. In a polymerase chain reaction (PCR)-based study, conducted in Denmark, FN  
32  
33 was detected in 15% of throat swabs from tonsillitis patients aged 18 to 32 years, and the  
34  
35 investigators concluded that FN could be a cause of AT and may account for some of the cases  
36  
37 previously assumed to be of viral aetiology [32]. Also using PCR, Aliyu et al. identified FN in 10 %  
38  
39 of throat swabs from patients presenting to general practitioners with pharyngitis, but they were  
40  
41 unable to recover FN from the throats of healthy control subjects [33].  
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49  
50 We found that the probability of detecting the pathogens isolated from pus and PTA side core was  
51  
52 the same whether swabbing the surface of PTA side or AT side tonsil (Table 3). This finding  
53  
54 confirmed the high concordances between the AT and PTA side and likely reflects the high  
55  
56 concentrations of bacteria in the acutely infected tonsils. No former studies have made these  
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1 comparisons, but Brook et al have shown the necessity of swabbing both tonsils in patients with AT  
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3 in order to detect all cases of acute GAS tonsillitis [37]. Our results do not confirm the relevance of  
4  
5 swabbing both tonsils, but it might reflect the fact that surface swabs were obtained under optimal  
6  
7 circumstances in anaesthetized patients and using mouth gag.  
8  
9

10 We found that surface swabs are not reliable at detecting anaerobes, such as FN (Table 4). In  
11  
12 contrast, surface swabs were better at detecting aerobes, for example 86% of BHS isolated from  
13  
14 cores was detected. We found that bacterial detection rates from surface swabs were higher in  
15  
16 acutely infected tonsils than in non-infected tonsils, but consistent with the trend of detecting  
17  
18 aerobes more frequently than anaerobes in surface swabs. These findings have important clinical  
19  
20 implications as cases of AT caused by FN, would be missed by a surface swab of the infected  
21  
22 tonsils. Whether PCR and other more sensitive detection methods would be helpful in making the  
23  
24 diagnosis remains unknown.  
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29 In part the lack of consistency with regards to microbiologic findings in former PTA studies may be  
30  
31 attributable to differences in culture methods, in specimen collection and handling, and in the  
32  
33 patient population (e.g. age, geography). Interpretation of bacteriologic findings in former studies  
34  
35 is made even more obscure by the fact that in many studies patients with and without prior  
36  
37 antibiotic treatment are pooled together. Some studies have found quantitative and qualitative  
38  
39 differences in bacteriologic culture results after antibiotic treatment [3, 6, 8, 13] while others have  
40  
41 not [4-5]. Only Flodström et al [15], in 1976, have studied the microbiologic flora exclusively in  
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43 PTA patients with no prior antibiotic treatment.  
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49 None of the former PTA studies have explored the significance of bacteria isolated from PTA  
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51 patients by comparing the findings with the bacterial flora of non-acutely infected tonsils.  
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54 To make such a comparison, comparable materials must be obtained and tonsillar core tissues are  
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56 therefore needed as culture specimens. We hypothesized that potential pathogens isolated from  
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1 aspirated pus would also be present in PTA side core tissue. However, even more potential  
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3 pathogens were isolated from PTA side cores than aspirated pus, and only very few pathogens were  
4  
5 isolated in pus only (Table 4). We therefore believe that tonsillar core tissues formed appropriate  
6  
7 basis of comparison to the flora found in clinically non-infected tonsils of electively  
8  
9 tonsillectomized patients.  
10

