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SOURCES OF STAPHYLOCOCCUS AUREUS FOR PATIENTS ON CONTINUOUS AMBULATORY PERITONEAL DIALYSIS

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← Objective: This study was designed to determine whether family members and health care workers are a source of Staphylococcus aureus for patients on peritoneal dialysis.
← Design: Over 36 months, cultures were obtained from the nares of patients, family members that cared for the patients' catheters, and health care workers in a dialysis unit. Pulsed-field gel electrophoresis was performed on all S. aureus isolates.
← Setting: A university-based peritoneal dialysis program.
← Participants: 74 patients, 32 family members, and 17 health care workers.
← Interventions: None.
← Main Outcome Measures: The number of patients that acquired S. aureus strains during the study period.
← Results: Of the 48 patients whose initial nares cultures were negative, 7 (15%) acquired S. aureus strains. Overall, 24 of 53 (45%) patients that had 2 or more cultures obtained during the study gained strains. Potential sources were not identified for strains gained by 11 (46%) patients. Five patients appeared to acquire their strains from family members; however, other patients also shared related strains; 8 patients acquired strains shared by other patients.
← Conclusions: Family members and other patients appeared to be important sources of S. aureus for patients on peritoneal dialysis. Health care workers that carry S. aureus transiently may be important intermediaries. Good hand hygiene is essential to prevent transmission of S. aureus to these susceptible patients.

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KEY WORDS: *Staphylococcus aureus*; nasal carriage; cross-infection; pulsed-field gel electrophoresis.

Staphylococcus aureus is an important cause of peritonitis, tunnel infections, and exit-site infections, which are the most frequent and serious complications of peritoneal dialysis (PD) (1–5). Several investigators have correlated *S. aureus* nasal colonization with subsequent *S. aureus* infections in patients treated with dialysis (6–11). We previously evaluated isolates from two large studies of patients on PD (Herwaldt LA, Boyken LD, Luzar MA. Molecular epidemiology of *Staphylococcus aureus* isolated from patients on chronic ambulatory peritoneal dialysis. Presented at the 2nd Annual Meeting of the Society for Hospital Epidemiology of America, 12–14 April 1992, Baltimore, Maryland; Herwaldt LA, Boyken LD, Coffman S. Epidemiology of *S. aureus* nasal carriage in patients on continuous ambulatory peritoneal dialysis who were in a multicenter trial of mupirocin. Presented at the 36th Interscience Conference on Antimicrobial Agents and Chemotherapy, 15–18 September, 1996, New Orleans, Louisiana). In these studies, 19% – 33% of patients were infected with strains of *S. aureus* they did not carry.

Investigators have not identified the source of *S. aureus* infections in patients that are not carriers. We designed this study to determine whether family members and health care workers that carry *S. aureus* in their nares serve as reservoirs of this organism for patients on PD.

METHODS

Cultures of the nares were obtained from patients on PD in a university-based PD program, their family members, and health care workers every 3 months during a 36-month period. During the study period, the dialysis unit was not using antimicrobial agents to prevent infections. Premoistened cotton swabs were rotated in both anterior nares, plated onto 5% blood agar and MacConkey agar plates, and incubated at 35°C for 48 hours. *Staphylococcus aureus* isolates were identified by colony morphology, Gram stain characteristics, and positive tests for catalase and coagulase. Isolates were stored at –20°C.

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Pulsed-field gel electrophoresis (PFGE) was done as described previously (12). Isolates were considered to be the same strain if all bands matched, subtypes of the same strain if 1 to 3 bands differed, and different strains if more than 3 bands differed (13).

The Institutional Review Board approved the study. Potential participants were informed of the purpose of the study and those that agreed to participate signed a consent form. Baxter Healthcare Inc. funded the study but had no role in doing the study or in analyzing or interpreting the data.

RESULTS

Seventy-four patients, 32 family members (of 28 patients), and 17 health care workers each had at least 1 culture obtained. Four patients had cultures obtained from sites of infection but not from their nares. Nares cultures (228) were obtained from 70 patients (median 2.5 cultures, range 1 – 11 cultures), 32 family members (n = 55, median 1, range 1 – 6), 6 nurses (n = 28, median 5.5, range 1 – 7), and 11 physicians (n = 26, median 1, range 1 – 6).

Thirty-one (42%) patients had only negative nares cultures, 17 (55%) of who had more than 1 culture obtained (median 2, range 1 – 5). Nine of 48 (19%) patients whose initial nares cultures were negative and that had more than 1 nares culture obtained acquired *S. aureus* nasal carriage 1.25 to 14 months (median 5.4 months) after entering the study. Five of these patients acquired only unique strains and did not have cultures obtained from their family members (n = 4) or their family members had negative nares cultures (n = 1). Consequently, the sources of their isolates were not identified. Two patients acquired two different strains at the same time. Each of these patients acquired one strain that was not shared with other study participants and another strain that was related to strains carried by other patients. One patient became infected with a subtype of his mother's strain 7 months after entering the study. A nares culture was not done at this point. Five months later, he had another exit-site infection caused by the same strain and his nares culture was positive for this strain. One patient acquired a strain that was identical to the strain carried previously by a family member and was related to strains shared by four other patients and the spouse of another patient. Two nurses subsequently acquired this strain.

