ANTIBIOTIC SUSCEPTIBILITIES OF STREPTOCOCCI FROM THE MOUTH AND BLOOD OF PATIENTS TREATED WITH PENICILLIN OR LINCOMYCIN AND CLINDAMYCIN

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It is well known that when patients receive antibiotics the oral streptococcal flora regularly becomes resistant to the agent used (Krumwiede, 1949; Garrod and Waterworth, 1962; Naiman and Barrow, 1963; Tozer, Boutflower and Gillespie, 1966; Stirland and Shotts, 1967; Sprunt, Redman and Leidy, 1968; Bentley, Frank and Hahn, 1971; Drucker and Jolly, 1971; Phillips and Warren, 1972; Sukhotiratama, Linton and Fletcher, 1975). It is not known whether this is due to selection of resistant mutants from a variety of sensitive streptococcal strains, or to the enrichment of certain intrinsically resistant species that may be present in the flora in very small numbers or may be acquired from elsewhere by patients who are receiving antibiotics. The present study was designed to answer this question with reference to penicillin and lincomycin, and to compare the efficacies of these antibiotics in curtailing bacteraemia after dental extraction.

PATIENTS AND METHODS

Patients. All patients needing dental clearance (total extraction) before operations on the heart, or dental clearance or extraction of third molars for purely dental indications, and seen during a 6-month period in St Thomas' Hospital, were included in the study. Their pre-operative condition was assessed as good, fair or poor on the results of a combined evaluation of oral hygiene, periodontal condition, including the determination of Russell's Index (Russell, 1956), and any obvious oral infection. Details of any antibiotic treatment received during the previous 3 months were recorded.

Prophylactic chemotherapy. All patients having a dental clearance before an operation on the heart were given lincomycin 600 mg intramuscularly 1 h before extraction of the teeth, and then a course of oral clindamycin 150 mg four times daily for 5 days. The remaining patients were alternately given no antibiotic, the same regimen as the cardiac patients, or benzylpenicillin 600 mg intramuscularly 1 h pre-operatively followed by phenoxymethylpenicillin 250 mg four times daily for 5 days.

Samples for bacteriological examination. Samples of blood were collected for culture at the time of intubation during the induction of general anaesthesia, and 2 min. after the completion of the dental operation. The 20-ml sample was divided between a 50-ml bottle of warmed Reinforced Clostridial Medium (Oxoid CM149) and a 50-ml bottle of warmed digest broth containing glucose 0.1 % (w/v) and *p*-aminobenzoic acid 0.01 % (w/v) (Southern Group Laboratory 0505B), the latter bottle containing an iron nail. A small volume of blood (1-2 ml) was retained for antibiotic assay. The first bottle was incubated anaerobically with

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the cap loose in a GasPak jar (Baltimore Biological Laboratory) and the other in an air incubator, both at 37°C. Anaerobic conditions were used because we were also interested in isolating anaerobes for another purpose.

Duplicate subcultures were made from each blood-culture bottle after incubation for 24 h, and then weekly until a total of five subcultures had been made, on to blood-agar plates (Oxoid CM271); one plate was incubated at 37°C in air plus CO₂ (10%), and the other was incubated anaerobically.

Extracted teeth were placed in sterile containers (all from one patient in a single container) and transported to the laboratory in a thermally insulated container at the end of the operating session. On the 5th–7th post-operative day, sutures were removed from the gum, placed in sterile containers and taken to the laboratory.

In a preliminary experiment on seven patients who had received benzylpenicillin 600 mg intramuscularly, blood collected post-operatively was divided into two portions and inoculated into two bottles of blood-culture medium, one of which contained penicillinase (BBL Penase Concentrate).