11  
12 Ideally our bacteriologic findings in patients with PTA would be compared to the flora of tonsillar  
13  
14 tissue of healthy subjects (without a history of prior tonsillar disease). Unfortunately, for ethical  
15  
16 reasons, such specimens were unobtainable in the present study. Instead, tonsils from patients  
17  
18 undergoing elective tonsillectomy were used, thus isolates may not represent “normal” tonsillar  
19  
20 flora. A few studies have been conducted comparing core tissue from normal tonsils with that from  
21  
22 patients suffering from RT and tonsillar hypertrophy (TH) [28,38-39]. Brook et al., in a study of  
23  
24 eight children, found similar organisms in normal and recurrently inflamed tonsils, but the  
25  
26 concentration of all BHS, all Bacteroides species, and all Peptostreptococcus species was higher in  
27  
28 recurrently inflamed tonsils [38]. A study by Stjernquist-Desatnik et al. detected significantly fewer  
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30 BHS, in particular GAS, as well as Haemophilus influenzae, in control patients with sleep apnea  
31  
32 compared to patients with TH and RT [39]. However, further studies by Stjernquist-Desatnik et al.,  
33  
34 using a semi-quantitative method to compare the culture results from the above patient group, found  
35  
36 no significant differences between groups with regards to frequency and quantity of aerobic and  
37  
38 anaerobic bacteria [28]. In the present study, the culture results from the four subgroups of electively  
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40 tonsillectomized patients were comparable to those found in the tonsillar cores of healthy control  
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42 patients in the studies discussed above. Hence, we believe that tonsillar tissue from patients  
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44 undergoing elective tonsillectomy can serve as a control in our study.  
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55 Due to the amount of specimens, some of which were obtained at night, we kept the specimens at  
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57 minus 80° C until cultures were made. Studies of the effect of freezing specimens at minus 80 °C  
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1 do not seem to alter the ability to isolate organisms [40-42]. A weakness of the study is that we did  
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3 not test the effect of freezing on recovery. Some bacteria sensitive to freezing or in low numbers  
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5 might not have been detected. However, as bacteria were commonly found in high numbers and  
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7 control specimens were treated in the same way, the risk of bias of results seems limited.  
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10 In summary, the present study is the first to compare bacteriological data from PTA patients with  
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12 non-clinically infected tonsils. Patients were from the same geographic area, over the time period  
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14 from November, 2005 to February, 2009, were well age matched between the PTA and the control  
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16 group, and had not taken antibiotics in the month preceding the tonsillectomy. FN and GAS were  
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18 isolated significantly more frequently from tonsillar cores of PTA patients, both at the side of the  
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20 abscess and the contralateral side, than from tonsillar cores of electively tonsillectomized patients.  
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23 Our findings add to the growing body of evidence that FN is a prominent pathogen in PTA and AT.  
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26 As FN and GAS were isolated as frequently from the PTA side as from the AT side, and as growth  
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28 in culture from the two sides seemed comparable, it appears that other factors play an important role  
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30 in the development of PTA. Further studies to investigate the viral composition of the tonsils and  
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32 immunologic studies are warranted.  
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1 **Tables**

2  
3  
4 Table 1. Isolation rates of organisms from tonsillar surfaces and cores from PTA side and AT side of  
5 PTA patients and right sided surfaces and cores of electively tonsillectomized patients (controls)

| Organism                   | Surface            |                    |          | Core               |                    |          |
|----------------------------|--------------------|--------------------|----------|--------------------|--------------------|----------|
|                            | PTA side           | AT side            | Controls | PTA side           | AT side            | Controls |
| <i>Aerobic</i>             |                    |                    |          |                    |                    |          |
| BHS                        |                    |                    |          |                    |                    |          |
| Group A                    | 18% <sup>***</sup> | 15% <sup>***</sup> | 4%       | 19% <sup>***</sup> | 19% <sup>***</sup> | 6%       |
| Group C                    | 9%                 | 9%                 | 8%       | 8%                 | 8%                 | 10%      |
| Group G                    | 6%                 | 6%                 | 5%       | 9%                 | 6%                 | 9%       |
| Not grouped                | 6%                 | 6%                 | 6%       | 6%                 | 3%                 | 6%       |
| Total                      | 39%                | 36%                | 23%      | 42%                | 36%                | 31%      |
| Streptococcus group B      | 0%                 | 3%                 | 3%       | 3%                 | 3%                 | 1%       |
| Streptococcus pneumoniae   | 0%                 | 0%                 | 0%       | 3%                 | 0%                 | 0%       |
| Viridans streptococci      | 94%                | 100%               | 96%      | 89%                | 89%                | 93%      |
| Staphylococcus aureus      | 24% <sup>***</sup> | 30%                | 50%      | 33% <sup>***</sup> | 36%                | 56%      |
| Coag.-neg. staphylococci   | 9%                 | 6%                 | 8%       | 3%                 | 6%                 | 4%       |
| Haemophilus influenzae     | 0%                 | 0%                 | 5%       | 0%                 | 0%                 | 6%       |
| Haemophilus parainfluenzae | 0%                 | 0%                 | 1%       | 0%                 | 0%                 | 1%       |
| Eikenella corrodens        | 3%                 | 3%                 | 3%       | 6%                 | 3%                 | 15%      |
| Neisseria species          | 73%                | 73%                | 74%      | 69%                | 67%                | 78%      |
| Moraxella catarrhalis      | 3%                 | 0%                 | 0%       | 0%                 | 0%                 | 1%       |
| Corynebacterium species    | 36%                | 45%                | 36%      | 44%                | 44%                | 30%      |
| <i>Anaerobic</i>           |                    |                    |          |                    |                    |          |
| Fusobacterium necrophorum  | 27% <sup>***</sup> | 27% <sup>***</sup> | 10%      | 56% <sup>*</sup>   | 58% <sup>*</sup>   | 24%      |
| Fusobacterium species      | 33% <sup>**</sup>  | 33% <sup>**</sup>  | 66%      | 28% <sup>*</sup>   | 28% <sup>*</sup>   | 65%      |
| Prevotella species         | 79%                | 73%                | 80%      | 91%                | 88%                | 94%      |
| Other anaerobes            | 9%                 | 6%                 | 11%      | 3%                 | 3%                 | 6%       |
| Yeast                      | 6%                 | 6%                 | 8%       | 9%                 | 9%                 | 4%       |