When assessing the source of the infecting strains, we considered only a patient's first infection during the study period. Thirty (41%) patients had at least 1 exit-site infection, 9 (30%) of who had no prior nares cultures (Figure 1). Eight of 21 (38%) patients that had prior nares cultures were infected with isolates identical to those in their nares. Three (14%) patients were infected with strains that were different from those in their nares. Ten (48%) of these 21 patients acquired infections 0 to 22 months (median 3.5 months) after entering the study, despite having negative nares cultures. Two of these 10 patients became infected with strains similar or identical to those carried by family members. Of note, these isolates were related to strains carried by 9 other patients and 1 physician when he entered the study. One patient was infected with a strain related to those carried by or infecting 3 other patients and another patient's family member. Another patient was infected by a strain that was related to those carried by or infecting 3 other patients and 1 physician. The physician had a negative nares culture 1 year prior to his positive culture and the patient became infected during that period. Thus, we could not determine whether the patient or the physician acquired the organism first (Figure 2). Five patients were infected with unique strains. One patient's isolates were not typable by PFGE.

Twenty-four of 32 (75%) family members did not carry *S. aureus*, 9 of who had more than 1 culture. Five of 8 family members that had positive cultures carried the same strains as their related patients (Figure 2). In four of these pairs, the family member clearly had the strain before the patient acquired it. The fifth patient's first nares culture was negative; 5 weeks later, he had an exit-site infection. His wife's first nares culture was done at this time and was positive for the same strain.

Only 2 of 17 health care workers had positive nares cultures on entry into the study; both were physicians. One physician carried a unique strain and the other carried a strain that was similar to those carried by or infecting 11 patients and 3 family members. One physician had negative nares cultures for 21 months (2 negative cultures) and then acquired a strain that was similar to that carried by or infecting 6 patients. Nares cultures from the remaining 8 physicians were all negative.

All 6 nurses had negative nares cultures on entry into the study. Each of the 4 nurses that had 5 or more nares cultures gained *S. aureus*; 3 of the 4 became persistent nasal carriers. Two nurses acquired a strain that was similar to strains shared by 4 patients and 1 family member (Figure 2); 2 nurses acquired unique strains.

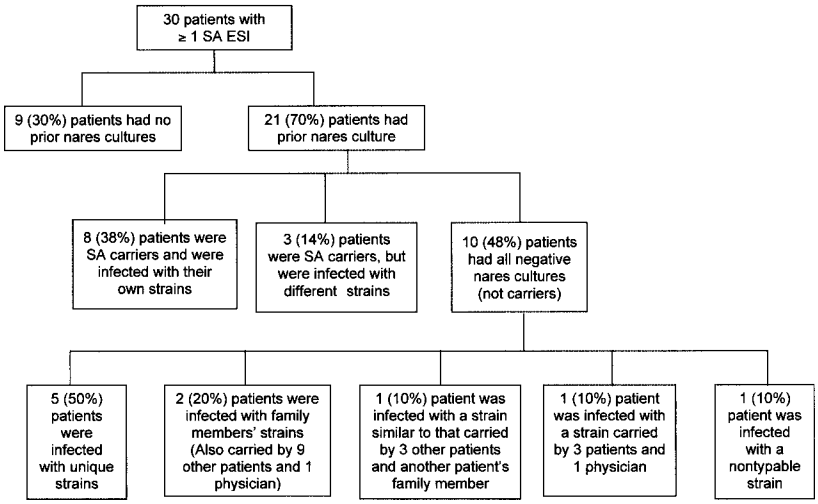

Figure 1 — Flow diagram of all patients that had at least one *Staphylococcus aureus* (SA) exit-site infection (ESI).

