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Methicillin-Resistant *Staphylococcus aureus* Colonization and Infection in a Rehabilitation Facility

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Methicillin-resistant *Staphylococcus aureus* (MRSA) colonization and infection in a rehabilitation hospital (Rancho Los Amigos Hospital [RLAH]) were studied from October 1977 to May 1980. Eighty-four episodes of MRSA colonization or infection were observed in 81 patients (attack rate, 0.44 per 100 admissions). The MRSA was considered to have been acquired at RLAH in 65% of the episodes and from transferring hospitals in 34%. The infection rate was 35% among MRSA-colonized patients, and only one death was attributed to MRSA infection. Colonization for more than 100 days occurred most frequently in wounds and anterior nares. All but two of the MRSA isolates were resistant to aminoglycosides, and 80% of those typed belonged to phage type 83A. The patients were allowed to continue participation in rehabilitation programs. Spread of the MRSA occurred in wards where intensive medical and nursing care was being practiced. There was no evidence of MRSA spread in the services with less intense medical and nursing care and where physical and occupational therapy was continued. Patients in a rehabilitation hospital with MRSA colonization may receive intensive physical and occupational therapy as long as special precautions are observed to prevent MRSA spread.

Methicillin-resistant *Staphylococcus aureus* (MRSA) was first isolated in Europe 20 years ago (1, 17, 19). Outbreaks of MRSA infection remained initially confined to European countries (16, 26) until 1968, when Barrett et al. reported the first large outbreak in the United States (2). Several reports have since then discussed the possible influence of antibiotic use, the changing antibiotic susceptibility patterns (5, 22, 23, 28, 29), virulence (7, 12, 20), and the clinical importance of MRSA. At Rancho Los Amigos Hospital (RLAH), which is a rehabilitation hospital, we have observed MRSA colonization and infection involving a number of our patient population over a 32-month period. We have, therefore, reviewed these patients to gain a clearer perspective of the epidemiology and clinical significance of the MRSA problem in an institution such as ours.

MATERIALS AND METHODS

RLAH is a 600-bed rehabilitation hospital. Almost all of the patients are initially referred from other institutions. The patients on services such as Spinal Cord Injury, Head Trauma, and Stroke are usually not acutely ill. The rehabilitation areas (Physical and Occupational Therapy) are decentralized so that each service has its own rehabilitation areas. Patients developing acute medical problems are treated in the medical intensive care unit or the general medical ward.

Bacteriological cultures. Cultures of nares, throat, and perineum were collected with cotton swabs (Culturette II; Marion Scientific, Kansas City, Mo.). Urine samples were obtained by clean-catch midstream collection or by catheterization. Colonies of *S. aureus* were initially recognized on mannitol salt agar and sheep blood agar plates (Clinical Standards Laboratories, Carson, Calif.). This screening procedure, however, may miss rare strains that are both mannitol negative and nonhemolytic. The isolates were then identified on the basis of Gram stain, catalase production, tube coagulase test, and DNase production. Antibiotic susceptibility testing was done by the Bauer-Kirby disk diffusion method (4), as well as the agar overlay method (3). Incubation temperatures of 30 and 35°C were used for methicillin and cephalothin susceptibility testing (8, 23, 32). Zone inhibition diameters were read after 18 to 24 h of incubation. Phage typing of 34 isolates was performed by the Centers for Disease Control, Atlanta, Ga.

Environmental cultures were taken in three of the MRSA isolation rooms. Saline-moistened sterile swabs were used to culture floors and bedrails. Mannitol salt and sheep blood agar settle plates were set out for 30 min during morning care of the patients, which was the usual time of maximal room activity. Cultures of the bed sheets were obtained by contact plates (blood and mannitol salt agar).

Definitions. Patients were considered colonized when two or more consecutive cultures from any body site were positive for MRSA (may be used interchangeably with term "carriage" in the text). Colonization was considered to be transient when MRSA was isolated from any body site only once and at least three subsequent cultures were negative for MRSA. The duration of colonization was calculated from the first to the last day of positive MRSA culture at RLAH or to the first of the three consecutive negative cultures.

