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Are ECG Welsh cup electrodes effectively cleaned?

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Summary: Re-usable Welsh electrocardiograph (ECG)-electrodes are potential vehicles for cross infection. This study confirmed that in-use ECG-electrodes are frequently contaminated with organisms such as coagulase-negative staphylococci and Gram-negative bacilli. The efficacy of five cleaning procedures was evaluated. Immersing the electrodes in water at 60°C for one hour was the most effective method of decontamination tested, following challenge with a standardised suspension of *Staphylococcus saprophyticus*. Significant contamination persisted following simple cleaning measures. It is suggested that this was promoted by the inadequate removal of electrode gel which provided a protective environment for microorganisms.

Keywords: Cross-infection; electrodes; sterilisation.

Introduction

The principal route of bacterial cross infection in hospitals is thought to involve direct transfer from the hands and clothing of members of staff and fomites rather than airborne transmission (Lowbury *et al.*, 1975; Parker, 1983). Numerous species of bacteria have been implicated in this type of spread of infection, including *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Unfortunately, despite many detailed investigations and various preventive measures, cross infection still occurs in hospitals. The continued relatively high incidence of nosocomial infections, particularly in high dependency units, may be associated with the increasing complexity of medical care and the failure to recognise potential infection hazards. One possible mode of transfer of microorganisms resulting in cross infection is reusable ECG electrodes, which are commonly used in many hospitals. Attention has been drawn in the past to this possible mode of transfer with wet-pad ECG electrodes (Lockley, Parker & Casewell, 1973; Lewis, 1987).

Reusable Welsh ECG electrodes are commonly used in many hospitals. More recently, it has been demonstrated that these electrodes have the potential for being vehicles of cross infection (Cefai & Elliott, 1988). In the

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present study, the degree of contamination of in-use equipment following routine cleaning methods was assessed, together with the efficacy of various alternative methods of decontaminating the electrodes after a standard microbial challenge. *Staphylococcus saprophyticus* was selected for the experiments, as it facilitated differentiation from other skin commensals already present. The survival of microorganisms in three commercially available electrolyte gels was also determined.

Materials and methods

Evaluation of the in-use cleaning method

The routine method utilised by the Cardiology Department involved wiping clean the electrode bells after each electrocardiograph with a dry tissue removing most of the gel (Camcare—Cambmac Instruments Limited, Denny Industrial Centre, Waterbeach, Cambridge). At the end of each session, during which approximately 8 patients would have an ECG recorded, both the bells and bulbs were washed in a 0·1% aqueous solution of chlorhexidine (Hibiscrub—Imperial Chemical Industries, Macclesfield, Cheshire) in warm water for approximately 2 min with a scrubbing brush. To investigate the efficacy of this cleaning method, ECG electrodes attached to one machine were examined bacteriologically four times during a day: before use in the morning; mid-session; at the conclusion of a day's session; and following final cleaning as outlined above. The sampling was repeated on four separate days over a period of one month. The cardiology staff were unaware of the nature of the investigation and did not have advance knowledge of the sampling times. Sampling was carried out by firmly pressing each Welsh electrode onto both 5% horse blood agar and cystine–lysine electrolyte deficient agar (CLED) (Oxoid Limited, Basingstoke, Hampshire), leaving an impression of the rim of the bell (Figure 1). This inoculum was then spread out and the plates incubated at 37°C for 48 h. Subsequent bacterial colonies were counted and identified using standard laboratory methods.

Evaluation of alternative cleaning methods

Sterile Welsh cup electrodes were contaminated with a standard *Staphylococcus saprophyticus* prepared in one of three electrolyte preparations: Camcare, Cardijel (Cardiac Recorders Limited, London) and Dracard electrolyte cream (Dracard Limited, Maidstone, Kent). One ml of each electrolyte was thoroughly mixed with 0·2 ml of 10% plasma in normal saline containing up to 5×10^5 cfu ml^{-1} of *Staphylococcus saprophyticus*. 0·5 ml of the contaminated electrolyte was then injected into separated electrode rubber bulbs and the bulbs and bells reattached. A further 0·5 ml of contaminated electrolyte was spread over the inner surface of each electrode bell. Bulbs and bells were both bacteriologically sampled after one of the following cleaning procedures.