41 \* P< .001, Fisher exact test. Compared to controls

42 \*\* .001< P<.01, Fisher exact test. Compared to controls

43 \*\*\* .01< P<.05, Fisher exact test. Compared to controls

44  
45  
46 BHS: Beta-haemolytic streptococci

47  
48 Coag.-neg. staphylococci: Coagulase-negative staphylococci

1 Table 2. Number of isolates from PTA aspirates and PTA side core  
 2 tissues

| 3<br>4<br>5 Organism                | 6 No. isolates       |                   |                          |
|-------------------------------------|----------------------|-------------------|--------------------------|
|                                     | 7 Aspirate<br>8 only | 9 Core<br>10 only | 11 Aspirate<br>12 & Core |
| 13 <i>Aerobic</i>                   |                      |                   |                          |
| 14 Beta-haemolytic streptococci     |                      |                   |                          |
| 15 Group A                          | 16 0                 | 17 0              | 18 7                     |
| 19 Group C                          | 20 0                 | 21 1              | 22 2                     |
| 23 Group G                          | 24 1                 | 25 2              | 26 1                     |
| 27 Not grouped                      | 28 1                 | 29 1              | 30 1                     |
| 31 Total                            | 32 2                 | 33 4              | 34 11                    |
| 35 Streptococcus group B            | 36 0                 | 37 1              | 38 0                     |
| 39 Streptococcus pneumoniae         | 40 0                 | 41 1              | 42 0                     |
| 43 Viridans streptococci            | 44 2                 | 45 18             | 46 38                    |
| 47 Staphylococcus aureus            | 48 0                 | 49 10             | 50 2                     |
| 51 Coagulase-negative staphylococci | 52 2                 | 53 0              | 54 1                     |
| 55 Eikenella corrodens              | 56 1                 | 57 2              | 58 0                     |
| 59 Neisseria species                | 60 0                 | 61 20             | 62 5                     |
| 63 Corynebacterium species          | 64 1                 | 65 16             | 66 2                     |
| 67 <i>Anaerobic</i>                 |                      |                   |                          |
| 68 Fusobacterium necrophorum        | 69 2                 | 70 1              | 71 19                    |
| 72 Fusobacterium species            | 73 0                 | 74 4              | 75 6                     |
| 76 Prevotella species               | 77 0                 | 78 17             | 79 27                    |
| 80 Other anaerobes                  | 81 0                 | 82 1              | 83 0                     |
| 84 <i>Yeast</i>                     |                      |                   |                          |
| 85 Yeast                            | 86 0                 | 87 2              | 88 0                     |

Table 3. Bacterial concordances between PTA side and AT side surface swabs and core tissues