Colonization was considered RLAH acquired when the first MRSA-positive culture was reported more than 7 days after RLAH admission and considered acquired from outside institutions when positive MRSA cultures were recovered within the first week of admission to RLAH or when the patient had positive MRSA cultures from the transferring facility or both. Infections were defined as outlined by the Centers for Disease Control (31).

Epidemiological measures. A hospital protocol outlining control measures was introduced in January 1978. The plan of action included: (i) active surveillance of all reported isolates of MRSA from clinical specimens. These patients were seen by the nurse epidemiologist and after evaluation, recommendations of the use of isolation were made on the patient's chart. (ii) Nose, throat, wound, perineal, and urine cultures were taken in each of these patients to define the type of carriage throughout their hospital stay. (iii) All infected and colonized patients were isolated in private rooms. Patients were housed in rooms that contained up to four patients when clusters of cases occurred. Wound and skin isolation procedures were practiced, and masks were worn by personnel having close contact with patients with colonized tracheostomy sites. Hand washing with hexachlorophene by personnel was required, except for pregnant women (9).

The patients were permitted to go to the Physical and Occupational Therapy and diagnostic areas when necessary. The personnel on these areas were notified. Patients with actively draining wounds or incontinent of infected urine were removed from group therapy areas. Other wounds were securely covered with dressings. Colonized patients were kept separate from other patients. Personnel were instructed to wash their hands with hexachlorophene soap after handling patients. All equipment used by the patients in the Physical and Occupational Therapy areas was subsequently cleaned with Staphene.

Cultures of those sites on patients found to be positive for MRSA were taken weekly. The patients remained in isolation until three consecutive negative cultures over a time period of 1 to 2 weeks were obtained. At the time of the third culture, all previous negative sites were also recultured.

In the event of a cluster of cases in any single area of the hospital, swab cultures of the anterior nares were obtained from staff and personnel. Education of all personnel having close contact with the patients in these areas was provided by the nurse epidemiologist. Daily hexachlorophene bathing was recommended for all patients (21), except when contraindicated (10), and topical Bacitracin ointment three times daily for 5 days was recommended for all patients with colonization of the anterior nares. Colonized patients were not moved to other facilities (hospitals or nursing homes) without prior notification of that facility. These patients, however, were permitted to be discharged home.

Carriers among the personnel who were identified were made aware of their status. These persons were seen at the Employee Health Clinic, where topical Bacitracin ointment for nasal carriers and bathing with hexachlorophene soap were recommended.

RESULTS

General data. From October 1977 to May 1980 a total of 81 patients at RLAH had cultures of various body sites that were positive for MRSA. During this same time period, there were 18,379 admissions to the hospital (attack rate, 0.44 per 100 admissions). Three of these patients had recurring episodes of colonization (total of 84 episodes of MRSA colonization).

Of the 84 incidences of MRSA carriage, 55 (65%) were considered acquired at RLAH and 29 (34%) were considered acquired from outside institutions (Fig. 1). Of these 29 patients, 23 were felt to have acquired their MRSA from Los Angeles County—University of Southern California Medical Center, where MRSA colonization had been an ongoing problem (personal communication, Peter Heseltine) and from which most of the referrals to RLAH originate; 4 patients could have acquired their MRSA from either of two community hospitals in the vicinity; and 2 patients could have acquired their MRSA either from home or from the RLAH outpatient clinic facility where they were being seen. Thus, all of the 29 patients had had some hospital contact before their admission to RLAH.