In the laboratory, teeth were scraped, particularly in the region of the cervical margin, scrapings pooled for each patient, and samples plated on blood agar, MacConkey's Agar (Oxoid CM7), Mitis-Salivarius Agar (Difco B298), and blood agar containing either penicillin 1 µg per ml, tetracycline 2 µg per ml, vancomycin 2 µg per ml, rifampicin 1 µg per ml or clindamycin 1 µg per ml, and incubated aerobically at 37°C for 48 h. Sutures were rubbed on the surface of the same range of media, all from each patient on the same plate, and incubated in the same way.

Streptococci were initially selected from the primary culture plates on the basis of their colonial morphology and the appearance of gram-stained films. A representative of each colonial type was taken from each medium, and each isolate was tested for the fermentation of mannitol and sorbitol, the hydrolysis of aesculin and arginine, and the production of acetylmethylcarbinol. A selection was then made of organisms with different morphology and different results in these tests, from antibiotic-free and from antibiotic-containing media. Organisms with identical results in biochemical tests but different antibiotic susceptibilities were included. Most of these organisms were submitted to additional biochemical and serological tests, and classified as described by Parker and Ball (1976).

Minimum inhibitory concentrations (MICs) of penicillin, clindamycin, cephaloridine, erythromycin and tetracycline were determined for all isolates on solid media. Antibiotics were incorporated in suitable concentrations in Diagnostic Sensitivity Test Agar (DST, Oxoid CM261). The inoculum, applied with a multiple inoculator, contained approximately 10⁴ colony-forming units. MICs were determined after incubation of the plates for 24 h at 37°C, as the lowest concentrations of antibiotic completely inhibiting growth.

Serum concentrations of antibiotics were determined by standard large-plate assay.

RESULTS

Table I gives information about the state of the teeth and gums before operation, the dental procedures performed, and the history of previous chemotherapy in the groups of patients given each regimen of prophylaxis. Because allocation to these groups was not random, more patients in the lincomycin group than in the other two groups had severe dental disease, and required dental clearance.

The preliminary experiment on the effect of penicillinase showed that organisms were often still viable in the blood in the presence of penicillin. Five of seven cultures to which penicillinase was added yielded either streptococci or a variety of anaerobes, whilst only one of the same but untreated samples yielded growth.

TABLE I

(A) Dental condition and procedures, and (B) details of previous chemotherapy of patients in relation to the allocated regimen of prophylactic chemotherapy

A Prophylaxis given	Number of patients					
	examined	with dental disease of severity*			undergoing	
		1	2	3	dental clearance	extraction of wisdom teeth
None	20	10	6	4	6	14
Penicillin	21	10	7	4	8	13
Lincomycin and clindamycin	26	2	14	10	19	7

B Prophylaxis given	Number of patients who had previously† received						
	penicillin or ampicillin	tetra- cycline	linco- mycin	cotrim- oxazole	erythro- mycin	strepto- mycin	any chemo- therapy
None	6	2	0	1	0	0	9
Penicillin	1	1	0	0	0	1	3
Lincomycin and clindamycin	9	0	1	0	1	0	11

* See text for grading of severity.

† Within 3 months.

Streptococci isolated from teeth, blood and sutures

Of a total of 456 isolates, 449 were submitted to additional biochemical and serological tests. After full identification, 148 isolates were considered to be identical with others in biochemical reactions and antibiotic susceptibilities and were discarded. Table II lists the final collection of 301 streptococci isolated from teeth, blood and sutures. Of 21 isolates from blood, 17 came from the blood culture taken immediately after the dental operation. None of 21 patients receiving penicillin and only five of 26 receiving lincomycin yielded streptococci from blood cultures.

