CHAPTER V

RESULT

1. Selected demographic of patients at the burn unit

Table 5-1 showed the selected demographic of all burn patients (30 patients) at the burn unit during the specimen collection. It was found that there are 16 patients (53.33%) infected with MRSA with the mean age of 24.86 years, while the mean age of 14 MRSA-negative patients (46.67%) was 13.95 years. There were only 4 MRSA-positive patients who were first admitted at the burn unit were new cases, while the number of MRSA-negative new cases were 10. There were 12 MRSA-positive patients in the burn unit transferred from other hospitals. Almost all of the MRSA positive patients (15 out of 16) acquired MRSA from the burn unit. There was only one patient who had MRSA on the first day of admission and this patient was transferred from another hospital. The average length of hospitalization for patients who had MRSA infection and had no MRSA infection was 34.38 and 28 days, respectively. The average length of hospitalization among the patients prior to the detection of MRSA was 12.38 days. Thirteen of the 16 burn patients (81.25%) who had MRSA had previous history of receiving antimicrobial agents, while 10 of the 14 burn patients (71.43%) who had no MRSA had no history of receiving any antimicrobial agents. In addition, only 4 of the 14 patients who had no MRSA had previous history of receiving antimicrobial agents.

2. Incidence of *Staphylococcus aureus* (*S.aureus*) and Methicillin-resistant *Staphylococcus aureus* (MRSA) carriers

2.1. Nasal carriers in Medical personnel at Burn unit

The prevalence of *S. aureus* and MRSA which were isolated from nasal cavities of 54 medical personnel at burn unit was shown in Table 5-2. There were 25 (46.30%)

out of 54 medical personnel carried *S. aureus* in nasal cavities. Among these people, 8 personnel (32.0%) carried MRSA, and 24 personnel (96.0%) carried Methicillin-sensitive *Staphylococcus aureus* (MSSA). The other organisms found were coagulase-negative staphylococci (96.30%) and miscellaneous bacteria (66.67%) including *Streptococcus* sp., *Proteus* sp. and non-fermentative gram-negative rods.

Table 5-3 showed the frequency of positive isolation of MRSA, MSSA, and coagulase-negative staphylococci from medical personnel. Among 8 personnel who carried MRSA (a5, a8, a11, b2, b4, c6, d11, and d15), there was only one personnel (b2) whom MRSA was detected twice. The numbers of specimen from doctors (d1-d24) were fewer than the other groups of medical personnel because they had been worked in this unit for only certain period of time.

2.2. Nasal, hand and wound carriers in the burn patients

The 30 cases of burn patients from the burn unit were studied. The prevalence of staphylococci and MRSA infection was shown in Table 5-4. Coagulase-positive staphylococci were isolated from all patients (100%) while 16 patients (53.33%) carried MRSA. Among the MRSA-positive patients, 2 patients (6.67%) carried MRSA in either nasal cavities or wound. Another 14 patients (46.67%) carried MRSA in nasal cavities, hand and wound. The other organisms which were found in these patients consisted of coagulase-negative staphylococci (96.67%), and other organisms other than staphylococci (90.0%).

2.3. MRSA carriers in medical equipment at the burn unit

The total specimens; bed rails , enteral pumps , bath tub No. 1 and bath tub No. 2 were 191 , 191 , 64 and 64 , respectively. The prevalence of organism isolated from these equipment was shown in Table 5-5 and 5-6. Coagulase-positive staphylococci were found in all equipment but in a low number (3.92%). Fourteen isolates of MRSA were found in all kind of equipment (2.75%). There was no growth in about half of the

environmental samples. MRSA were most frequently isolated from the button of enteral pumps (8 isolates, 4.2%). The rest of 6 MRSA isolates were recovered; 4 from bed rails (2.1%), one from bath tub no. 1 (1.6%) , and one from bath tub no. 2 (1.6%).

2.4. MRSA carriers in the patients and the medical personnel at the Traumatic Intensive Care Unit (TICU) when MRSA emerged

During specimen collection at the burn unit, MRSA was also isolated from 3 patients at the TICU. The specimen were taken from nasal cavities, hands and wounds of the 11 patients, and from nasal cavity of 24 medical personnel and the medical equipment included bed rails and enteral pump.

Of 5 patients who carried coagulase-positive staphylococci, there were 3 patients carried MRSA. Among this group, there was one patient (IB2) carried MRSA only on hand, another one (IB8) carried MRSA only in nasal cavity, and the last one (IB4) carried MRSA both on hand and wound. There were 6 patients carried coagulase-negative staphylococci (54.55%). The other bacteria such as *Pseudomonas aeruginosa, Proteus* sp., *Bacillus* sp. and streptococci were also found from the patients. The results of MRSA prevalence in the patients from TICU were shown in Table 5-7 and 5-8.

There was no MRSA in nasal cavities of medical personnel in this unit. There were 9 medical personnel (37.5%) who carried MSSA in their nasal cavities. Coagulase-negative staphylococci was found in 15 medical personnel (54.17%) and the other bacteria such as streptococci and *Bacillus* sp. was found in 13 personnel (54.17%). The results were shown in Table 5-7.

3. The antimicrobial susceptibility pattern of MRSA

3.1. The antimicrobial susceptibility pattern of 231 MRSA isolates from the burn unit

The 231 MRSA isolates from burn patients, medical personnel, and medical equipment at the burn unit were tested against 15 antimicrobial agents in order to study

the susceptibility patterns of the organism. The result was summarized in Table 5-9 which show that there were 22 susceptibility patterns or antibiograms found among all of the isolates tested. Most of the isolates (61 isolates) were in antibiogram pattern 17 which were resistant to co-trimoxazole (trimethoprim/sulfamethoxazole), amoxycillin/clavulanic acid, ampicillin/sulbactam, cefoperazone/sulbactam, erythromycin, clarithromycin, gentamicin, and ciprofloxacin. Fifty-five MRSA isolates were in antibiogram pattern 14 and were susceptible to vancomycin, teicoplanin, fosfomycin, chloramphenical, netilmicin and co-trimoxazole, while 30 MRSA isolates were in antibiogram pattern 15 and were susceptible to vancomycin, teicoplanin, fosfomycin, chloramphenicol, netilmicin, and clindamycin. There were only few MRSA isolates in each of the rest antibiogram patterns.

3.2. Percentage of the susceptible MRSA isolates from the burn unit

There were 7 MRSA-positive patients whom MRSA were isolated from wound before the organisms were found in nares or hands. Among these 7 isolates, none of them were susceptible to amoxycillin/clavulanic acid, ampicillin/sulbactam, cefoperazone/sulbactam, erythromycin, clarithromycin, gentamicin and ciprofloxacin. Two of the isolates (28.57%) were susceptible to co-trimoxazole, 57.14% to imipenem, 71.43% to clindamycin, chloramphenicol, and netilmicin, 85.71% to fosfomycin and 100% to vancomycin and teicoplanin. (Table 5-10)

The percentage of susceptibilty of MRSA isolates which were found in nasal cavities first were seem to be closed to the susceptible percentage of susceptible wound isolates except for the susceptibility to chloramphenicol, clindamycin and co-trimoxazole. Among the 12 MRSA isolates from the nasal cavities of burn patients, none of them was susceptible to amoxycillin/clavulanic acid, ampicillin/sulbactam, cefoperazone/sulbactam, erythromycin, clarithromycin, gentamicin, and ciprofloxacin. Only 41.67% of the isolates were susceptible to imipenem and clindamycin, 58.33% to

co-trimoxazole, 75% to netilmicin, 83.33% to fosfomycin, 91.67% to chloramphenicol, and 100% to vancomycin and teicoplanin (Table 5-10)