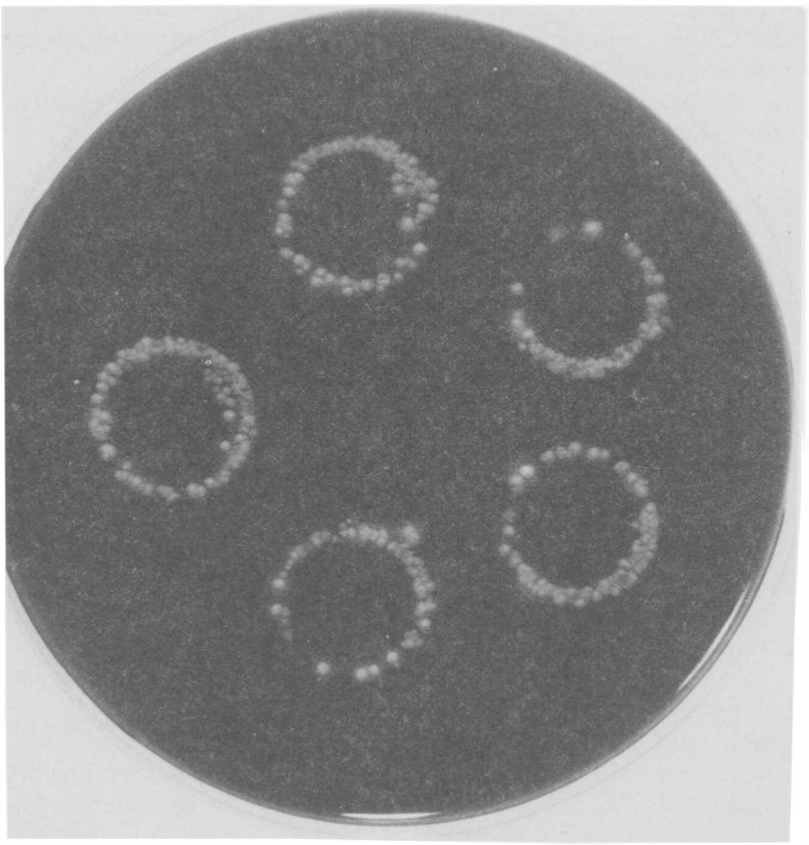

Figure 1. A 5% horse blood agar plate after 48 h incubation at 37°C having been inoculated by pressing Welsh ECG electrodes, contaminated by patient use, onto the surface. Numerous colonies of bacteria associated with the inoculum sites are shown.

(a) The bulbs were compressed to express electrolyte and the bells wiped across all surfaces three times with a dry tissue, emulating the routine method of cleaning.

(b) The bells were wiped with a dry tissue to remove excess electrolyte. They were then wiped across their surface three times with a 'Steret' (Schering Prebbles Ltd., Merseyside, Liverpool) which contained 70% v/v isopropyl alcohol.

(c) The electrodes were immersed in 70% ethyl alcohol at room temperature for 10 min. Alcohol was drawn into the bulbs by depressing the bulbs at least twice.

(d) The electrodes were cleaned adhering as closely as possible to the manufacturers instructions (Hewlett Packard, Stockport, Cheshire). Gel was removed from the surface of the electrodes by wiping with a dry tissue.

Bulbs were separated from electrodes and both were then immersed in water at 50°C for 2 min, and then allowed to dry in an inverted position at room temperature for 3 h.

(e) The electrodes, with bulbs and bells separated were immersed in water at 60°C for 1 h.

The bells were sampled with a dry sterile swab which was pressed firmly across the inner surfaces several times. The swabs were then inoculated onto 5% horse blood agar plates. One ml of sterile saline was next pipetted into each of the bulbs and after mixing, by pressing the bulbs several times, the contents were added to 20 ml of nutrient agar at 45°C and four plates prepared. These were incubated at 37°C for 48 h and the number of colonies of *S. saprophyticus* determined.