Among the predominantly "α-haemolytic" taxa, we classified as *Streptococcus sanguis* 64 isolates that gave positive results in at least two of the three tests for aesculin hydrolysis, arginine hydrolysis, and the formation of dextran from sucrose, and as *S. mitior* 60 isolates that gave negative reactions in all three of these tests, but we classified separately as "*S. mitior*, dextran positive", 17 isolates that gave negative results in the aesculin- and arginine-hydrolysis tests but formed dextran (Colman and Williams, 1972). This left an unclassified "viridans" group of 33 dextran-negative isolates that gave a positive reaction in the arginine or the aesculin test but not in both. In addition to these we recognised 36 isolates each of *S. mutans* and *S. milleri*, 18 of *S. salivarius*, and

TABLE II
Distribution of streptococcal species or groups among isolates
from teeth, blood, or sutures of 88 patients

Species or group of <i>Streptococcus</i>	Numbers (and percentages) of the stated categories of streptococci isolated from							
	teeth* of 49 patients		blood† of 67 patients		sutures‡ of 37 patients		all sites	
<i>sanguis</i>	44	(23)	1	(5)	19	(21)	64	(21)
<i>mitior</i>	41	(22)	6	(29)	13	(14)	60	(20)
<i>mitior</i> , dextran positive	9	(5)	0		8	(9)	17	(6)
"viridans"	18	(9)	4	(19)	11	(12)	33	(11)
<i>mutans</i>	30	(16)	1	(5)	5	(6)	36	(12)
<i>milleri</i>	21	(11)	5	(24)	10	(11)	36	(12)
<i>salivarius</i>	13	(7)	0		5	(6)	18	(6)
<i>faecalis</i>	0		0		11	(12)	11	(4)
Other enterococci	1	(<1)	1	(5)	0		2	(<1)
Group C	0		0		1	(1)	1	(<1)
Other mannitol fermenting	4	(2)	1	(5)	0		5	(2)
Other laevis positive	3	(2)	1	(5)	1	(1)	5	(2)
Unidentified	6	(3)	1	(5)	6	(7)	13	(4)
Any streptococcus	190	(100)	21	(100)	90	(100)	301	(100)

* After extraction.

† Before dental extraction, 4 isolates; immediately afterwards, 17 isolates.

‡ Five to 7 days after the extraction of teeth.

TABLE III
Streptococci isolated from teeth, blood and sutures of patients receiving no prophylaxis,
penicillin, or lincomycin and clindamycin*

Species or group of <i>Streptococcus</i>	Number of isolates from								
	teeth of patients receiving			blood of patients receiving			sutures of patients receiving		
	0	P	L	0	P	L	0	P	L
<i>sanguis</i>	9	18	17	1	0	0	6	7	6
<i>mitior</i>	9	15	17	3	0	3	4	8	1
<i>mitior</i> , dextran positive	2	3	4	0	0	0	1	6	1
"viridans"	6	9	3	4	0	0	3	7	1
<i>mutans</i>	11	6	13	0	0	1	2	1	2
<i>milleri</i>	3	14	4	5	0	0	4	6	0
<i>salivarius</i>	3	1	9	0	0	0	3	2	0
<i>faecalis</i>	0	0	0	0	0	0	0	7	4
Other streptococci	3	2	9	3	0	1	2	5	1
Any streptococcus	46	68	76	16	0	5	25	49	16

0 = No antibiotic; P = penicillin; L = lincomycin and clindamycin.

* See footnotes to table II.

11 of *S. faecalis*, two of other enterococci, and one β -haemolytic group-C streptococcus. Unclassified isolates included five mannitol-fermenting, bile-sensitive non-dextran-forming streptococci, five laevan-producing streptococci that differed from *S. salivarius* in their arginine or sugar reactions or both, and 13 other single isolates that could not be allocated to any group.

The major difference in the range of streptococci isolated from the three sites was the absence of faecal streptococci from the teeth and the blood and their presence in the sutures, in all cases in patients who had received antibiotics (table III). Other differences, such as the non-isolation of *S. salivarius* and dextran-positive *S. mitior* strains from the blood cultures and the rarity of *S. mutans* in the blood, are not statistically significant, but are of interest.

