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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

Introduction

A peritonsillar abscess (PTA) is defined as a collection of pus between the tonsillar capsule and the pharyngeal constrictor muscle. It is the most frequent complication of acute tonsillitis (AT) and the prevailing cause of acute admission to the ENT-department at Aarhus University Hospital [1]. Adolescents and young adults are most commonly affected [2]. Management requires surgical drainage and antimicrobial therapy.

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

The high incidence of Streptococcus Group A (GAS) in surface swabs from AT patients and in pus aspirates from PTA patients, as well as the detection of streptococcal antibodies in these same patients has established GAS as a key pathogen in AT and PTA [4-5, 11, 16, 18-19]. Large colony-forming beta-haemolytic streptococci Group C and G have also been recovered from patients with AT and PTA [3-5, 20-22].

The importance of anaerobes in PTA formation has been suspected for decades [3-7], however, few attempts have been made to explore which strains are of pathogenic importance. Immune responses to Fusobacterium nucleatum and Prevotella intermedia have been detected in patients with PTA [23-24], as well as in patients suffering from recurrent acute tonsillitis (RT) [25], AT [26], peritonsillar cellulitis [23-24], and mononucleosis [27]. However, Fusobacterium nucleatum and Prevotella intermedia are also commonly found in clinically non-infected tonsils [28-30].

In Denmark, PTA patients under the age of 30 years are most often treated with acute bilateral tonsillectomy. To further elucidate the pathogenic significance of various bacteria associated with

PTA, the present study compares bacteriologic culture results from the tonsils of PTA patients with results from clinically non-infected tonsils from electively tonsillectomized patients. Isolates from the tonsilar surface are compared with those from the tonsillar core, and those from pus aspirates. Moreover, the bacteriology of acutely infected tonsils, without abscess formation, is examined by comparing growth from the abscessed side to that from the contralateral non-abscessed side.

Subjects and methods

Patients:

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

Specimen collection:

For all patients after the induction of anaesthesia, coal-coated cotton swabs were rubbed thoroughly on the surfaces of each of the tonsils and placed in transport media (Stuart´s medium, SSI Diagnostic, Hilleröd, Denmark). In PTA patients, the abscess was punctured through the

peritonsillar mucosa, and pus was aspirated into a sterile syringe. The tonsils were removed by blunt dissection, and placed in sterile containers separately. None of the patients received antibiotics before collection of specimens had been completed. Tonsillar tissue, pus aspirates, and surface swabs in Stuart's media were placed in a minus 80^{o} C freezer within minutes of collection. Surface swabs of three group 1 patients were lost before cultures were performed.

Microbiological analysis:

Microbiological analysis was carried out at the Department of Clinical Microbiology, at Aarhus University Hospital. Samples were stored at minus 80^{o} C until bacteriologic investigations were performed. Specimens were processed in a class-2 laminar airflow safety cabinet by aseptic technique. Tissue samples, aspirates and swabs were cultured semi-quantitative onto 5% blood agar plates, chocolate agar plates and anaerobic plates (all from SSI Diagnostic, Hilleröd, Denmark). Semi-quantitation of growth was done by plating on the various agar plates using the dilution streak technique. The first quadrant of the plate was streaked using the tissue or swab and each successive quadrant was streaked using a new bacteriologic loop in order to dilute the number of bacteria in each quadrant. The plates were incubated at 35^{o}C in either a carbon dioxide (CO_2) enriched atmosphere for three days or anaerobically for five days using the Concept 400 anaerobic workstation (Fisher Scientific, Denmark). Quantification was expressed as 1+, 2+, 3+, or 4+ based on the number of quadrants that demonstrated bacterial growth. Bacterial growth limited to quadrant 1 was categorized as 1+, bacterial growth limited to quadrants 1 and 2 was categorized as 2+, bacterial growth limited to quadrants 1, 2, and 3 was categorized as 3+, and bacterial growth that extended to all 4 quadrants was categorized as 4+. Speciation for microorganisms was performed by standard methods [35] or by using the VITEK 2 system. Special care was taken to differentiate (small colony) beta-hemolytic group C and G streptococci (Voges-Proskauer test-

negative) from *Streptococcus anginosus* (Voges-Proskauer test-positive). Antibiotic sensitivities were determined by a standard disc diffusion method using the protocol from WWW.SRGA.ORG on isosensitivity plates (Oxoid, Denmark). Organisms of the same species were deemed indistinguishable if they had the same colony morphology, the same basic biochemical features and an identical antibiogram.