Nine MRSA isolates from medical personnel were shown to be susceptible to vancomycin, teicoplanin, fosfomycin, chloramphenical, netilmicin, imipenem, clindamycin, and co-trimoxazole (trimethoprim/sulfamethoxazole). The percentages of the susceptible isolates to antimicrobial agents were 100.0, 100.0, 88.89, 88.89, 88.89, 66.67, 55.56 and 33.33, respectively. (Table 5-10)

3.3 Percentage of the susceptible MRSA isolated from the Traumatic ICU (TICU)

Among 4 isolates from patients with wound infection in the TICU, all of isolates were susceptible to vancomycin, teicoplanin, imipenem and fosfomycin. Only one isolate from nasal cavity of patient No. IB8 was susceptible to clindamycin, The isolates from hands of patient No. IB2 and IB4 were resistant to netilmicin, and the isolates from patients No. IB4 (from wound and hand) were susceptible to co-trimoxazole. (Table 5-11)

4. Previous history of antimicrobial administration in the 30 burn patients

4.1. MRSA isolates from 16 burn patients with and without previous antimicrobial treatment

As shown in the Table 5-12, 13 out of the 16 (81.25%) MRSA-positive burn patients had previous history of antimicrobial treatment at least 3 days before the organisms were isolated from such patients. Among 3 patients who had not been on antimicrobial agents for at least 7 days before MRSA isolation, there was only one patient (Patient D) who had not received any antimicrobial agents throughout the time of admission. The other 2 patients had been treated with antimicrobial agents after the organisms were detected. History of antimicrobial treatment would not be obtained in the patient L who transferred from the other hospital.

The most common antimicrobial agents which were used in these patients were the beta-lactams including cefazolin, ceftriaxone, ciprofloxacin, and amoxycillin.

4.2. Antimicrobial administration in 14 MRSA-negative burn patients before discharged

Before discharge from burn unit, there were only 4 out of 14 (28.57%) MRSA-negative burn patients who had received antimicrobial administration for at least 3 days, while another 10 out of 14 (71.43%) MRSA-negative burn patients had not received antibiotics before discharged. All these data was shown in Table 5-13

5. Detection for beta-lactamase

All isolates of MRSA were detected for beta-lactamase production by chromogenic cephalosporin method. It was found that all MRSA isolates were beta-lactamase producing strains.

6. Profiles of MRSA using restricted-fragments of chromosomal DNA patterns from PFGE (Pulsotype)

6.1. MRSA isolated from the burn unit

PFGE analysis of *Sma*I restricted fragments of chromosomal DNA from 142 MRSA isolates from patients, medical personnel, and medical equipment in the burn unit revealed 5 different pattern (figure 5-1) : A , B , C , D , and E with subtype A1 , A2 , A3 , B1 , B2 , B3 , B4 , B5 , B6 and E1, respectively (Figure 5-2 and 5-3)(Table 5-14).

Genomic DNA type B (94 isolates) was the most prevalent pulsotype in the burn unit (70.68%). Pulsotype B was also distinguished into 6 subtypes: B1, B2, B3, B4, B5 and B6. In each subtype B, there were 16, 3, 1, 2, 1 and 2 isolates, respectively. Twelve out of 16 MRSA-positive patients (D, F, J, Q, T, U, X, Y, Z, BB, CC, and DD) shared the same pulsotype (B and its subtypes). During the time of admission, patients

F, T, Z and DD carried only pulsotype B MRSA. The MRSA pulsotype B were switched to the subtype (B1-B6) because of the ocurrence of the single point mutation as described by Tenover *et. al.* (113). The subtypes of pulsotype B were found in patient D, Q, U, X, and CC, but pulsotype B were still found in them. MRSA subtype B1 was isolated from patient Y throughout his admission in the unit. Patient BB carried both MRSA subtype B1 and B4. MRSA was isolated from assistant nurse b2 twice, and the two isolates were pulsotype B. MRSA with pulsotype B were isolated from medical personnel a5, a11, and d15 once, while the medical personnel b4 and c6 carried MRSA subtype B1 in their nares. MRSA subtype B2 were isolated from bath tubs BT1 and BT2 once.

The MRSA pulsotype A and its subtypes (A1-A3) were isolated from patient C, I, J, and K. Patient C carried MRSA pulsotype A and subtype A3. Patient I carried only MRSA pulsotype A, while MRSA pulsotype A and subtype A1 were isolated from patient J. All MRSA which isolated from patient K were pulsotype A, except one isolate from his medical equipment (enteral pump) which was subtype A2. The MRSA pulsotype A were also isolated from nasal cavities of medical personnel a8 and d11.

Pulsotype D was unique and could be isolated only from patient L. This pulsotype had persisted in such patient until he was discharged from the burn unit. Therefore, the patient was transferred from other hospital which might be the place where the patient had obtained MRSA which was promptly isolated from him upon his admission to the burn unit. Pulsotype C, E, and subtype E1 were detected only once for each type. Type C was found in nasal cavity of patient X, type E and E1 were isolated from hand and nasal cavity, respectively of patient D.

When multiple isolates from a single patient were analyzed, there was an important observation. There were 3 patients that carried multiple MRSA isolates with different pulsotype; patient D carried pulsotype B, E, and E1, patient J carried both pulsotype A and B , and patient X carried pulsotype B and C.

6.2 MRSA isolated from the Traumatic ICU (TICU)

Four MRSA isolates were electrophorosed. The MRSA which were isolated from the nasal cavity of patient IB8 was pulsotype A and the MRSA which were isolated from hand and wound of patient IB2 and from hand of patient IB4 were pulsotype B1.

7. Comparison of pulsotype and antibiogram

The correlation between the pulsotypes and the antibiograms was summarized in Table 5-15. It was shown that MRSA strains with pulsotype B which was the most prevalent type in this study shared various different antibiogram patterns. It was found that there was no correlation between the pulsotype and the antibiogram.

8. Summary of the occurrence of MRSA in each burn patients and environments during 32-weeks of the study

The results were summarized in Table 5-16.

8.1. MRSA pulsotype in the burn patients

At first time of specimen collection, there were 4 patients admitted in burn unit (A, B, C and D). There was no MRSA isolation from these patients at this time. MRSA was isolated from 2 patients (C and D) at the second time of specimen collection in the same week. These MRSA were different in pulsotype, patient C carried MRSA with pulsotype A and patient D with pulsotype B. These two patients was continuously carried MRSA where the organisms were detected from nasal cavities, hands, wounds or both sites. Patient C carried MRSA pulsotype A for the whole time of admission, and finally was discharged from the hospital when no MRSA was isolated from his wound. However, this patient still carried MRSA in his nare and hand. For the whole 8 weeks of admission, patient D carried MRSA pulsotype B, but different MRSA pulsotype : pulsotype E and subtype E1 were found from hand and nare of this patient twice.

Patient A and B stay in the burn unit for 1.5 and 4.5 weeks, respectively, with no MRSA isolated from them. Patients E admitted in burn unit at the second week of the study. It was found that she had no MRSA, and was discharged within one week.

At the first specimen collection of the 5th week when patient F was admitted into this unit and there were 4 patients in the burn unit (B, C, D, and F). MRSA was isolated from only patient C and D in this period. After 2 weeks of admission, MRSA was detected from patient F who shared the same pulsotype with patient D. MRSA from patient F were persisted for two weeks until she was discharged with MRSA in her nasal cavity, hand and wound.