Nosocomial acquisitions of the MRSA at RLAH was arbitrarily considered to have occurred when colonization was detected more than 7 days after admission. It is possible that some patients in the hospital were colonized and not detected since routine screening cultures were not performed on admission. Colonization of patients for weeks or months before the MRSA was detected at RLAH could have occurred in some patients. In an attempt to make some assessment of the likelihood of acquisition in the hospital, we examined the proximity of the patient to other colonized patients. We found that 37 of the 55 (67%) patients who acquired the MRSA nosocomially were in a unit where nosocomial transfer of MRSA from a known carrier could have occurred. When we examined these 37 episodes more closely, we found that these episodes occurred in seven services: General Medicine (including the medical intensive care unit), Diabetes, Spinal Cord Injury, Plastic and Reconstructive Unit, Pulmonary, and Liver Services where patients were generally more ill and required more intensive medical and nursing care. The other services

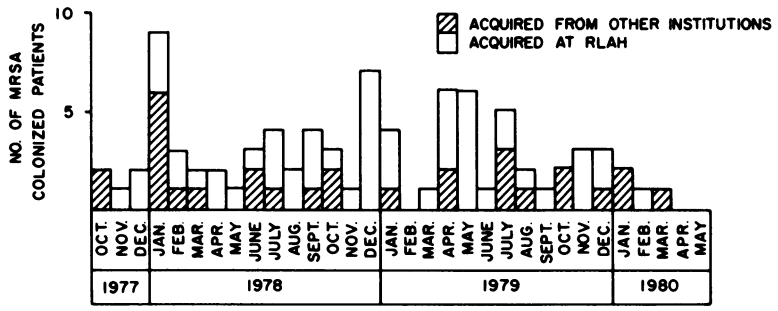

FIG. 1. Number of patients identified with MRSA colonization.

(Tuberculosis, Neurology, Cardiology, Head Injury, Stroke, Rheumatology, and Spine Deformity), which were almost totally rehabilitation services, had no single known cases of MRSA acquisition (Table 1). We believe this strongly suggests that the isolation procedures were adequate on those services where physical and occupational therapy were the main activities. Some transfer of MRSA occurred despite precautions in the wards where there was relatively greater medical and nursing care.

Patient characteristics. The mean age of the patients was 48 years, the youngest being 3 years and the oldest 88 years of age. There were 28 females and 53 males. Sixteen (20%) of the patients were admitted with a diagnosis of diabetes mellitus. Nineteen (23%) of the patients were admitted with a primary diagnosis of spinal cord injury. Six of the patients had alcoholic liver disease, and five had tuberculosis. Ten of the patients were admitted for treatment of open wounds. The remaining patients had varied diagnoses.

Length of hospitalization. Eleven of the patients had been at RLAH for more than 3 months, 28 for 1 to 3 months, and the rest for less than 1 month when they were first discovered to have positive MRSA cultures.

Infection and colonization. Twenty-eight (34.5%) of the patients developed infection with MRSA. Seven wound infections were at the site of previous surgery. Ten additional wound infections included skin abscesses secondary to drug abuse, gangrene, ingrown toenails, and infected pressure areas. We were impressed by the persistence of wound colonization in patients with clean granulating wounds and healed wounds. Wound colonization persisted for greater than 1 month in 13 patients. The MRSA persisted on the skin surface over the scar at the site of the wound sometimes for months. Attempts to alter this colonization in these patients with this type of colonization using betadine, hexachlorophene, or Bacitracin ointment were unsuccessful.

Of the 28 infections, 11 were urinary tract infections (27). One patient had MRSA aspirated from the knee joint (she was also found to have nasal colonization with MRSA) and was treated with intravenous vancomycin and surgery. Only one patient (with underlying scleroderma) had positive MRSA blood cultures.

Table 2 shows the duration of patient MRSA carriage by the site colonized. The mean range of days of MRSA colonization of any patient was 94.7 days, the range being 1 to 675 days. When transient carriage was excluded, the shortest carriage duration was 6 days. The patient with the longest duration of carriage (675 days) had overlapping durations of nasal and wound carriage. Wounds were colonized in 82% of the patients who had their wounds cultured. These patients were not felt to have clinical symptomatology attributable to active MRSA infection. Seven patients carried MRSA for greater than 100 days, and 22 patients had only transient carriage. The second most frequently colonized site was the anterior nares. Forty-three percent of the patients who had nasal cultures had MRSA colonization. Five of these patients had nasal colonization for longer than 100 days. Bacitracin applied to the anterior nares removed the MRSA in 2 of 10 patients. Colonization of the anterior nares with MRSA cleared spontaneously in three of eight patients who did not receive Bacitracin.