Between experiments the bulbs and bells were separated and washed in water. The bells were autoclaved at 121°C for 15 min and the bulb immersed in water at 60°C for 1 h. No organisms were present on either the bulb or bell after this procedure.

In all experiments one electrode was left uncleaned to act as a control. Bacteriological sampling of all the electrodes involving bulbs and bells as described above, was performed immediately after the cleaning procedure had been completed.

The survival of microorganisms in electrolyte gels

The ability of *Staphylococcus aureus, Staphylococcus epidermidis, Pseudomonas aeruginosa, Escherichia coli, Enterobacter spp., Serratia spp.* and a β-haemolytic streptococcus Lancefield group A to survive in the three electrolyte gels was also investigated.

Broth cultures of the bacteria left overnight were diluted in normal saline to obtain approximately 10^5 cfu ml^{-1}. 0·1 ml of the bacterial suspension was mixed with 0·5 ml of electrolyte which was then spread onto the inner surface of a Welsh electrode bell. The electrodes were kept at room temperature. At 0, 2, 4, 6, 8 and 24 h, approximately 10 µl of the electrolyte was sampled, and spread onto 5% horse blood agar which was incubated at 37°C for 48 h and the number of colonies counted.

Results

Efficacy of the in-use cleaning method

Six electrodes were sampled during one day on four occasions in the course of one month. Bacteria were present in all the samples (Figure 2), and at all times, including pre-use and after cleaning. The predominant organisms at pre-use, during, and after use (A, B, and C in Figure 2) were coagulase-negative staphylococci. Other organisms isolated included micrococci, *Bacillus spp.* and *Klebsiella spp.* Following washing on two occasions, *Pseudomonas spp.* was the predominant organism present. No

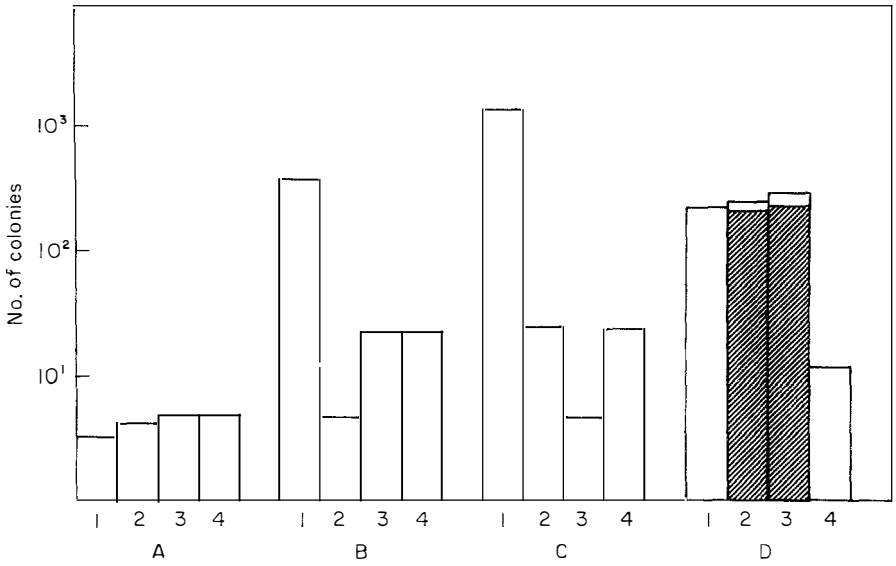

Figure 2. The total number of bacteria (cfus) recovered from ECG electrodes at the following times: pre-use (A), mid-session (B), after use (C) and after 'routine' cleaning (D). This was repeated on four separate occasions (1, 2, 3, 4) and at each time a total of six ECG electrodes were sampled. Most bacteria isolated were coagulase-negative staphylococci or *Pseudomonas spp.* (shaded).

Pseudomonas spp. were recovered from the Welsh electrodes after they had been stored overnight at room temperature with bulbs and bells still coupled.

Evaluation of alternative methods of decontamination

Five methods of cleaning the electrodes were evaluated. The average number of organisms isolated from the electrodes after each of the methods is shown in Table I. The effect of the different electrolytes and counts in the absence of electrolyte are also shown. Control electrodes were not cleaned. The only method which eradicated all bacteria was heating at 60°C for 1 h. A few bacteria persisted after the manufacturers' recommended method when Camcare and Cardijel electrolyte were used.