Patient G, H, and I were admitted in the burn unit at the late 5th week period. There were 6 patients (C, D, F, G, H, and I) in the unit at this time. MRSA were still recovered from patient C and D, but there was no MRSA detection from the rest of the patients. Patient G was admitted for a very short time and then discharged. Patient H and I were remained in this ward. There was no MRSA isolation from patient H , although he was in the unit for 4.5 weeks. Patient I had been in the ward for 3 weeks, before MRSA was isolated from his nasal cavity, wound and the button of enteral pump.

Patient J did not carried MRSA in his first week of admission, when there were 3 patients in the unit who were infected with MRSA (patient C with MRSA pulsotype A and patient D and F with pulsotype B). At his second week of admission, MRSA pulsotype A and pulsotype B were alternately isolated from his. MRSA pulsotype A were also found in his wound during the stay in the burn unit.

At the 10th week of the study when patient K was admitted in the burn unit, there was no MRSA patient in this unit. Patient K stayed in the unit for less than one week (6 days) when MRSA pulsotype A was isolated from his nasal cavity. The rest two week of his admission, MRSA pulsotype A were still isolated from his nasal cavity, hand, wound, and the button of enteral pump.

Patient L was transferred from Bangkok hospital to the burn unit. Siriraj hospital in the 11th week of this study. At that time, there was only patient K who was admitted in the burn unit. Patient L had MRSA pulsotype D in his nasal cavity upon his admission. The organism was also remained in his wound until he was discharge from the ward.

Patient M was admitted in the burn unit for 3 days, while there were 2 patients who infected with MRSA (patient K with pulsotype A and patient L with pulsotype D). However, there was no MRSA isolated from this patient.

Patient N, O, and P stayed at the burn unit for 3.5, 2, and 0.5 weeks, respectively. No MRSA was isolated from them.

At the 14th week of the study, there were 4 patients in burn unit (patient M, N, O, and P). There was no MRSA found in these patients, eventhough there were 3 patients (patient Q, R, and S) admitted in the ward. Until the 17th week of the specimen collection, MRSA pulsotype B was detected in patient Q after his 2.5 weeks of admission. There was no MRSA isolated from the medical personnel in the burn unit. MRSA was remained in patient Q until he was discharged.

Patient T was admitted in the burn unit at the 18th week of the study. After 2.5 week of his admission. MRSA pulsotype B were continuously isolated from his nare, hand and wound for 1.5 week. Before discharge, MRSA was isolated in his medical equipment.

Patient U was admitted into the unit at the 19th week. MRSA pulsotype B was isolated from him after 2.5 week of his admission. MRSA remained in his nasal cavity, hand, and wound until he discharged from the ward. MRSA was also isolated from his medical equipment which he used.

Patient V and W were admitted in the burn unit and stayed for 1.5 and 1/3 week, respectively . The two patients did not carried MRSA.

Patient X was admitted in the burn unit at the 18th week of this study, there was no MRSA at first admission. A few days later, MRSA pulsotype B was isolated from

her bed rail. The same MRSA pulsotype (pulsotype B) was then found in her nasal cavity. A couple days later, MRSA was also continuously isolated from her nasal cavity, hand, and wound for 2 weeks until she was discharged. MRSA pulsotype C was also found in her nasal cavity together with pulsotype B.

Patient Y and Z were admitted in this ward at the 25th and 26th week of specimen collection, respectively. There was no MRSA in the first week of these admissions. After one week MRSA subtype B1 was then isolated from patient Y who carried the organism continuously until she was discharged. Patient Z carried MRSA pulsotype B in her nare, hand and wound all the time even when she left the unit.

Patient AA admitted at this unit for one week. No MRSA was isolated from him. Patient BB, CC, and DD were admitted in burn unit at the 28th, 29th, and 30th week of this study. There was no MRSA at the first week of admission, then there were MRSA pulsotype B detection in both 3 patients. These MRSA remained at all sites studied in patient CC until he was discharged while the other 2 patients carried MRSA pulsotype B in their nares and on hands. There were 2 patients that not found MRSA in their wound, but found in their nasal cavities.

8.2. MRSA pulsotype in the medical personnel and medical equipment at the burn unit

The first MRSA was isolated from medical staff (d11) at the 4th week of the study. This medical personnel carried the same pulsotype as in patient C (pulsotype A). In the following week, MRSA were also isolated from nurse (a5) and assistant nurse (b4) but the organisms were in pulsotype B which were difference from the first isolates. There was no more MRSA detection until the 7th week of specimen collection that MRSA were isolated from medical equipment.

At the 9th week of the study, MRSA pulsotype A was again isolated from medical staff. During this time, there was the patient who carried MRSA pulsotype A in the burn unit.

Eventhough there were the patients who carried MRSA type A and D in the unit during the 14^{th} –17^{th} week of the study, there was no MRSA detection from medical staff. MRSA was detected from medical personnel again at the 22^{nd} week of the study. At this time MRSA pulsotype B were isolated from medical staffs. At the 24^{th} week of collection, when MRSA pulsotype B2 isolated from bath tub, there were patients who shared this pulsotype in the ward.

MRSA had not again been found indicated from the nasal cavities of the medical personnel until the 26^{th} week of the study when MRSA pulsotype B was isolated from nasal cavity of assistant nurse (b2).

At the 29^{th} week of specimen collection, there were 4 patients who infected with MRSA pulsotype B and the medical staff also carried the same pulsotype of MRSA.

MRSA pulsotype B was again isolated from the same medical staff (b2) at the 26^{th} week of the study. After that there was no MRSA isolation until the end of this study (the 32^{nd} week of specimen collection).

Table 5-1 Selected Demographic of the 30 burn patients in the burn unit.

	MRSA – positive	MRSA-negative
Number of MRSA-positive patients	16 cases (53.33%)	-
Number of MRSA-negative patients	-	14 cases (46.67%)
Number of new cases	4 cases (25.0%)	10 cases (71.43%)
Number of patients who were transferred other hospitals	12 cases (75.0%)	4 cases (28.57%)
Number of patient who had MRSA on the first day of admission	1 case (6.25%)	-
Number of patients who acquired MRSA after admitted in the burn unit	15 cases (93.75%)	-
Average Length of stay of the patients in the burn unit until MRSA were isolated	12.38 days	-
Average length of stay of the patients in the burn unit	34.38 days	28 days
Number of the patients who previously received antimicrobial agents 3-7 days prior to MRSA positive	13 cases (81.25%)	-

Table 5-2 The prevalence of staphylococci, MRSA and other bacteria isolated from nasal cavities of 54 medical personnel at the Burn unit during 32 weeks of the study.

Organisms	Number of medical personnel from which organisms were isolated from their nasal cavities (%)
1. Staphylococci	53 (98.15)
: coagulase-positive staphylococci	25 (46.30)
- MRSA	8 (14.81)
- MSSA	24 (44.44)
: coagulase-negative staphylococci	52 (96.30)
2. Other bacteria	36 (66.67)

Table 5-3 The recovery rate of staphylococci (MRSA, MSSA, and coagulase-negative staphylococci) which were isolated from the 54 medical personnel during 32 weeks of the study.

Medical personnel Code	Proportion of positive culture to total specimen		
	MRSA	MSSA	Coagulase-negative staphylococci
a1	0/31	28/31	20/31
a2	0/30	0/30	22/30
a3	0/29	1/29	13/29
a4	0/30	0/30	16/30
a5	***1/29***	16/29	15/29
a6	0/29	0/29	15/29
a7	0/28	0/28	20/28
a8	***1/21***	0/21	13/21
a9	0/29	0/29	23/29
a10	0/30	0/30	21/30
a11	***1/30***	9/30	15/30
b1	0/30	0/30	20/30
b2	***2/30***	10/30	22/30
b3	0/29	5/29	17/29
b4	***1/30***	4/30	20/30
b5	0/16	0/16	14/16
b6	0/31	7/31	18/31
b7	0/29	3/29	21/29
b8	0/30	0/30	25/30

a = nurses , b = assistant nurses , c = workers , d1 - d24 = Residents , and d25 – d26 = assigned doctors at the burn unit.