Sensitivities of the isolates to penicillin and clindamycin

Table IV shows the distribution of MICs of penicillin for each species isolated. Most of the isolates of each of the organisms, with the exception of *S. faecalis*, were inhibited by penicillin 0.12 μ g per ml or less, but each species or group included some isolates that were more resistant; most of the *S. faecalis*, and an occasional isolate of each of the other common species, were even more resistant, with an MIC in excess of 1 μ g per ml. The percentage of resistant strains was greatest among isolates from sutures—12% had an MIC of 0.25–1.0 μ g per ml; 21% had an MIC of >1.0 μ g per ml—and least among those from teeth—4% had an MIC of 0.25–1.0 μ g per ml; 3% had an MIC of >1.0 μ g per ml. This difference was only partly accounted for by the fact that the isolates from the sutures included all 11 of the *S. faecalis* strains.

TABLE IV

Penicillin sensitivities of isolates of various species or groups of streptococci

Species or group of <i>Streptococcus</i>	Total number of isolates	Percentage of isolates with a penicillin MIC (μ g per ml) of			
		<0.01	0.01–0.12	0.25–1.0	>1.0
<i>sanguis</i>	64	30	66	3	1
<i>mitior</i>	60	12	83	2	3
<i>mitior</i> , dextran positive	17	6	65	24	5
"viridans"	33	6	70	3	21
<i>mutans</i>	36	26	60	9	5
<i>milleri</i>	36	8	83	6	3
<i>salivarius</i>	18	6	72	11	11
<i>faecalis</i>	11	0	0	18	82
Other streptococci	26	19	65	8	8
All streptococci from					
teeth	190	18	75	4	3
blood	21	10	75	5	10
sutures	90	13	54	12	21
all sites	301	16	68	7	9

TABLE V
Penicillin sensitivities of streptococci from patients on the different antibiotic regimens

Species or group of <i>Streptococcus</i>	Number of isolates, from patients who had received								
	no antibiotic, with a penicillin MIC (μg per ml) of			penicillin, with a penicillin MIC (μg per ml) of			lincomycin and clindamycin, with a penicillin MIC (μg per ml) of		
	≤ 0.12	0.25-1.0	> 1.0	≤ 0.12	0.25-1.0	> 1.0	≤ 0.12	0.25-1.0	> 1.0
<i>sanguis</i>	16	0	0	23	2	0	22	0	1
<i>mitior</i>	15	1	0	21	1	1	20	0	1
<i>mitior</i> , dextran positive	2	0	1	6	3	0	4	1	0
"viridans"	10	0	3	12	1	3	3	0	1
<i>mutans</i>	12	1	0	7	0	0	12	2	2
<i>milleri</i>	12	0	0	17	2	1	4	0	0
<i>salivarius</i>	5	1	0	1	0	2	8	1	0
<i>faecalis</i>	0	0	0	0	0	7	0	2	2
Other streptococci	7	1	0	6	1	0	9	0	2
Any streptococcus	79	4	4	93	10	14	82	6	9

TABLE VI
Clindamycin sensitivities of streptococci from patients receiving the different antibiotic regimens*

Species or group of <i>Streptococcus</i>	Number of isolates, from patients who had received					
	no antibiotic or penicillin, with a clindamycin MIC (μg per ml) of			lincomycin and clindamycin, with a clindamycin MIC (μg per ml) of		
	≤ 0.12	0.25-4.0	> 4.0	≤ 0.12	0.25-4.0	> 4.0
<i>sanguis</i>	41	0	0	21	1	1
<i>mitior</i>	39	0	0	17	3	1
<i>mitior</i> , dextran positive	3	0	0	4	1	0
"viridans"	29	0	0	4	0	0
<i>mutans</i>	20	0	0	14	1	1
<i>milleri</i>	32	0	0	4	0	0
<i>salivarius</i>	9	0	0	9	0	0
<i>faecalis</i>	0	0	7	0	0	4
Other streptococci	13	1	0	11	0	0
Totals	176	1	7	84	6	7

* Twenty of the 301 streptococci were not tested.

