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Preoperative screening cultures in the identification of staphylococci causing wound and valvular infections in cardiac surgery

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Summary: Cultures of nasal or presternal swabs form part of the routine preoperative screening of patients on the cardiac surgical ward. During a trial of antibiotic prophylaxis in 314 patients, preoperative isolates of *Staphylococcus aureus* and coagulase-negative staphylococci were compared with strains associated with postoperative sternal wound breakdown (24 patients) and prosthetic valve endocarditis (3 patients). Morphology, antibiotic sensitivity pattern, plasmid analysis and phage typing were used to differentiate strains. In only three cases of wound infection and one of prosthetic valve endocarditis were pathogenic staphylococci not distinguishable from preoperative isolates. The collection of superficial swabs for this purpose before cardiac surgery is therefore unlikely to be cost effective.

Keywords: Wound infection; heart surgery; *Staphylococcus aureus*.

Introduction

Preoperative screening of nasal or presternal swabs is commonly performed on cardiac surgical wards to identify patients carrying *Staphylococcus aureus*, particularly methicillin-resistant strains, that might later be responsible for sternal wound infection or prosthetic valve endocarditis (Keighley & Burdon, 1979). In practice, preoperative isolation of *Staphylococcus aureus* has rarely, if ever, altered perioperative management and the commonest potential pathogen, *Staphylococcus epidermidis*, was often disregarded (Harris *et al.*, 1984; Farrington *et al.*, 1985, Wilson *et al.*, 1988a). The cost of processing preoperative samples might be justified if the source of an operative infection could be identified as endogenous, and selective prophylaxis altered appropriately.

As part of a study of antibiotic prophylaxis (Wilson *et al.*, 1988*b*), preoperative nasal or sternal swabs were collected from patients admitted

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for cardiac surgery. Preoperative isolates of staphylococci were compared with those isolated postoperatively from sternal wound infection or prosthetic valve endocarditis.

Materials and Methods

Patients and preoperative cultures

Cultures were obtained from patients who entered into a prospective randomized clinical trial to compare two prophylactic regimens for cardiac surgery: teicoplanin (400 mg iv with induction of anaesthesia and 200 mg 24 h later), or flucloxacillin and tobramycin (500 mg flucloxacillin iv/po 6 hourly for 5 d, tobramycin 80 mg 8 hourly iv for 3 d) (Wilson *et al.*, 1988*b*). Exclusion criteria were age under 18 years, pregnancy, a history of allergy to penicillin or vancomycin, serum creatinine over 150 $\mu mol\,l^{-1}$, active infection or antibiotic treatment within the last 7 days.

Swabs were taken by the nursing staff from the anterior nares of all patients before and one week after operation. Cultures were made from the presternal skin immediately prior to operation. To increase the yield of bacteria, swabs were first moistened in sterile water. Postoperatively, swabs were taken from all discharging wounds and, in cases of endocarditis, cultures made from blood or the excised valve.

Wound infections were assessed by the ASEPSIS method (Wilson *et al.*, 1986) in which a score is used to describe the extent and clinical significance of wound breakdown. A score less than 11 points indicates satisfactory healing of the wound, while minor, moderate and severe wound infections were defined by scores above 20, 30 and 40 points, respectively. Early prosthetic-valve endocarditis was defined as the growth of an indistinguishable organism from two or more sets of blood cultures in the presence of fever, within 4 months of operation. The diagnosis was usually confirmed by the finding of vegetations at operation or post-mortem examination.

Bacterial isolation and typing

Any bacterial growth (one or two predominant colony types) after 48 h was identified by standard methods. When staphylococci were isolated in both preoperative and postoperative cultures, strains were differentiated by colonial morphology, pigmentation and haemolytic activity (Kloos & Schleifer, 1975). Sensitivities to 14 antibiotics were performed by a modified Stokes method on Isosensitest agar with lysed blood (Oxoid) (i.e., methicillin, clindamycin, tobramycin, teicoplanin, novobiocin, penicillin, gentamicin, erythromycin, fusidic acid, trimethoprim, ciprofloxacin, vancomycin, rifampicin and tetracycline). Resistance to methicillin was tested by incubation at 30°C. Strains were considered distinct if they differed by two or more unrelated resistance mechanisms.

All strains underwent plasmid analysis, by a method modified from

Wilson, Totten & Baldwin (1978). Briefly the strain was treated with lysostaphin followed by RNAse and protease. The plasmid DNA was precipitated with isopropanol and analysed by electrophoresis on a submerged agarose gel. Molecular weights were determined with reference to standards at 20, 2.7, 2.3 and 1.8 megadaltons and strains were distinguished by one or more different plasmids.

Strains not differentiated by these methods were speciated by the API-Staph system and typed by bacteriophage at the Staphylococcal Reference Laboratory, Colindale. Strains were distinguishable if two or more strong differences were present in lysis by phages (Williams & Rippon, 1952). Coagulase-negative staphylococci causing prosthetic valve endocarditis were also speciated and examined for slime production (Christensen *et al.*, 1983).