Statistical analysis:

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

The study was approved by The Ethical Committee of Aarhus County (Number 20050034). Informed consent was obtained from all patients, in accordance with the guidelines set by The Danish National Board of Health.

For the purpose of this study, "PTA side" refers to the tonsil in close relation to the abscess and "AT side" refers to the contralateral, acutely infected tonsil (without abscess formation).

Results

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

Three of the PTA patients had a history of RT. Within the two years preceding admission, a history of AT was noted in eight of the PTA patients: four had one case of AT, one had two cases, and three had three cases of AT. None of the patients had bilateral PTA.

In PTA patients, three or more bacterial strains were isolated from all tonsillar surface swabs, two or more were isolated from all tonsillar core tissue specimens, and at least one from each pus aspirate. Mixed aerobic and anaerobic flora was present in all but two surface swabs and in all but one core tissue specimen. In pus aspirates, mixed aerobes and anaerobes were detected in 29 patients, while four cultures yielded anaerobes only and three aspirates contained aerobes only.

An average of 5.1 isolates (3.7 aerobes and 1.4 anaerobes) was detected in surface swabs, 5.8 isolates (3.8 aerobes and 2.1 anaerobes) were grown in core tissues, and 3.7 isolates (2.2 aerobes and 1.5 anaerobes) were found in pus aspirates.

The aerobic bacteria most frequently isolated from both surface swabs and core tissues, obtained from PTA patients, were Viridans streptococci, Neisseria species, Corynebacterium species, and Staphylococcus aureus (Table 1). The predominant anaerobic bacteria at both the surface and in the core were Prevotella species, Fusobacterium necrophorum, and other Fusobacterium species (Table 1).

Tonsillar core isolates: PTA side vs. controls:

Compared to core tissue of clinically non-infected tonsils, FN and GAS were detected significantly more frequently in core tissue from the PTA side (P=.001 and P=.046, respectively; Fisher exact

test). In contrast, Fusobacterium species and Staphylococcus aureus were isolated significantly less frequently (P<.001 and P=.028, respectively) (Table 1) in core tissue from the PTA side. A semi-quantitative analysis revealed also significantly lighter growth of Staphylococcus aureus (P<.001, Kruskal-Wallis test), Prevotella species (P=.002) and Fusobacterium species (P=.023) in the cultures from the PTA side cores than from control cores.

Tonsillar core isolates: AT side vs. controls:

Similar to culture results from the PTA side core, FN and GAS were detected significantly more frequently in the core of the AT side (P<.001 and P=.046, respectively) than in the core of control tonsils. In contrast, Fusobacterium species was isolated significantly less frequently from the AT side core (P<.001; Fisher exact test) compared to the control core (Table 1). Significantly lighter growth of Staphylococcus aureus (P<.001), Prevotella species (P<.001), Fusobacterium species (P=.026), and Viridans streptococci (P=.006) was obtained in cultures from the AT side core than from control cores.

Core isolates from the PTA side vs. isolates from pus aspirates:

Nearly all bacterial strains isolated from aspirates were also grown from the PTA side core (Table 2). Three patients had pure growth of one bacterial strain from aspirated pus: FN was detected in two of these patients and in one patient GAS was isolated. The semi-quantitative analysis revealed significantly lighter growth of Neisseria species (P=.034) in pus than PTA side core.