The isolation of penicillin-resistant organisms was not limited to patients who had received prophylactic penicillin (table V). In all, MICs of 0.25 μg per ml or more were found for eight of 87 isolates (9%) from patients who had received no prophylactic antibiotics, 15 of 97 isolates (15%) from those

TABLE VII

Susceptibilities to penicillin and clindamycin of streptococci other than S. faecalis isolated from sutures, in relation to the prophylactic regimen employed

Prophylactic antibiotic	Number of isolates of streptococci from sutures with			
	a penicillin MIC (μg per ml) of		a clindamycin MIC (μg per ml) of	
	≤ 0.06	≥ 0.12	≤ 0.06	≥ 0.12
None	19	6	24	1
Penicillin	22	19	42	0
Lincomycin and clindamycin	9	3	7	4
Statistical analysis*	$\chi^2 = 3.96$; $p < 0.05$		$\chi^2 = 13.78$; $p = 0.0005$	

* For each set of sensitivity tests, results for organisms from patients receiving that antibiotic were compared with a combination of those from patients receiving the other antibiotic or no antibiotic in a 2×2 test; χ^2 was corrected for small numbers by Yates' method.

who had received lincomycin and clindamycin, and 24 of 117 (20%) isolates from those who had received penicillin. If the *S. faecalis* isolates from the latter two groups are excluded, those percentages are respectively 9%, 12% and 15%.

Resistance to clindamycin (table VI) was in general less frequent than to penicillin, but all 11 strains of *S. faecalis* had an MIC in excess of $4 \mu\text{g}$ per ml for clindamycin. Only 270 of the 290 other streptococci were tested for clindamycin sensitivity; six of these had an MIC of 0.25 – $4.0 \mu\text{g}$ per ml and three of $>4.0 \mu\text{g}$ per ml. All these resistant strains were isolated from patients who had received lincomycin and clindamycin prophylactically.

When the organisms isolated from sutures, other than *S. faecalis*, were compared, statistically significant differences emerged (table VII). Penicillin prophylaxis resulted in the emergence of penicillin-resistant but not of lincomycin-resistant strains, and lincomycin-clindamycin prophylaxis resulted in the emergence of clindamycin-resistant but not penicillin-resistant strains.

Sensitivities to other antibiotics

The susceptibilities of all the streptococci, other than *S. faecalis*, to cephaloridine, tetracycline and erythromycin, are summarised in table VIII. Correlation is difficult because of the small numbers of organisms in some of the groups. However, excluding *S. faecalis*, there was some correlation between penicillin and cephaloridine sensitivity; and organisms showing some degree of resistance to cephaloridine (MIC $\geq 0.12 \mu\text{g}$ per ml) were more commonly isolated from sutures after penicillin prophylaxis (39%) than after no prophylaxis (24%) or after clindamycin (28%). We have no explanation for the

TABLE VIII

Susceptibilities of all isolates other than S. faecalis to cephaloridine, tetracycline and erythromycin

Antibiotic	Percentage of isolates that were		
	fully sensitive*	intermediate†	resistant‡
Cephaloridine	79	15	6
Tetracycline	62	15	23
Erythromycin	95	3	2

* MIC of cephaloridine and erythromycin ≤ 0.06 μg per ml, and of tetracycline ≤ 1.2 μg per ml.† MIC of cephaloridine and erythromycin 0.12 μg per ml to 1.0 μg per ml, and of tetracycline 2.5–10 μg per ml.‡ MIC of cephaloridine and erythromycin ≥ 2.0 μg per ml, and of tetracycline ≥ 20 μg per ml.

finding that a similar degree of resistance was found in only 12% of streptococci from teeth. Tetracycline resistance (MIC ≥ 2.5 μg per ml) was common among streptococci from teeth (42%) and had a similar frequency among streptococci from sutures. Resistance to erythromycin (MIC ≥ 0.12 μg per ml), as to clindamycin, was uncommon among streptococci from teeth (2%); a marked increase in the frequency of erythromycin resistance (to 16%) was observed only among streptococci from the sutures of patients receiving clindamycin.