Table 5-3 (cont.) The recovery rate of staphylococci (MRSA, MSSA, and coagulase-negative staphylococci) which were isolated from the 54 medical personnel during 32 weeks of the study.

Medical personnel Code	Proportion of positive culture to total specimen		
	MRSA	MSSA	Coagulase-negative staphylococci
b9	0/30	0/30	12/30
b10	0/29	1/29	8/29
b11	0/30	5/30	12/30
c1	0/31	11/31	21/31
c2	0/31	0/31	25/31
c3	0/31	2/31	26/31
c4	0/1	0/7	6/7
c5	0/2	0/2	0/2
c6	***1/22***	3/22	20/22
d1	0/1	0/1	1/1
d2	0/4	1/4	4/4
d3	0/4	0/4	2/4
d4	0/5	3/5	4/5
d5	0/4	0/4	3/4
d6	0/4	0/4	3/4
d7	0/4	0/4	3/4
d8	0/4	0/4	4/4
d9	0/4	0/4	4/4
d10	0/4	0/4	4/4

a = nurses , b = assistant nurses , c = workers , d1 – d24 = Residents , and d25 – d26 = assigned doctors at the burn unit.

Table5-3 (cont.) The recovery rate of staphylococci (MRSA, MSSA, and coagulase-negative staphylococci) which were isolated from the 54 medical personnel during 32 weeks of the study.

Medical personnel Code	Proportion of positive culture to total specimen		
	MRSA	MSSA	Coagulase-negative staphylococci
d11	*1/4*	2/4	0/4
d12	0/7	1/7	6/7
d13	0/7	5/7	3/7
d14	0/6	2/6	6/6
d15	*1/6*	0/6	5/6
d16	0/5	0/5	5/5
d17	0/2	0/2	2/2
d18	0/3	3/3	2/3
d19	0/9	6/9	5/9
d20	0/12	2/12	10/12
d21	0/7	0/7	5/7
d22	0/7	0/7	6/7
d23	0/5	0/5	4/5
d24	0/1	0/1	1/1
d25	0/27	0/27	21/27
d26	0/28	12/28	20/28

a = nurses , b = assistant nurses , c = workers , d1 – d24 = Residents , and d25 – d26 = assigned doctors at the burn units

Table 5-4 The prevalence of staphylococci , MRSA and other bacteria isolated from the nasal cavities , hands and wound of the 30 burn patients during hospitalization.

Organisms	Number of patients from which organisms were isolated from nasal cavities (%)							
	n*	h**	w***	n+h	n+w	h+w	n+h+w	total
1. Staphylococci								
: coagulase-positive staphylococci	3 (10.0)	0 (0.0)	3 (10.0)	0 (0.0)	4 (13.3)	3 (10.0)	17 (56.7)	**30** (100)
- MRSA	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	$2^{d,f}$ (6.67)	0 (0.0)	$14^{a,b,c,e,g}$ (46.7)	**16** (53.3)
- MSSA	$3^{b,f}$ (10.0)	0 (0.0)	$3^{d,g}$ (10.0)	0 (0.0)	2^{c} (6.67)	3^{e} (10.0)	4^{a} (13.3)	**15** (50.0)
: coagulase-negative staphylococci	3 (10.0)	2 (6.67)	1 (3.33)	4 (13.3)	2 (6.67)	1 (3.33)	16 (58.3)	**29** (96.7)
2. Other bacteria	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.33)	7 (23.3)	1 (3.33)	18 (60.0)	**27** (90.0)

n* = nasal cavities, h** = hands, w*** = wound

a: There was one patient who carried MRSA and MSSA in all sites ; nasal cavity, hand and wound (Patient C).

b: There was one patient who carried MRSA in all sites and MSSA only in nasal cavity (Patient D).

c: There was one patient who carried MRSA in all sites and MSSA in both nasal cavity and wound (Patient F).

d: There was one patient who carried MRSA in both nasal cavity and wound and MSSA only in wound (Patient I).

e: There were 3 patients who carried MRSA in all sites and MSSA in both hands and wounds (Patient J, K, and T).

f: There was one patient who carried MRSA in both nasal cavity and wound and MSSA only in nasal cavity (Patient L).

g: There was one patient who carried MRSA in all sites and MSSA only in wound. (Patient Q)

Table 5-5 Sites of MRSA first isolation from the nasal cavities, hands, and wounds of the 16 MRSA-positive burn patients.

Sites of MRSA first isolation	Number of patients (%)
nasal cavities only	3 (18.75)
hands only	-
wounds only	2 (12.5)
nasal cavities and hands	4 (25.0)
nasal cavities and wounds	3 (18.75)
hands and wounds	1 (6.25)
Both nasal cavities , hands and wounds	3 (18.75)

Table 5-6 The prevalence of staphylococci, MRSA and other bacteria isolated from the medical equipment during 32 weeks of specimen collection.

Medical equipment	Number of isolates (%)					Total specimen
	MRSA	MSSA	Coagulase -negative Staph.*	Other bacteria	No growth	
Bed rails	4** (2.1)	2 (1.0)	34 (17.8)	19 (9.9)	132 (69.1)	191
The button of Enteral pump	8** (4.2)	3 (1.6)	42 (21.9)	59 (30.1)	79 (41.4)	191
Bath tub No. 1	1 (1.6)	1 (1.6)	5 (7.8)	16 (25)	41 (64.1)	64
Bath tub No. 2	1 (1.6)	0 (0.0)	2 (3.1)	10 (15.6)	51 (79.7)	64

MRSA = Methicillin-resistant *Staphylococcus aureus*

MSSA = Methicillin-sensitive *Staphylococcus aureus*

* Coagulase-negative staphylococci.

** MRSA strains isolated from the medical equipment which had been used by the MRSA-positive patients.

Table 5-7 The prevalence of MRSA , staphylococci and other bacteria isolated from the nasal cavities , hands , and wounds of the 11 patients and nasal cavities of the 24 medical personnel at the Traumatic ICU (TICU).

Organisms	Number of isolates (%)			
	Patients			Medical personnel
	Nasal cavities	Hands	Wounds	Nasal cavities
1. Staphylococci	6 (54.55)	6 (54.55)	6(54.55)	24 (100.0)
: coagulase-positive staphylococci	2 (18.18)	2 (18.18)	1 (9.09)	9 (37.50)
- MRSA	1 (9.09)	2 (18.18)	1 (9.09)	0 (0)
- MSSA	1 (9.09)	2 (18.18)	0 (0.0)	9 (37.50)
: coagulase-negative staphylocci	6 (54.55)	5 (45.45)	5 (45.45)	15 (62.50)
2. Other bacteria	8 (72.72)	7 (63.63)	6 (54.55)	13 (54.17)

Table 5-8 The result of MRSA isolation from the TICU patients.