PTA side vs. AT side:

Isolation rates from the PTA side compared to the AT side were not significantly different, neither from the core nor from the surface, for all of the detected bacterial strains (Table 1).

Eighty five percent of aerobic isolates and 84% of anaerobic isolates were common to both the PTA side core and the AT side core (Table 3). Beta-haemolytic streptococci (BHS) concordance was 87% and FN concordance was 95% (Table 3). Results were similar for PTA vs. AT side surface (Table 3). No significant semi-quantitative differences between the PTA and AT side core were found. Nineteen of 27 BHS recovered from cores were isolated as heavy growth (4+), seven as moderate growth (3+), and one as sparse growth (2+). Similarly, 33 of 41 FN recovered from cores were isolated as heavy growth (4+) and eight as moderate growth (3+).

Isolates from the core vs. from the surface for PTA side, AT side, and controls:

Eighty five percent of aerobes and 65% of anaerobes isolated from the PTA side core were also detected from swabs of the PTA side surface (Table 4). For BHS and FN respectively, 86% and 56% of core isolates were also detected on the surface. Similarly, 84% of aerobes and 55% of anaerobes isolated from the AT side core were detected also at the AT side surface. Aerobes were predominant on the tonsillar surface compared to anaerobes, both on the PTA side and the AT side (P=.005, logistic regression analysis).

Discussion

Within the past five years, there has been an emerging focus on Fusobacterium necrophorum (FN) as a pathogen in AT [32-34]. Furthermore, in a retrospective study of 847 PTA patients treated at our department from 2001 to 2006, we found FN to be the most prevalent bacterial strain in pus specimens. Patients infected with this bacterium displayed significantly higher neutrophil counts

and CRP values than patients infected with other bacteria, indicating a larger immune response and suggesting that FN is of pathogenic importance in PTA [2].

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

When FN was present at the abscessed site we were able to recover it in nearly all cases from both the abscess aspirate, as well as the tonsillar core. However, swabs of the abscessed tonsil yielded FN much less frequently (56% incidence in cores of abscessed tonsils vs. 27% in surface swabs from the same tonsils) indicating that swabs are not a reliable clinical tool for detecting the organism, or that our method of collection of the swabs was not optimal for culturing FN downstream.

FN, an obligate, anaerobic, Gram-negative rod, is most commonly associated with Lemierre´s Syndrome. However, unlike in Lemierre´s Syndrome, most FN infections remain localised [35]. In contrast to FN, Fusobacterium species are not considered of pathogenic importance in ENT infections.

In Finland, Jousimies-Somer at al. detected FN in 38% of PTA aspirates and found an association to previous tonsillar / peritonsillar infections and previous use of antimicrobial therapy [4]. We did not find an association between incidence of FN and previous events of AT. Brook [14] and Jokipii et al [3] also detected FN in 13% and 7% of PTA aspirates, respectively.

As expected, GAS was also detected significantly more frequently from the cores of the PTA side than from the control cores confirming the well-documented role of GAS in PTA. In our study,

GAS was isolated in 19% of PTA patients, which is less than reported by some studies [4, 10, 15] and similar to the findings of other studies [3, 8, 9, 11-14].

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

By comparing the bacteriology from the PTA side and the non-abscessed, but acutely inflamed, contralateral tonsil, we conclude that the core bacteriology was almost identical between the PTA side and AT side (Table 3). This suggests that other factors are of major importance in the development of PTA. It also indicates that growth of FN is not a subsequent overgrowth phenomenon once an abscess is formed, but that FN is a primary pathogen with importance not only in the pathogenesis of PTA, but also in severe, non-abscessed AT. This is in agreement with recent studies suggesting FN could be involved in AT [32-34, 36]. Batty et al. found FN in 10% of all throat swabs and a clinical diagnosis of tonsillitis was equally likely to be associated with GAS or FN infection [36]. In a polymerase chain reaction (PCR)-based study, conducted in Denmark, FN was detected in 15% of throat swabs from tonsillitis patients aged 18 to 32 years, and the investigators concluded that FN could be a cause of AT and may account for some of the cases previously assumed to be of viral aetiology [32]. Also using PCR, Aliyu et al. identified FN in 10 % of throat swabs from patients presenting to general practitioners with pharyngitis, but they were unable to recover FN from the throats of healthy control subjects [33].