Antibiotic content of the blood of patients

Among patients treated with penicillin, assays were performed on 17 blood samples collected at the beginning of the operation and 18 collected at the end. Mean penicillin concentrations were 4.4 μg per ml (standard deviation ± 2.1) and 3.5 μg per ml (standard deviation ± 1.9). Among those given lincomycin, assays were performed on 21 pre-operative and 20 post-operative samples, and mean lincomycin concentrations were 7.9 μg per ml (standard deviation ± 2.2) and 7.0 μg per ml (standard deviation ± 1.7).

DISCUSSION

This study was undertaken to compare the effect of lincomycin and penicillin as separate prophylactic agents when administered during dental extraction. The case for an alternative to penicillin is based on the argument that patients having a dental extraction some weeks before an operation on the heart should be given an antibiotic that, apart from being effective in preventing endocarditis, will not result in the emergence of a bacterial population that is resistant to antibiotics that will be used prophylactically at the time of the cardiac operation. For this reason, the prophylactic regimens used could not be entirely randomised, and the group of patients receiving lincomycin had more severe dental disease and more extensive dental operations, both of which factors might well have resulted in more organisms gaining access to

the bloodstream, making prophylaxis more difficult. There was, however, no obvious difference between the incidence of bacteraemia in patients undergoing dental clearance and in those having only extraction of wisdom teeth.

The organisms isolated from teeth belonged largely to species that we had expected to find there, namely *S. sanguis*, *S. mitior*, *S. mutans* and *S. milleri*. There were relatively few isolates of *S. salivarius*, not unexpectedly as the tongue is the preferred habitat of this organism. *S. faecalis* was not isolated, and there was only one isolate of another enterococcus. This finding is in agreement with that of most investigators except, possibly, Ross (1972) who found *S. faecalis* in the saliva of 42% of 50 school-children.

Although the number of streptococci isolated from blood was small, it was interesting that *S. mitior* and unclassified "viridans" streptococci were relatively more common in the blood than on the teeth, and that among patients given no prophylaxis *S. milleri* was the commonest single species isolated; *S. sanguis* was somewhat more rare in the blood than on the teeth, but none of these differences is statistically significant. Porterfield (1950) found that most of the streptococci found in the blood after dental extraction were *S. mitior*, with a few *S. sanguis*.

The sutures removed from the patients' gums 5-7 days after dental treatment were shown, in a preliminary study, to have a streptococcal flora similar to that of the gums themselves, and were, therefore, a convenient means of sending a sample to the laboratory. Culture of the sutures provided the answer to one of our major questions, in that *S. faecalis* was isolated only from them and not from the teeth, whose flora was assumed to be unaffected by chemotherapy. Furthermore, *S. faecalis* was isolated only from patients who had had a course of an antibiotic. Chemotherapy with either penicillin or clindamycin therefore resulted in the appearance of *S. faecalis* in the oral flora. This finding is in some contrast to that of Sukchotiratama *et al.* (1975) who reported no *S. faecalis* in the oral flora after giving penicillin and clindamycin. However, they worked on samples from normal volunteers.

Streptococci of other types were isolated from sutures in much the same proportions as from teeth, and an assessment of the susceptibility of these organisms gave the remainder of the answer to our first major question. Resistant isolates of each of the streptococcal species were detected. Investigation of organisms from teeth and blood showed that similar organisms were present before chemotherapy, but were detectable less often, presumably because they were in relatively small numbers.