Patient Code	MRSA isolated from		
	Nasal Cavities	Hands	Wounds
IB1	-	-	-
IB2	-	+	-
IB3	-	-	-
IB4	-	+	+
IB5	-	-	-
IB6	-	-	-
IB7	-	-	-
IB8	+	-	-
IB9	-	-	-
IB10	-	-	-
IB11	-	-	-

IB1 – IB11 = Code of the patients at the TICU

+ = MRSA- positive

- = MRSA- negative

Table 5-9 The antimicrobial susceptibility patterns (antibiogram) and frequency in each pattern of 231 MRSA isolated from the burn unit

type	Va	TEC	FF	C	NET	CC	SXT	IPM	AMC	SAM	75/30	E	CLR	GM	CIP	No. of isolates
1	S	S		S	S											1
2	S	S			S	S										2
3	S	S			S		S									1
4	S	S		S	S	S										10
5	S	S		S	S		S									3
6	S	S		S	S			S								1
7	S	S	S		S	S										9
8	S	S	S		S		S									5
9	S	S	S	S		S										11
10	S	S	S	S			S									9
11	S	S	S		S	S		S								10
12	S	S	S	S		S		S								6
13	S	S	S	S			S	S								8
14	S	S	S	S		S										55
15	S	S	S	S	S	S										30
16	S	S	S	S	S		S	S								3
17	S	S	S	S	S	S		S								61
18	S	S		S	S	S	S	S					S		S	1
19	S	S			S	S	S	S				S	S		S	2
20	S	S	S	S			S	S	S	S	S					1
21	S	S	S	S	S	S		S		S		S	S			1
22	S	S	S	S	S	S	S	S	S	S	S					1

Va = Vanscomycin , TEC = Teicoplanin , FF = Fosfomycin , C = Chloramphenicol , NET = Netilmicin , CC = Clindamycin , SXT = Trimethoprim-sulfamethoxazole , IPM = Imipenem , AMC = Amoxycillin-clavulanic acid , SAM = Ampicillin-sulbactam , 75/30 = Cefoperazone-sulbactam , E = Erythromycin , CLR = Clarithromycin , GM = Gentamicin , CIP = Ciprofloxacin

Table 5-10 Percentage of Antimicrobial susceptibility of MRSA isolated from the 16 burn patients and the 8 medical personnel.

Antimicrobial agents	Number of susceptible strain (%)		
	Patients		Medical personnel
	Nasal cavities (12 isolates)	Wounds (7 isolates)	Nasal cavities (9 isolates)
1. Amoxycillin / clavulanic acid	0 (0.0)	0 (0.0)	0 (0.0)
2. Ampicillin / sulbactam	0 (0.0)	0 (0.0)	0 (0.0)
3. Cefoperazone / sulbactam	0 (0.0)	0 (0.0)	0 (0.0)
4. Imipenem	5 (41.67)	4 (57.14)	6 (66.67)
5. Vancomycin	12 (100.0)	7 (100.0)	9 (100.0)
6. Teicoplanin	12 (100.0)	7 (100.0)	9 (100.0)
7. Fosfomycin	10 (83.33)	6 (85.71)	8 (88.89)
8. Chloramphenicol	11 (91.67)	5 (71.43)	8 (88.89)
9. Erythromycin	0 (0.0)	0 (0.0)	0 (0.0)
10. Clarithromycin	0 (0.0)	0 (0.0)	0 (0.0)
11. Clindamycin	5 (41.67)	5 (71.43)	5 (55.56)
12. Gentamicin	0 (0.0)	0 (0.0)	0 (0.0)
13. Netilmicin	9 (75.0)	5 (71.43)	8 (88.89)
14. Ciprofloxacin	0 (0.0)	0 (0.0)	0 (0.0)
15. Co-trimoxazole	7 (58.33)	2 (28.57)	3 (33.33)

Table 5-11 Antimicrobial susceptibility of 4 MRSA isolated from the patients at the Traumatic ICU.

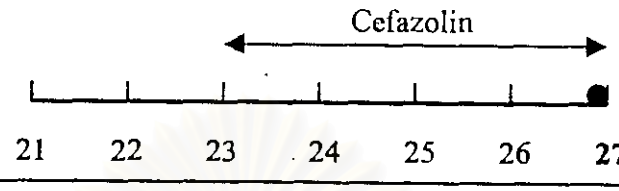
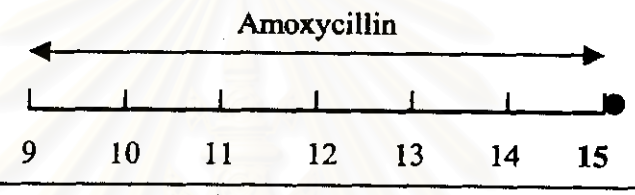
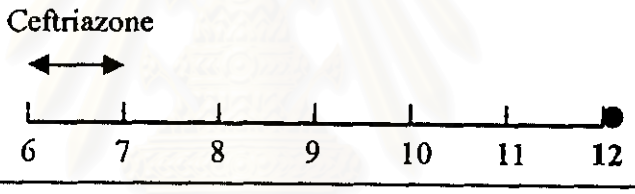
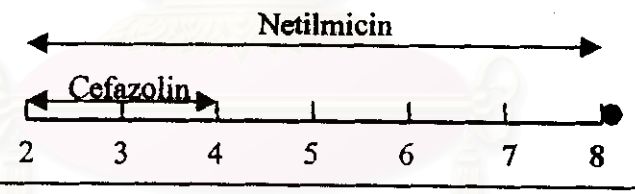
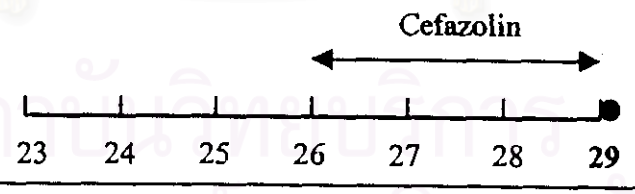
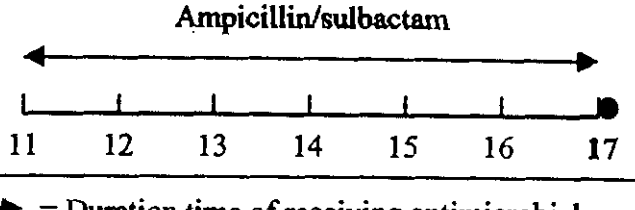
Antimicrobial agents	The susceptibility patterns of MRSA strains from			
	Nasal cavities	Hands		Wounds
	IB8n	IB2h	IB4h	IB4w
1. Amoxycillin/ clavulanic acid	R	R	R	R
2. Ampicillin/sulbactam	R	R	R	R
3. Cefoperazone/ sulbactam	R	R	R	R
4. Imipenem	S	S	S	S
5. Vancomycin	S	S	S	S
6. Teicoplanin	S	S	S	S
7. Fosfomycin	S	S	S	S
8. Chloramphenicol	R	R	R	R
9. Erythromycin	R	R	R	R
10. Clarithromycin	R	R	R	R
11. Clindamycin	S	R	R	R
12. Gentamicin	R	R	R	R
13. Netilmicin	S	R	R	S
14. Ciprofloxacin	R	R	R	R
15. Co-trimoxazole	R	R	S	S
Type	11	23	24	25