We found that the probability of detecting the pathogens isolated from pus and PTA side core was the same whether swabbing the surface of PTA side or AT side tonsil (Table 3). This finding confirmed the high concordances between the AT and PTA side and likely reflects the high concentrations of bacteria in the acutely infected tonsils. No former studies have made these

comparisons, but Brook et al have shown the necessity of swabbing both tonsils in patients with AT in order to detect all cases of acute GAS tonsillitis [37]. Our results do not confirm the relevance of swabbing both tonsils, but it might reflect the fact that surface swabs were obtained under optimal circumstances in anaesthetized patients and using mouth gag.

We found that surface swabs are not reliable at detecting anaerobes, such as FN (Table 4). In contrast, surface swabs were better at detecting aerobes, for example 86% of BHS isolated from cores was detected. We found that bacterial detection rates from surface swabs were higher in acutely infected tonsils than in non-infected tonsils, but consistent with the trend of detecting aerobes more frequently than anaerobes in surface swabs. These findings have important clinical implications as cases of AT caused by FN, would be missed by a surface swab of the infected tonsils. Whether PCR and other more sensitive detection methods would be helpful in making the diagnosis remains unknown.

In part the lack of consistency with regards to microbiologic findings in former PTA studies may be attributable to differences in culture methods, in specimen collection and handling, and in the patient population (e.g. age, geography). Interpretation of bacteriologic findings in former studies is made even more obscure by the fact that in many studies patients with and without prior antibiotic treatment are pooled together. Some studies have found quantitative and qualitative differences in bacteriologic culture results after antibiotic treatment [3, 6, 8, 13] while others have not [4-5]. Only Flodström et al [15], in 1976, have studied the microbiologic flora exclusively in PTA patients with no prior antibiotic treatment.

None of the former PTA studies have explored the significance of bacteria isolated from PTA patients by comparing the findings with the bacterial flora of non-acutely infected tonsils.

To make such a comparison, comparable materials must be obtained and tonsillar core tissues are therefore needed as culture specimens. We hypothesized that potential pathogens isolated from

aspirated pus would also be present in PTA side core tissue. However, even more potential pathogens were isolated from PTA side cores than aspirated pus, and only very few pathogens were isolated in pus only (Table 4). We therefore believe that tonsillar core tissues formed appropriate basis of comparison to the flora found in clinically non-infected tonsils of electively tonsillectomized patients.

Ideally our bacteriologic findings in patients with PTA would be compared to the flora of tonsillar tissue of healthy subjects (without a history of prior tonsillar disease). Unfortunately, for ethical reasons, such specimens were unobtainable in the present study. Instead, tonsils from patients undergoing elective tonsillectomy were used, thus isolates may not represent "normal" tonsillar flora. A few studies have been conducted comparing core tissue from normal tonsils with that from patients suffering from RT and tonsillar hypertrophy (TH) [28,38-39]. Brook et al., in a study of eight children, found similar organisms in normal and recurrently inflamed tonsils, but the concentration of all BHS, all Bacteroides species, and all Peptostreptococcus species was higher in recurrently inflamed tonsils [38]. A study by Stjernquist-Desatnik et al. detected significantly fewer BHS, in particular GAS, as well as Haemophilus influenzae, in control patients with sleep apnea compared to patients with TH and RT [39]. However, further studies by Stjernquist-Desatnik et al., using a semi-quantitative method to compare the culture results from the above patient group, found no significant differences between groups with regards to frequency and quantity of aerobic and anerobic bacteria [28]. In the present study, the culture results from the four subgroups of electively tonsillectomized patients were comparable to those found in the tonsillar cores of healthy control patients in the studies discussed above. Hence, we believe that tonsillar tissue from patients undergoing elective tonsillectomy can serve as a control in our study.