Survival in different electrolytes

Table II shows the survival times of organisms in each of the three electrode gels. Most bacteria remained viable in the electrolyte gel for between 6 to 8 h. In Dracard cream the number of organisms fell more rapidly as compared with the other two electrolytes.

Discussion

A previous report has indicated that wet pad ECG-electrodes may be a

Table I. *The isolation of bacteria from Welsh cup electrodes (with and without addition of electrolyte preparations) after contamination with a standard suspension of* Staphylococcus saprophyticus *and subjected to different cleaning procedures*

Cleaning procedure	No. of bacteria present (cfu)							
	No electrolyte		Dracard		Camcare		Cardijel	
	Bell	Bulb	Bell	Bulb	Bell	Bulb	Bell	Bulb
Plain tissue wipe	30	SC	13	>400	>100	>400	>100	>400
'Steret'	0	SC	8	>400	>700	>400	>100	SC
70% alcohol	0	0	>100	0	>100	0	SC	0
Manufacturers instructions	0	0	0	0	2	10	0	3
60°C for 1 h	0	0	0	0	0	0	0	0
Control	SC	SC	SC	SC	SC	SC	SC	SC

The figures represent the mean values obtained for five electrodes. * SC = Semiconfluent growth (>1000 cfu/plate).

Table II. *The survival of various bacterial species on an ECG electrode in the presence of three electrolyte preparations*

Organism	Survival time (h)		
	Dracard	Camcare	Cardijel
Pseudomonas aeruginosa	4	8	8
Escherichia coli	6	8	24
Enterobacter spp.	4	8	8
Staphylococcus aureus	6	8	8
Staphylococcus epidermidis	4	6	8
Serratia spp.	6	8	24
β-haemolytic streptococcus	0	0	8

vehicle of cross infection (Hockley, Porter & Casewell, 1975). Similarly, it has been demonstrated that Welsh cup ECG-electrodes (Cefai & Elliott, 1988) could result in the transfer of organisms from one patient to another. In the present study it has been confirmed that Welsh cup electrodes can become contaminated during routine use with skin commensals and Gram-negative bacilli, including *Pseudomonas spp.* Cleaning with warm water, as recommended by the manufacturers, was shown to result in a marked reduction in contamination when a standardised suspension of *Staphylococcus saprophyticus* was used, although a few organisms remained. Residual gel probably contributed to the persistence of the organisms. This was observed when the bells were only immersed in 70% alcohol and both

gel and bacteria remained. In contrast, when the alcohol was drawn into the bulbs several times, most of the gel and bacteria were removed. Electrolyte was also difficult to remove with water at 50°C, and further experiments demonstrated prolonged survival of organisms in this medium. However, immersion of bulbs and electrodes in water for an hour at 60°C was an effective method of decontamination. None of the less time consuming techniques tested, including those often used by cardiology departments, were adequate.

The occurrence of *Pseudomonas spp.* after cleaning was probably associated with the presence of relatively large numbers of these organisms in the sink where the cleaning of the electrodes was performed.

Evidence implicating ECG electrodes as potential vectors for the spread of hospital organisms, suggests that for all ECG procedures, reusable electrodes should be adequately decontaminated between patients. This study has demonstrated that immersing in water at 60°C for one hour will achieve this. Following use with human immunodeficiency virus antibody positive or hepatitis B antigen positive patients, it has been recommended that these electrodes are immersed overnight in a 10% hypochlorite solution after scrubbing in hot water to remove adherent material (Murray, Kriss & Evans, 1986). Consideration in these circumstances should also be given to the use of autoclavable electrodes. However, it is not always possible to identify high-risk patients prior to ECG and, in view of the time taken to clean the electrodes correctly, we would advocate the use of disposable ECG electrodes. The extra cost of such a system should be balanced against the potential cost saving on reduced cross infection. A different approach could be to use bactericidal electrolytes, though they may have additional problems, including selection of resistant organisms, hypersensitivity and providing a false sense of security.

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