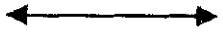
R = resistant and S = susceptible

IB2, IB4, and IB8 = Code of the patients at the TICU

n = nose, h = hand, w = wound

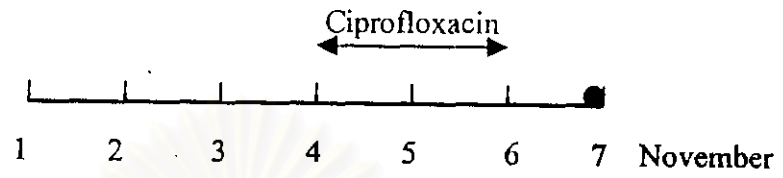
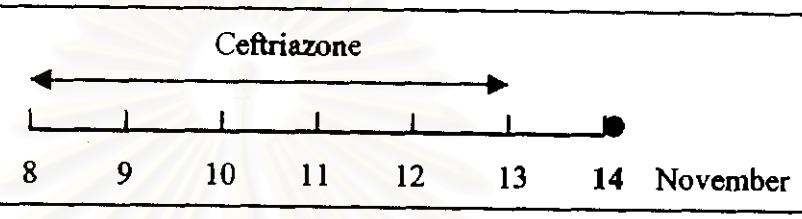
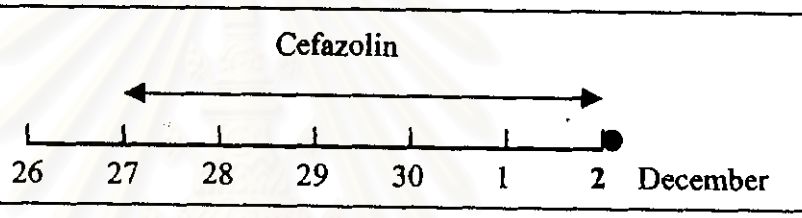
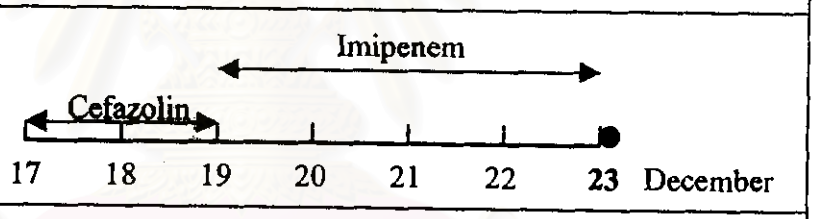
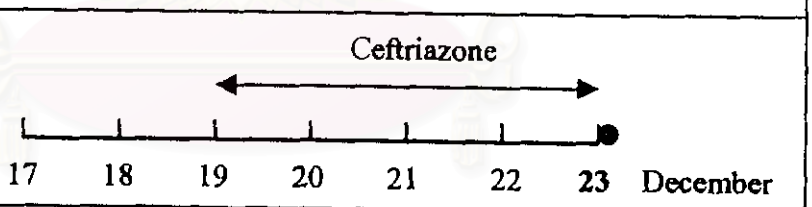
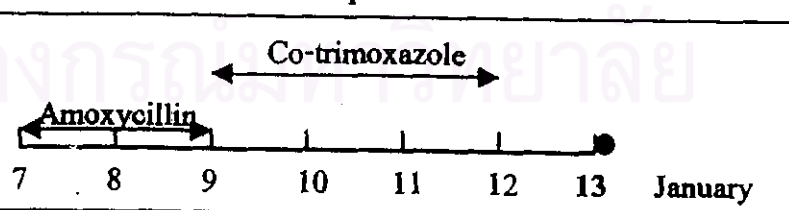
Table5-12 Antimicrobial agent administration of the 16 burn patients days prior to first MRSA isolation.

Patient Code	
C	
D	Not received antimicrobial agents during the 7 days before MRSA-positive
F	
I	
J	
K	
L	Not received antimicrobial agents during the 7 days before MRSA-positive
Q	

 = Duration time of receiving antimicrobial agents

● = The first day of MRSA-positive

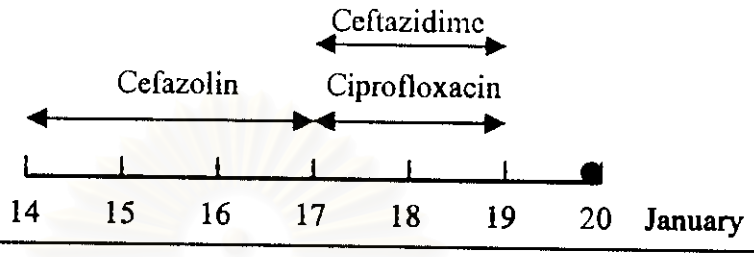
Table 5-12 (cont.) Antimicrobial agent administration of the 16 burn patients days prior to first MRSA isolation.

Patient Code	
T	
U	
X	
Y	
Z	
BB	Not received antimicrobial agents during the 7 days before MRSA-positive
CC	

 = Duration time of receiving antimicrobial agents

● = The first day of MRSA-positive

Table 5-12 (cont.) Antimicrobial agent administration of the 16 burn patients days prior to first MRSA isolation.

Patient Code	
DD	

= Duration time of receiving antimicrobial agents

● = The first day of MRSA-positive

Table5-13 Antimicrobial administration of the 14 MRSA-negative burn patients during 7 days before they were discharged.

Patient Code	
A	-
B	Fucidine 17 18 19 20 21 22 **23** July
E	-
G	-
H	-
M	-
N	-
O	Cloxacillin 20 21 22 23 24 25 **26** September
P	-
R	-
S	-
V	Amoxycillin 13 14 15 16 17 18 **19** November
W	-
AA	Netilmicin 30 31 1 2 3 4 5 January

◆▶ = Duration time of receiving antimicrobial agents, ■ = discharged date

- = Not receiving antibiotic before discharge

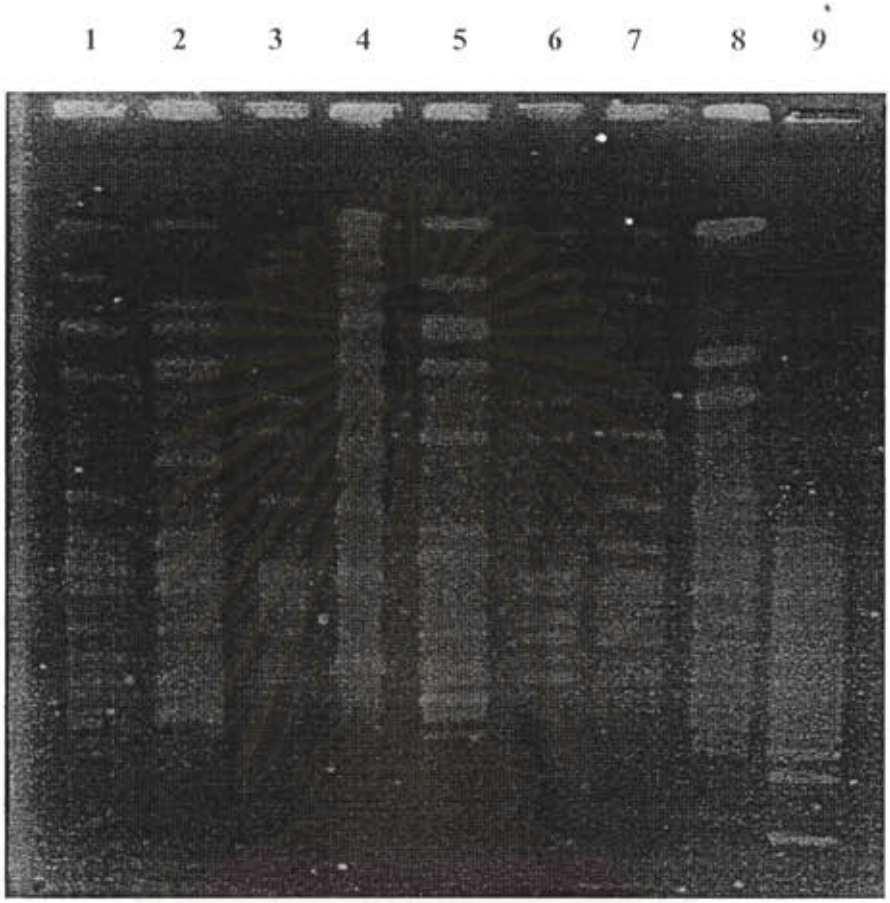


Figure 5-1 Chromosomal DNA pulsotypes obtained by pulsed-field gel electrophoresis after digestion with *Sma*I restriction endonuclease enzyme : lane 1, pulsotype A, lane 2, pulsotype B, lane 3, pulsotype C, lane 4, the lambda ladder marker, lane 5, pulsotype D, lane 6, pulsotype E, lane 7, subtype E1, lane 8, *S. aureus* ATCC 25923, and lane 9, the 5 kilobases marker.