Due to the amount of specimens, some of which were obtained at night, we kept the specimens at minus 80^{o} C until cultures were made. Studies of the effect of freezing specimens at minus 80 ^{o}C

do not seem to alter the ability to isolate organisms [40-42]. A weakness of the study is that we did not test the effect of freezing on recovery. Some bacteria sensitive to freezing or in low numbers might not have been detected. However, as bacteria were commonly found in high numbers and control specimens were treated in the same way, the risk of bias of results seems limited.

In summary, the present study is the first to compare bacteriological data from PTA patients with non-clinically infected tonsils. Patients were from the same geographic area, over the time period from November, 2005 to February, 2009, were well age matched between the PTA and the control group, and had not taken antibiotics in the month preceding the tonsillectomy. FN and GAS were isolated significantly more frequently from tonsillar cores of PTA patients, both at the side of the abscess and the contralateral side, than from tonsillar cores of electively tonsillectomized patients. Our findings add to the growing body of evidence that FN is a prominent pathogen in PTA and AT. As FN and GAS were isolated as frequently from the PTA side as from the AT side, and as growth in culture from the two sides seemed comparable, it appears that other factors play an important role in the development of PTA. Further studies to investigate the viral composition of the tonsils and immunologic studies are warranted.

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Tables

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

	Surface			Core		
Organism	PTA side	AT side	Controls	PTA side	AT side	Controls
Aerobic						
BHS						
Group A	18%***	15%***	4%	19%***	19%***	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%***	30%	50%	33%***	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%
Anaerobic						
Fusobacterium necrophorum	27%***	27%***	10%	56%*	58%*	24%
Fusobacterium species	33%**	33%**	66%	28%*	28%*	65%
Prevotella species	79%	73%	80%	91%	88%	94%
Other anaerobes	9%	6%	11%	3%	3%	6%
Yeast	6%	6%	8%	9%	9%	4%

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

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

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

BHS: Beta-haemolytic streptococci

Coag.-neg. staphylococci: Coagulase-negative staphylococci

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

Organism	No. isolates		
	Aspirate only	Core only	Aspirate & Core
Aerobic			
Beta-haemolytic streptococci			
Group A	0	0	7
Group C	0	1	2
Group G	1	2	1
Not grouped	1	1	1
Total	2	4	11
Streptococus group B	0	1	0
Streptococcus pneumoniae	0	1	0
Viridans streptococci	2	18	38
Staphylococcus aureus	0	10	2
Coagulase-negative staphylococci	2	0	1
Eikenella corrodens	1	2	0
Neisseria species	0	20	5
Corynebacterium species	1	16	2
Anaerobic			
Fusobacterium necrophorum	2	1	19
Fusobacterium species	0	4	6
Prevotella species	0	17	27
Other anaerobes	0	1	0
Yeast	0	2	0

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

Organism	Surface			Core		
	PTA / AT side only	Both sides	Concor-dance	PTA / AT side only	Both sides	Concor-dance
Aerobic						
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%
Moraxeela 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%
Anaerobic						
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	
Aerobic				
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%
Streptococcus pneumoniae	0	1	0	0%
Viridans streptococci	6	1	51	98%
Staphylococcus aureus	2	6	6	50%
Coagulase-negative staphylococci	2	0	1	50%
Eikenella corrodens	0	1	1	50%
Neisseria species	2	1	22	96%
Moraxella catarrhalis	1	0	0	
Corynebacterium species	4	6	9	60%
Total aerobic isolates	18	18	102	85%
Anaerobic				
Fusobacterium necrophorum	0	8	10	56%
Fusobacterium species	6	4	5	56%
Prevotella species	1	12	28	70%
Other anaerobes	2	0	1	100%
Total anaerobic isolates	9	24	44	65%
Yeast	0	1	2	67%