Phage type and antibiogram. Twenty-seven of the thirty-four isolates (80%) that were phage-typed belonged to phage type 83A. Six isolates were untypable with the phages used, and one was type 29/52/52A/80. This latter strain was sensitive to tetracycline, erythromycin, clindamycin, and cephalothin by disk diffusion at 35°C. Three of the strains were sensitive in vitro by disk susceptibility testing to gentamicin, eight were sensitive to clindamycin, and thirty strains were sensitive to cephalothin at 35°C incubation temperature. All were sensitive in vitro to vancomycin. Tube dilution sensitivity studies to methicillin and cephalothin have been reported in a separate communication (8).

Surveillance cultures of patients and personnel.

TABLE 1. Acquisition of MRSA by different ward units

Ward unit	Total patient days[a]	No. of patients colonized[b]	No. colonized per 10,000 patient days
General Medicine (includes intensive care unit)	21,569	16	7.42
Spinal Cord Injury	13,825	7	5.06
Diabetes	15,043	8	5.28
Liver	22,025	3	1.36
Pulmonary	6,374	1	1.57
Plastic Surgery	7,448	2	2.69
Tuberculosis	6,828	0	0
Neurology	7,891	0	0
Cardiology	5,756	0	0
Head Injury	7,850	0	0
Stroke	3,534	0	0
Rheumatology	1,712	0	0
Spinal Deformity, Problem Joint, and Orthopedic Reconstruction	5,667	0	0

[a] Patient days, Days patients were exposed to known MRSA carriers multiplied by the number of patients at risk.

[b] Includes patients who could have acquired MRSA from a known carrier within the ward unit.

Surveillance cultures were taken in December 1978 because nosocomial cases were related to the medical ward and medical intensive care unit. The patients had cultures taken of the anterior nares, throat, and any wounds. The personnel, including the phlebotomist and respiratory therapists of the medical ward and medical intensive care unit had their anterior nares cultured. Only one nurse of the 67 people cultured was found to have nasal colonization at a time when 3 of the 23 patients were found to be colonized with MRSA.

DISCUSSION

In 1968 Barrett et al. predicted that MRSA might soon present itself as a clinical problem in the United States, and he was soon proven right by subsequent reports (18, 22). Crossley et al. described 108 nosocomial MRSA wound infections with a 32% incidence of MRSA bacteremia in patients with burns (12).

The incidence of severe infection was much less in our patient population than that reported by other investigators (12, 18, 23, 29). The single bacteremia patient in our series was severely debilitated and had scleroderma as an underlying disease. Almost 35% of our patients with demonstrated MRSA carriage, however, were felt to have had significant infection with tissue invasion. Lacey suggested that MRSA bacteremia is related to the changes in the type of hospital patient and that deaths are confined to patients with chronic or debilitating underlying disease or both (20). A recent article (13) reported a high (>50%) incidence of invasive disease in intravenous drug addicts, with community-acquired MRSA infection felt to be via person-to-person transmission. Sixty-four percent of the isolates that were typed belonged to phage type 29/52/80. The invasiveness of the MRSA in this outbreak may be related to the background of drug addiction or the propensity of this partic-

TABLE 2. Duration and sites of patient MRSA carriage

Site of carriage	No. of episodes of carriage (excluding transient episodes) (%)	Days of carriage			No. of patients with carriage >100 days	No. of episodes without carriage in specified sites (%)	No. of episodes of transient carriage[a] (%)
		Mean	Median	Range			
Nose	24/79[b] (34)	80	44	7–347	5	33/70 (47)	13/70 (19)
Throat	10/59 (17)	85	83	13–226	2	40/59 (68)	9/59 (15)
Perineum	3/63 (5)	31	30	17–46	0	38/63 (60)	22/62 (35)
Urine	17/79 (21)	79	30	7–428	2	50/79 (63)	12/79 (15)
Sputum[c]	11/28 (39)	77	29	6–372	2	10/28 (36)	7/28 (25)
Wound	22/60 (45)	89	44	6–426	7	11/60 (18)	22/60 (37)

[a] MRSA isolated only once with at least three subsequent negative cultures.