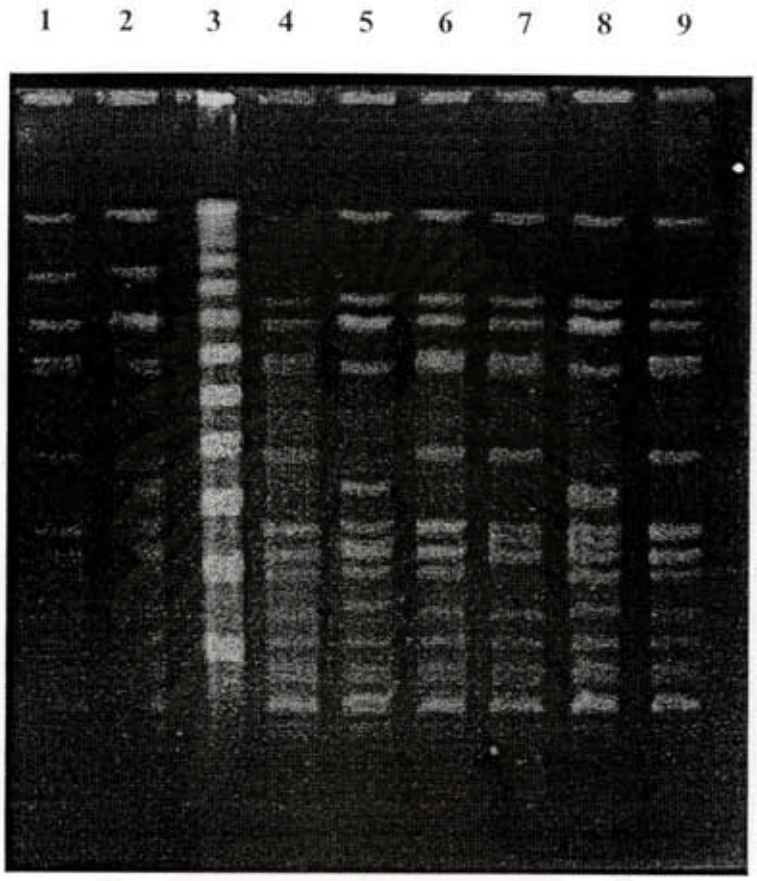


Figure 5-2 Chromosomal DNA subtypes obtained by pulsed-field gel electrophoresis after digestion with *SmaI* restriction endonuclease enzyme :lane 1-2 , subtypes A1 and A2 , respectively , lane 3 , the lambda ladder marker ,lane 4 , pulsotype B , and lane 5-9 , subtypes B1 , B2 , B3 , B4 , and B5 , respectively

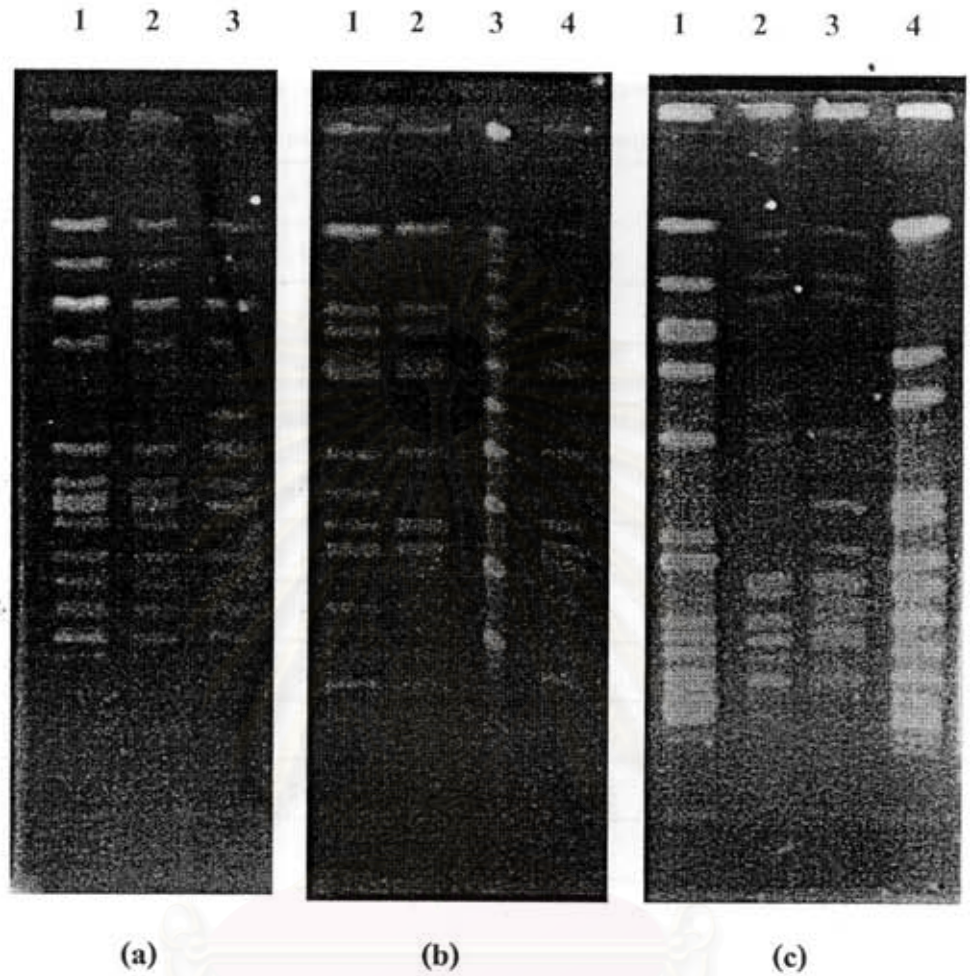


Figure 5-3 Chromosomal DNA pulsotypes and subtypes obtained by pulsed-field gel electrophoresis after *Sma*I restriction endonuclease enzyme.

(a) : Lane 1-2, pulsotype A, and lane 3, subtype A3.

(b) : Lane 1, subtype B6, lane 2, pulsotype B, lane 3, the lambda ladder marker, and lane 4, pulsotype B.

(c) : Lane 1, pulsotype D, lane 2, pulsotype E, lane 3, subtype E1, and lane 4, *S. aureus* ATCC 25923.

Table 5-14 The prevalence of pulsotype of MRSA in all subjects and medical equipment in the burn unit.

Pulsotype	Number of isolates from		
	Burn patients* (16 patients)	Medical personnel (8 persons)	Basin (2 bath tubs)
A	4 [a,b,c]	2	-
-A1	1 [a]	-	-
-A2	1 [b]	-	-
-A3	1 [c]	-	-
B	9 [a,d,e,f,g,i]	5	-
-B1	5 [d,e,h]	1	-
-B2	1 [f]	-	2
-B3	1 [f]	-	-
-B4	1 [h]	-	-
-B5	1 [i]	-	-
-B6	2 [d,f]		
C	1 [g]	-	-
D	1	-	-
E	1 [d]	-	-
-E1	1 [d]	-	-

* Each burn patient maybe isolated MRSA more than one different strain

a: There was one patient who carried pulsotype A, subtype A1, and pulsotype B (Patient J).

b: There was one patient who carried both pulsotype A and subtype A2 (Patient K).

c: There was one patient who carried both pulsotype A and subtype A3 (Patient C).

d: There was one patient who carried pulsotype B, E, subtype B1, B6, and E1 (Patient D).

e: There were 2 patients who carried both pulsotype B and subtype B1 (Patient Q and Z).

f: There was one patient who carried pulsotype B and its subtype (B2, B3, and B6) (Patient U).

g: There was one patient who carried both pulsotype B and C (Patient X).

h: There was one patient who carried both subtype B1 and B4 (Patient BB).

i: There was one patient who carried both pulsotype B and subtype B5 (Patient CC).