| Organism                     | Surface               |               |                  | Core                  |               |                  |
|------------------------------|-----------------------|---------------|------------------|-----------------------|---------------|------------------|
|                              | PTA / AT<br>side only | Both<br>sides | Concor-<br>dance | PTA / AT<br>side only | Both<br>sides | Concor-<br>dance |
| <i>Aerobic</i>               |                       |               |                  |                       |               |                  |
| Beta-haemolytic streptococci |                       |               |                  |                       |               |                  |
| Group A                      | 1 / 0                 | 5             | 83%              | 0 / 0                 | 7             | 100%             |
| Group C                      | 0 / 0                 | 3             | 100%             | 0 / 0                 | 3             | 100%             |
| Group G                      | 0 / 0                 | 2             | 100%             | 1 / 0                 | 2             | 67%              |
| Not grouped                  | 0 / 0                 | 2             | 100%             | 1 / 0                 | 1             | 50%              |
| Total                        | 1 / 0                 | 12            | 92%              | 2 / 0                 | 13            | 87%              |
| Streptococcus group B        | 0 / 1                 | 0             | 0%               | 0 / 0                 | 1             | 100%             |
| Streptococcus pneumoniae     |                       |               |                  | 1 / 0                 | 0             | 0%               |
| Viridans streptococci        | 0 / 4                 | 55            | 93%              | 0 / 5                 | 56            | 92%              |
| Staphylococcus aureus        | 1 / 3                 | 7             | 64%              | 3 / 4                 | 10            | 59%              |
| Coag.-neg. staphylococci     | 1 / 0                 | 2             | 67%              | 0 / 1                 | 1             | 50%              |
| Eikenella corrodens          | 0 / 0                 | 1             | 100%             | 1 / 0                 | 1             | 50%              |
| Neisseria species            | 2 / 2                 | 22            | 85%              | 1 / 0                 | 24            | 96%              |
| Moraxella catarrhalis        | 1 / 0                 | 0             | 0%               |                       |               |                  |
| Corynebacterium species      | 0 / 4                 | 13            | 76%              | 2 / 2                 | 16            | 80%              |
| Total aerobic isolates       | 6 / 14                | 112           | 85%              | 10 / 12               | 122           | 85%              |
| <i>Anaerobic</i>             |                       |               |                  |                       |               |                  |
| Fusobacterium necrophorum    | 0 / 0                 | 9             | 100%             | 0 / 1                 | 20            | 95%              |
| Fusobacterium species        | 1 / 1                 | 10            | 83%              | 2 / 2                 | 8             | 67%              |
| Prevotella species           | 2 / 4                 | 24            | 80%              | 2 / 4                 | 42            | 88%              |
| Other anaerobes              | 2 / 1                 | 1             | 25%              | 1 / 1                 | 0             | 0%               |
| Total anaerobic isolates     | 5 / 6                 | 44            | 80%              | 5 / 8                 | 70            | 84%              |
| Yeast                        | 0 / 0                 | 2             | 100%             | 0 / 0                 | 3             | 100%             |

Coag.-neg. staphylococci: Coagulase-negative staphylococci

Table 4. Number of isolates from PTA side surface swabs and core tissues

| Organism                         | No. isolates      |                  |                            | Percentage detected from surface swab |
|----------------------------------|-------------------|------------------|----------------------------|---------------------------------------|
|                                  | Surface swab only | Core tissue only | Surface swab & core tissue |                                       |
| <i>Aerobic</i>                   |                   |                  |                            |                                       |
| Beta-haemolytic streptococci     |                   |                  |                            |                                       |
| Group A                          | 0                 | 0                | 6                          | 100%                                  |
| Group C                          | 0                 | 0                | 3                          | 100%                                  |
| Group G                          | 0                 | 1                | 2                          | 67%                                   |
| Not grouped                      | 1                 | 1                | 1                          | 33%                                   |
| Total                            | 1                 | 2                | 12                         | 86%                                   |
| <i>Streptococcus pneumoniae</i>  | 0                 | 1                | 0                          | 0%                                    |
| Viridans streptococci            | 6                 | 1                | 51                         | 98%                                   |
| <i>Staphylococcus aureus</i>     | 2                 | 6                | 6                          | 50%                                   |
| Coagulase-negative staphylococci | 2                 | 0                | 1                          | 50%                                   |
| <i>Eikenella corrodens</i>       | 0                 | 1                | 1                          | 50%                                   |
| <i>Neisseria</i> species         | 2                 | 1                | 22                         | 96%                                   |
| <i>Moraxella catarrhalis</i>     | 1                 | 0                | 0                          |                                       |
| <i>Corynebacterium</i> species   | 4                 | 6                | 9                          | 60%                                   |
| Total aerobic isolates           | 18                | 18               | 102                        | 85%                                   |
| <i>Anaerobic</i>                 |                   |                  |                            |                                       |
| <i>Fusobacterium necrophorum</i> | 0                 | 8                | 10                         | 56%                                   |
| <i>Fusobacterium</i> species     | 6                 | 4                | 5                          | 56%                                   |
| <i>Prevotella</i> species        | 1                 | 12               | 28                         | 70%                                   |
| Other anaerobes                  | 2                 | 0                | 1                          | 100%                                  |
| Total anaerobic isolates         | 9                 | 24               | 44                         | 65%                                   |
| Yeast                            | 0                 | 1                | 2                          | 67%                                   |