[b] Denominator reflects number of patients cultured.

[c] Tracheal secretions obtained through tracheostomy in four patients and expectorated sputum obtained in seven patients.

ular phage type for invasiveness or both. Another study (6) described a 45% incidence of bacteremia in burned patients colonized with MRSA. Despite this high incidence of MRSA bacteremia in colonized burned patients, the above study demonstrated a lower mortality than predicted among burn patients colonized with MRSA.

Perhaps the phage type of our strain of MRSA (83A) is less invasive than those seen by others (5, 14, 29). Crossley et al. found the predominant phage types to be 6/75/85 and 29/52/80 (11). Only one of his strains phage typed 83A (our predominant strain). Even though this strain seems relatively noninvasive, it may still possess the characteristics of an opportunistic organism. The capacity of this organism to produce serious diseases is exemplified by its isolation from the blood in one patient from a closed joint space infection in another patient.

It is apparent from our data that many patients remained colonized for long periods of time. The anterior nares has been the site most frequently colonized long-term in previous studies. We also observed long-term carriage in wounds. Many of these wounds were well healed with only desquamating skin. The carriage of staphylococci in desquamated skin cells has been described previously (14, 15, 30).

It is important to understand the role of the carrier state in the dissemination and acquisition of MRSA. In our patients MRSA persisted in the nares and wounds. O'Toole et al. reported that only those patients with cutaneous lesions disseminated staphylococci into their immediate environment (22). Ransjö showed dispersal of organisms to be heavier from patients with large burns than from patients with smaller burn areas (25). Burned patients, therefore, constitute a significant reservoir for MRSA dissemination. Nasal colonization plays an unknown role in the perpetuation of outbreaks (11, 18, 22, 24). One nurse in our hospital with MRSA nasal carriage was allowed to continue working the intensive care unit with no evidence of dissemination of MRSA to the patients under her care. Urine colonization was a likely source of MRSA in patients on the Spinal Cord Injury Service and Diabetes Service.

There has been an association between the use of broad-spectrum antibiotics and the spread of MRSA (11, 12, 22, 28, 29). Our data, however, are difficult to evaluate because of the character of our patient population and since a control group was not used.

The majority of our colonized patients seemed to lose the MRSA spontaneously. The roles of topical Bacitracin ointment and Phisohex soap for bathing were not evaluated, but rarely eradicated carriage in our patient population. Failure of intranasal Bacitracin to eradicate nasal MRSA carriage has been reported (6). In a separate study from our institution, a 10-day course of oral rifampin failed to eradicate MRSA carriage in various body sites, and resulted in the development of in vitro resistance in three of the four posttreatment isolates (H. N. Canawati, W. J. Tuddenham, F. L. Sapico, J. Z. Montgomerie, and G. Aeilts, Abstr. Annu. Meet. Am. Soc. Microbiol. 1981, A70, p. 12).

Handwashing has been felt to be an important control measure to prevent the spread of MRSA. Some studies have emphasized the importance of person-to-person transmission of MRSA (6, 11, 13). We have not observed significant dissemination of MRSA in the rehabilitation therapy areas when special precautions are employed. Transfer of MRSA, however, has occurred in those services with more intensive medical and nursing care.

The RLAH patient population is unique and of major concern to us because they have carried the MRSA for long periods of time and because new MRSA-colonized patients continued to be admitted from other institutions. This is largely due to the nature of our institution, which is primarily a referral center for other hospitals, particularly the Los Angeles County-University of Southern California Medical Center. Thus, MRSA is frequently acquired elsewhere and brought in to our hospital by patients who are transferred in. Unless control of MRSA colonization is accomplished in these referring institutions, we may continue to see MRSA-colonized patients for some time to come.

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