Results

Of 419 patients who underwent cardiac surgery during the 15 months of the study, 314 completed the protocol. Coronary artery surgery was performed in 187 patients and valve replacement in 95, the remainder having other intracardiac surgery.

Of the 314 patients postoperative sternal wound infections were recorded as follows: severe wound infection (>40 points) in eight (2.5%); moderate infection (31–40 points) in three cases (1%); and minor infection (21–30 points) in 14 (4.5%) others. Disturbance of healing (11–20 points) was noted in 24 patients (7.6%). There were only two moderate and three minor leg-wound infections.

Preoperative nasal swabs were received from 280 (89%) patients and swabs of the sternal skin from 133 (42%) patients. Preoperative staphylococci were compared with those in the discharge from the sternal wound in 24 patients. In the three cases not shown in Table I, preoperative and postoperative strains were distinguished by coagulase, antibiogram and plasmids.

Wound sepsis due to Staphylococcus aureus

Prior to surgery, *S. aureus* was isolated from nasal swabs from 71 (25%) of 280 patients and from 4 (3%) of 133 swabs of the sternal skin. No methicillin-resistant strains were detected. *S. aureus* was present in both pre- and post-operative specimens in three patients, one with severe, one with minor infection, and one with disturbance of wound healing. Strains of *S. aureus* from the sternal wound of one patient and the leg wound of another were not distinguished from those in the preoperative nasal swab by any of the methods, including phage typing. Neither infection required antibiotics or drainage and the strains were sensitive to the prophylactic antibiotics used.

Table I. *Pairs of isolates of coagulase negative staphylococci (CNS) or* S. aureus *from preoperative and postoperative swabs from the nose and sternal skin in 21 patients*

Patient (Wound score*)	Culture site before surgery	Culture site after surgery	Species isolated	Tests for distinguishing features			
				Haemolysis	Antibiotic resistance	Plasmid analysis	Bacteriophage susceptibility (where performed)
Al (16)	Nose	–	*S. aureus*				
	Nose	Sternum	CNS	+	–	–	+
An (22)	Nose	Sternum	CNS	+	+	–	
Ca (11)	Nose	Nose/Sternum	CNS	–	+	+	
Co (12)	Sternum	Nose	CNS	–	–	+	
	Sternum	Sternum	CNS	+	+	+	
	Nose	–	*S. aureus*				
Da (23)	Nose	Nose/Sternum	CNS	–	–	+	
Em (41)	Nose	Nose	CNS	+	+	+	
	Nose	Sternum	CNS	+	–	+	
Ga (30)	Nose	Sternum	*S. aureus*	–	–	+	+
	Nose	Leg	*S. aureus*†	–	–	–	–
Hr (15)	Nose/Sternum	Sternum	CNS	+	–	+	
Hu (40)	Nose	Sternum	*S. epidermidis*†	–	–	–	–
	Nose	Sternum	CNS	–	+	+	
Ke (15)	Nose	Sternum	*Micrococcus sp*†	–	–	–	Not typable

La (11)	Nose	Sternum	CNS	−	−	+	
		Sternum	*S. aureus*				
Mu (16)	Nose	Nose	CNS	−	−	+	
	Nose	Sternum	CNS	−	+	+	
		Sternum	*S. aureus*				
Oc (43)	Nose	Nose/Sternum	CNS	−	+	+	
	Nose	Sternum	*S. aureus*	+	−	+	
Pa (23)	Sternum	Nose/Sternum	CNS	−	−	+	
Pd (20)	Nose	Sternum	CNS	−	−	+	
		Nose/Sternum	*S. aureus*				
Pm (14)	Nose	Nose	CNS	+	−	+	
	Nose	Sternum	CNS	−	+	+	
Ps (26)	Nose	Nose	CNS	+	+	+	
	Nose	Sternum	CNS	−	−	+	
Ra (11)	Nose	Sternum	CNS	−	−	+	
	Nose	Sternum	CNS	+	−	−	
	Nose	Sternum	*S. aureus*†	−	−	−	−
Sa (21)	Nose	Sternum	*S. epidermidis/ S. simulans*	−	−	−	Not typable
	Nose	Nose	CNS	+	−	+	
St (11)	Sternum	Sternum	CNS	−	−	+	
We (16)	Nose	Sternum	CNS	−	+	+	

The figure in brackets* is the ASEPSIS wound score. + indicates strains are distinct by stated criteria. † indicates isolates not distinguished.

Wound sepsis due to coagulase-negative staphylococci

Coagulase-negative staphylococci were isolated from 205 (73%) of 280 preoperative nasal swabs and from 89 (67%) of 133 preoperative sternal swabs. The organisms were present in swabs before and after operation from 20 patients (two severe, one moderate and five minor infections and 12 with disturbance of healing), including two of the three patients described with paired isolates of *S. aureus*. Pairs of strains from five patients, not distinguished by other methods, were speciated and phage typed. Three pairs were of the same species, but only one pair had a similar bacteriophage profile (*Staphylococcus epidermidis*) and one pair was not typable (*Micrococcus* sp.). One wound required drainage under local anaesthesia and daily dressing at home but antibiotics were not needed in either case. Both organisms were sensitive to the prophylactic antibiotics.