Table 5-15 The correlation between the pulsotypes and the antibiogram of 142 MRSA isolates from the patients, medical personnel and medical equipment in the burn unit.

antibiogram	Pulsotype														
	A	A1	A2	A3	B	B1	B2	B3	B4	B5	B6	C	D	E	E1
1					■										
2					■										
3									■						
4					■					■					
5						■							■		
6														■	
7					■										
8									■						
9					■		■								
10	■		■												
11					■										
12					■						■				
13	■	■													
14	■					■							■		
15					■										
16	■			■											
17					■	■	■				■				
18															
19						■									■
20	■														
21												■			
22								■							

Table5-16 Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Patient Code	1		2		3		4		5		6		7		8	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
A	-	-	-													
B	-	-	-	-	-	-	-	-	-							
		14,14	14,14,14,14	14,14,14	14,14,14	14,14	14,14	14,14	14	16,14	14,14,14	10,10				
C	-	nh	nhwEp	nhw	nhw	nw	nh	nh	h	nh	nhw	nh				
		AA	--AA	---	---	AA	--	--	A	A3-	AAA	AA				
		11	16,11	17	17	15	19,11,11	11,17	19,11	17,17	17	11,17	11,17	17	11	
D	-	w	hw	w	w	w	nnw	nw	nn	nh	w	nw	nw	w	n	
		B	EB	-	B	-	E1BB	--	B1B	B6B	-	--	BB	B	B	
E				-	-											
													17	17,17	17	17,17,17
F									-	-	-	-	n	nh	n	nhw
													B	BB	B	BBB
G										-						
H										-	-	-	-	-	-	-
															13,13,13	
I										-	-	-	-	-	nwEp	
															AAA	
							14		11,17					17		
BT , MP	-	-	-	-	-	-	d15	-	a5,b4	-	-	-	-	BT2	-	-
							A		B B					B2		

n = nasal cavities , h = hands , w = wounds , Ep = the button of enteral pumps , Br = Bed rails , BT = Bath tubs

A, B, C,.... , DD = burn patients code, MP = medical personnel, a-d = medical personnel code, Number 1,2,3,...= antibiogram patterns.

Table 5-16 (cont.) Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Code name	1		2		3		4		5		6		7		8	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
														13,12,13	13,16	17,14
J												-	-	nhw	nw	nh
														ABA	A1A	BA
							14		11,17					17		
BT , MP	-	-	-	-	-	-	d15	-	a5,b4	-	-	-	-	BT2	-	-
							A		B B					B2		

n = nasal cavities , h = hands , w = wounds , Ep = the button of enteral pumps , Br = Bed rails , BT = Bath tubs

A , B , C , ... , DD = burn patients code, MP = medical personnel, a-d = medical personnel code, Number 1,2,3,...= antibiogram patterns.

Table 5-16 (cont.) Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Code name	9		10		11		12		13		14		15		16	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	13,10,16	17														
J	nhw	n														
	AAA	B														
				10	10,10,10	20	10,10,14									
K			-	n	nhEp	n	nhw									
				A	AAA2	A	AAA									
						5	14,14	14	14	14						
L						n	nw	w	w	w	-	-	-			
						D	DD	-	-	D						
M							-									
N								-	-	-	-	-	-	-		
O									-	-	-	-				
P											-					
Q													-	-	-	-
R															-	-
	13															
MP, BT	a8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	A															

n = nasal cavities, h = hands, w = wounds, Ep = the button of enteral pumps, Br = Bed rails, BT = Bath tubs

A, B, C, ..., DD = burn patients code, MP = Medical personnel, a-d = medical personnel code, Number 1,2,3,...= antibiogram patterns.

Table 5-16 (cont.) Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Code name	17		18		19		20		21		22		23		24	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
		17,17	17,17	17,17,17,17	17,17	17										
Q	-	hw	nw	nhwBr	nh	n	-	-								
		BB1	BB	- - - B	- -	B										
R	-	-														
S	-															
							17,17,17	17,17	17,17		17					
T			-	-	-	-	-	nhw	hw	hw	-	Ep				
							BBB	- -	BB		B					
									17/17,12/	17,17,17	17,12/12,1	17,17,17,	12,17/	17,17		
									22		7/17,12/17	17	17/17			
U						-	-	-	-	nhhEp	nhw	mhhww	nhwBr	nnhw	nw	
												Br				
										BB-B3	- - B	—BB6B	B- - -	- - -	B2B	
V									-	-	-					
W										-						
													17		17	9,9,9
X													B	-	n	nhw
													B		B	BBB
											17		17		9	
MP,BT	-	-	-	-	-	-	-	-	-	-	d15	-	a11	-	BT1	-
											B		B		B2	

n = nasal cavities , h = hands , w = wounds , Ep = the button of enteral pumps , Br = Bed rails , BT = Bath tubs

A , B , C , ... , DD = burn patients code, MP = Medical personnel, a-d = medical personnel code, Number 1, 2, 3,...= antibiogram patterns.

Table 5-16 (cont.) Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Code name	25		26		27		28		29		30		31		32	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	9,9	15,9/9	21,9,7	15,15/15, 14	15,15,15	9,15	15,15,15		15,15,4	15,9/15/ 4,15	15,4					
X	nh	nnh	nnh	nhww	nhw	nw	nhw		nhw	nnhww	nw					
	- B	- - -	CB-	- - B-	B- -	- -	- B -		B- -	- - - - -	BB					
				14,14	14,14,14	14,14	14,14			14	14	14,5	14	14	5	
Y		-	-	nh	nhw	nh	nh		-	w	w	wEp	w	w	w	-
				B1B1	B1B1B1	- -	B1B1			B1	-	B1B1	- -	B1	-	
					7,7	7,7,7,14	7,7		2,7,2							
Z			-	-	nw	nhww	nh		nhw							
					BB	B - - B1	- -		BBB							
AA						-	-									
									8,14	8/8,14	14,8,8,14, 14	3				
BB							-		nh	nww	nnhhw	n				
									B4B1	- B4B1	- - B4 - -	B4				
											4,4	4,4,4				
CC									-	-	nw	nhw				
											BB	BB5B				
			9						14		1					
MP,BT	-	-	b2	-	-	-	-		c6	-	b2	-	-	-	-	-
			B						B1		B					

n = nasal cavities , h = hands , w = wounds , Ep = the button of enteral pumps , Br = Bed rails , BT = Bath tubs

A , B , C , ... , DD = burn patients code, MP= Medical personnel, a-d = medical personnel code, Number 1,2,3,... = antibiogram patterns.

Table 5-16 (cont.) Summary of the occurrence of MRSA in each burn patients and environments during the 32 weeks of the study

Code name	25		26		27		28		29		30		31		32	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
													15,15,15, 15	15,15	4,15	4,15,15
DD											-	-	nhwEp	nh	nw	nhEp
													BBBB	- -	- -	BBB
			9						14		1					
MP,BT	-	-	b2	-	-	-	-		c6	-	b2	-	-	-	-	-
			B						B1		B					

n = nasal cavities , h = hands , w = wounds , Ep = the button of enteral pumps , Br = Bed rails , BT = Bath tubs

A , B , C , ... , DD = burn patients code , MP= Medical personnel , a-d = medical personnel code, Number 1,2,3,... = antibiogram patterns.