Our results on the distribution of the various species of streptococci and their antimicrobial susceptibilities support the hypothesis that the oral streptococcal flora becomes resistant to penicillin after penicillin treatment, both by the acquisition of *S. faecalis* not normally present in the mouth, and by the selection of resistant populations of the resident species. Similarly the administration of clindamycin led to the acquisition of *S. faecalis* and small numbers of clindamycin-resistant variants of other species, a finding again in contrast to that of Sukchotiratama *et al.* in their studies on normal volunteers. There was evidence of cross-resistance, in organisms other than *S. faecalis*,

between penicillin and cephaloridine, and to some extent between clindamycin and erythromycin, findings largely in agreement with those of Sprunt, Redman and Leidy (1968), Paterson and Madden (1969) and Spencer *et al.* (1970). It follows that our practice of administering lincomycin and clindamycin to patients who would later require penicillin prophylaxis, to prevent the emergence of a penicillin-resistant flora by the time penicillin was administered, was probably well founded.

The second major area of study was the comparison of the effects of penicillin and lincomycin on dental bacteraemia. The incidence of post-extraction streptococcal bacteraemia was high, in keeping with the findings of others (Okell and Elliott 1935; Jones *et al.*, 1970; Cutcher *et al.*, 1971). It was apparently abolished by penicillin but not completely by lincomycin in the dose that we used. However, it became clear during the course of the study that the interpretation of the results of blood cultures was difficult. Dental bacteraemia lasts for about 10 minutes, and organisms that are going to survive presumably attach themselves to damaged heart valves during that time. No antibiotic can kill organisms with sufficient rapidity to remove them in this phase (Durack and Petersdorf, 1973). Their exposure to antibiotic presumably then changes, and we cannot mirror these changes in a standard blood-culture system. A major difference *in vitro* is that the blood is immediately diluted—in our system about five-fold. Concentrations of penicillin would thus drop to a mean of about 0.7 μg per ml for penicillin and 1.4 μg per ml for lincomycin. Because the modal MIC for lincomycin is about four to eight times that for penicillin for these organisms, lincomycin might be at an increased disadvantage as a result of this dilution. Having been diluted, the antibiotics then presumably decline in concentration in the blood-culture bottle, penicillin more quickly than lincomycin, but neither as quickly as they would *in vivo*, nor, in the case of penicillin, as quickly as after the addition of penicillinase. As a result of these factors, we can conclude only that organisms causing dental bacteraemia did not survive penicillin but that some did survive lincomycin, in the blood-culture bottles. The relevance of either of these findings to *in-vivo* events is impossible to assess, and one must use experimental models to assist in their interpretation (Durack and Petersdorf, 1973). It is possible that bacteristatic agents may be useless despite their ability to suppress bacteria in blood-culture systems (Southwick and Durack, 1974).

SUMMARY

Patients undergoing dental extractions were non-randomly allocated to three groups, one of which received no antibiotic, one benzylpenicillin followed by oral penicillin for 5 days, and the third intramuscular lincomycin followed by oral clindamycin. Dental extraction was performed at the beginning of the course of chemotherapy. Streptococci were isolated from the extracted teeth, from blood cultures collected before and immediately after dental extraction, and from sutures removed from the gums 5–7 days after the operation. The species of these organisms was determined, and their susceptibilities to penicillin, clindamycin, cephaloridine, erythromycin and tetracycline were assessed.

The majority of streptococci isolated from teeth belonged to the species *Streptococcus sanguis*, *S. mitior*, *S. mutans* and *S. milleri*. Occasional isolates of each of these organisms collected before the antibiotic could take effect were resistant to penicillin.

Three of these species, but not *S. mutans*, were the commonest streptococci to be isolated from the blood after dental extraction. Penicillin completely suppressed dental bacteraemia under the conditions of our investigation, and lincomycin reduced the incidence by about 60 per cent.

The commonest streptococci from sutures were also *S. sanguis*, *S. mitior*, *S. mutans* and *S. milleri*; *S. faecalis* was also isolated, but only in patients who had received antibiotics. Among the non-*faecalis* organisms, penicillin resistance was significantly more frequent among isolates from patients given penicillin than from patients not given this antibiotic, and clindamycin resistance was significantly more frequent among isolates from patients given lincomycin and clindamycin than from patients not given these antibiotics.

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