Early prosthetic-valve endocarditis

Endocarditis developed in three of the 95 patients having valve replacement during the study (Table II). The preoperative sternal isolate and postoperative blood isolate could not be distinguished in one patient, but the organism, which was identified as *Staphylococcus capitis*, had no antibiotic resistances or plasmids and could not be phage typed. The patient, a 57-year-old man, was first noted to have heart block two months after aortic valve replacement but endocarditis with a para-aortic root abscess was not diagnosed until four months later. Treatment with parenteral penicillin and gentamicin resulted in a bacteriological cure but the patient died four days after replacement of the infected valve. Antibiotic prophylaxis for the original operation had been teicoplanin (400 mg and 200 mg 24 h later iv), of which the MIC for the organism was 1 mg l^{-1}.

Discussion

Preoperative nasal swabs predicted the subsequent infecting strain of staphylococcus in only three (13%) of the 24 patients studied with sternal wounds that scored more than 10 points by the ASEPSIS method. Conventional criteria of wound infection, such as discharge of pus with erythema, would have identified only four of the 24 wounds as 'infected', the pathogen being similar to the preoperative strain in one case. As had been suspected, the estimated cost (£1300 for 314 patients) of preoperative nasal swabs could not be justified for this purpose and no change in antibiotic prophylaxis was indicated.

Nasal swabs were collected from 89% of patients but the timing of sternal swabs on the day of operation presented practical difficulties. Consequently, results were not available in 48% of those with wound scores over 10 points. Those that were obtained did not predict subsequent wound infection or the causative pathogen. A sternal swab identified the source of the infecting organism in one case of prosthetic valve endocarditis, but serum

Table II. *Isolates of staphylococci from preoperative nasal or sternal swabs and from blood and sternal wound after operation in three patients who developed prosthetic valve endocarditis*

Patient	Culture site before surgery	Culture site after surgery	Species isolated	Tests for distinguishing features			
				Slime production Y/N	Antibiotic resistance	Plasmid analysis	Bacteriophage susceptibility
Ho	Nose		*Staphylococcus saprophyticus*	N			
		Blood	*Micrococcus sp*	N	+	+	
		Nose	*Staphylococcus haemolyticus*	N	+	+	
		Sternum	*S. epidermidis*	N	+	+	
Po	Nose		*S. aureus**				
		Blood	*S. aureus*		−	+	Not typable
		Sternum	*S. aureus*		−	−	Not typable
		Sacrum	*S. aureus**		−	−	−
Sa	Sternum		*Staphylococcus capitis**	Y			
		Blood	*S. capitis**	Y	−	−	Not typable

+ Indicates isolates distinct by stated criteria; *indicates isolates not distinguished.

concentrations of the antibiotic used for prophylaxis would have been adequate to inhibit its growth (Wilson *et al.*, 1988*c*).

Preoperative screening did not identify any carriers of methicillin-resistant strains of *S. aureus*, but this practice may be warranted to prevent the unsuspected introduction of a carrier into a regional centre. Earlier work has shown that *S. epidermidis* in pure growth is associated with wound sepsis of similar severity to that due to *S. aureus* (Wilson *et al.*, 1988*a*). Screening for methicillin-resistant *S. epidermidis* might then be appropriate but would not have resulted in any change of management in this study.

Failure to isolate the infecting strain before operation does not necessarily indicate that the infections were exogenously acquired. Although nasal swabs were moistened to increase bacterial yield, fewer patients were found to carry *S. aureus* than might be expected from other studies (Williams, 1963). Repeated swabs collected by a trained investigator would have been necessary to establish the maximum rate of carriage but that was neither practical nor could it be achieved routinely on a busy cardiothoracic unit.

Seeding of staphylococci from the patient's skin flora into the wound at operation is a common occurrence (Kluge *et al.*, 1974). However, this study suggests that exogenous sources may be at least as important. Earlier work in this series of patients showed a single multiply-resistant strain of *S. epidermidis* to be associated with three severe wound infections (Wilson *et al.*, 1988a). Houang *et al.* (1986) examined the possible origins of four index strains from sternal wound infections and concluded that the intensive-care unit team was the most likely source, in view of the frequency of carriage in that group. Preoperative samples had not been obtained. In a retrospective analysis, Marples (1980) found two strains of *S. epidermidis* to be responsible for nine infected wounds, and three infected valves. Similar strains with multiple antibiotic resistance were acquired by patients in the intensive care unit, a finding confirmed by Hansen (1982).

In this investigation, preoperative nasal and sternal isolates of staphylococci were collected prospectively and compared with those causing subsequent wound infection and endocarditis. This is rarely practicable in clean surgery and was only achieved in the case of this study as part of a major clinical trial. However, screening does not appear to be cost effective as a predictor of wound infection or as an aid to prophylaxis. It remains to be seen whether a more intensive study with repeated sampling from several sites preoperatively could determine the rate of endogenous infection.

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