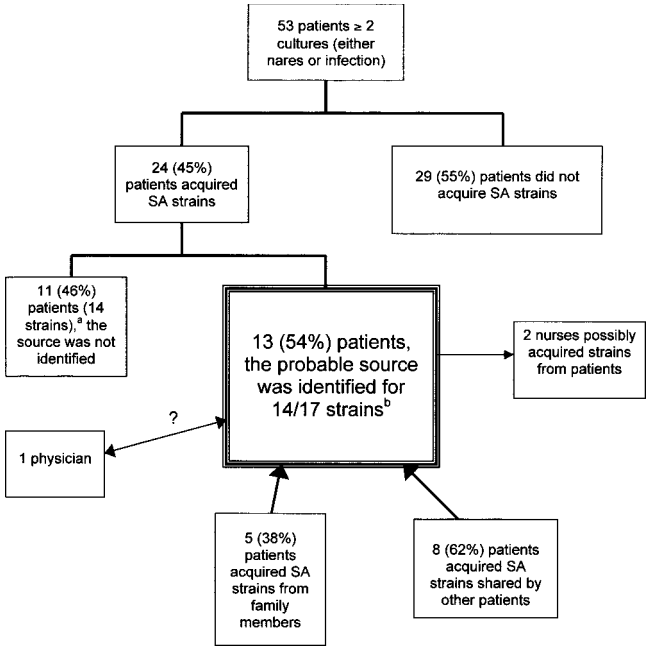

Figure 2 — Flow diagram of all patients that had two or more cultures during the study period. SA = *Staphylococcus aureus*. [a]Three patients acquired two strains at a time. [b]The source was identified for some but not all strains for patients that acquired more than one strain.

DISCUSSION

Numerous investigators have evaluated the source of *S. aureus* isolates infecting patients treated with PD. Most investigators found an association between nasal carriage and infection (6,8–11). In the current study, only 38% of the patients were infected with strains carried in their nares and 48% of the infected patients had negative nares cultures. This result is considerably different than those of most published studies and it suggests that the epidemiology of *S. aureus* infections may differ with patient populations.

No published study addresses the source of *S. aureus* for patients on PD that do not carry this organism in their nares and yet become infected. One intriguing case report suggests that family members may be a reservoir for *S. aureus* from which patients on PD acquire the organism (14). In this case report, the patient, who did not carry *S. aureus*, had recurrent exit-site infections. The patient's wife, who dressed his exit site, carried an identical strain in her nares. Several studies have assessed nasal carriage among patients on PD and their dialysis partners (15–17); however, none of these investigators could assess whether patients acquired strains from their dialysis partners.

Overall, 24 (45%) of 53 patients that had 2 or more cultures done acquired strains during our study (Figure 2). Potential sources were not identified for 11 (46%) patients. Five patients probably acquired strains from family members; however, other patients also shared related strains. Eight additional patients and 2 nurses may have acquired strains from patients.

Monsen and colleagues previously reported that three strains of *Staphylococcus epidermidis* and one strain of *S. aureus* were shared among patients on PD (18). We were surprised that so many of our PD patients shared strains because these patients do their own care at home and come to the Center only once per quarter for routine visits, or more often if they have problems such as infection. There are several explanations for this observation. First, several strains may have been endemic in our area and patients may have acquired them outside the health care setting. Our experience with typing

methicillin-susceptible *S. aureus* isolates suggests that epidemiologically unrelated persons rarely have the same strain. Second, we cannot rule out direct transmission from patient to patient during their visits at the Center, during hospitalizations, or during social interactions outside the hospital. We think the most likely explanation is that health care workers acquired strains while caring for infected or colonized patients when they came to the Center. These health care workers carried the strains transiently on their hands or in their nares and transmitted the strains to other patients.

If family members and transiently colonized health care workers are important sources of *S. aureus* for patients on PD, then good hand hygiene may be one of the most effective means of decreasing the rate of *S. aureus* infections in patients treated with PD. In fact, Pittet *et al.* previously demonstrated that use of an alcohol-based waterless hand rub significantly decreased the rate of nosocomial infections caused by methicillin-resistant *S. aureus* (19). Perhaps patients, health care workers in dialysis centers, and family members that help care for the patients' PD catheters should use such a product before and after handling the catheters.

The primary strategy for preventing *S. aureus* infection in patients treated with PD has been to use topical or systemic antimicrobial agents to decolonize the nares and/or the pericatheter area. Results of several studies, which used historical controls, suggest that applying mupirocin to the pericatheter area decreases the rate of *S. aureus* exit-site infections and peritonitis (20,21). Recently, two centers identified mupirocin-resistant *S. aureus* isolates several years after this strategy was implemented (22,23). Pérez–Fontán *et al.* noted a significant increase in the rate of *S. aureus* exit-site infections among patients colonized by mupirocin-resistant *S. aureus* isolates (23). Thus, we are concerned that using mupirocin as the only prophylactic agent may cause it to become useless for this and other purposes. We believe that investigators should evaluate the efficacy of other agents, such as povidone-iodine (24), before mupirocin-resistant *S. aureus* becomes problematic.

The results of our study suggest that the epidemiology of *S. aureus* infections in patients treated with PD may be more complex than previously thought. Family members and health care workers that transiently carry *S. aureus* may be important sources of this organism for patients on PD. We may need to consider decolonizing family members to improve the efficacy of protocols for decolonizing the patients. In addition, good hand hygiene is clearly one of the most important preventive measures.

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