ISSN 102

Department of Health
REPUBLIC OF CHINA

Vol. 11 No. 12/December 25,

Epidemiology Bulletin

A Survey of *Staphylococcus aureus* Nosocomial Infectic among Hospitalized Patients in a Medical Center

Abstract

Infections caused by *Staphylococcus aureus,* particularly nosocomial infe have increased in number and seriousness in recent years. A survey of hospi patients in a single institution over the past ten years showed the propor *Staphylococcus aureus* to all other clinically-isolated bacteria had increasec 6.9% in 1985 to 13.9% in 1994, or a 101% increase. The proport *Staphylococcus aureus* to all pathogenic bacteria of nosocomial infections ha increased from 9.8% to 16.7% in the same period, an increase of 70%. Of al of nosocomial infections caused by *Staphylococcus aureus,* skin infections and s site infections are most important. By location, this type of infection occurs in the Intensive Care Unit (ICU); the Internal Medicine, Nursery and Su Departments. *Staphylococcus aureus* has been found so far to be more tha resistant to all kinds of antibiotics except vancomycin; its drug resistance to o in particular, has increased from 26% in 1985 to 81% in 1994. The surve revealed that in the past four years, of all nosocomial infections caus *Staphylococcus aureus,* an average of 68% were caused by oxacillin-resistant s Because of its specific biological characteristics, its rapid development of resi to antibiotics and its significant contribution to an increase in nosocomial inf in the past two years, it is imperative that nosocomial infection cont made a priority, and that all related personnel review existing nosocomial in control measures and initiate more effective approaches to reduce this thr a minimum.

1. Introduction

Staphylococcus aureus is one of the normal flora found on the skin of human l in their oral and nasal cavities and in their intestinal tracts. Around one-third adults are constant nasal carriers of the bacteria; a half of all adults have been c

and around the perineum to increase chances of transmission. Surface antigens of *Staphylococcus aureus,* such as protein A, are resistant to the phagocytosis of the human body and, therefore, are the initial decisive factors in human infection. In addition, the bacteria also produce various enzymes and toxins such as coagulase, lipase, hyaluronidase, penicillinase, staphylokinase, nuclease, hemolysin, leukocidin, enterotoxin and exfoliative toxin to reinforce their pathogenicity.

Staphylococcus aureus is a major pathogenic bacterium of both community and nosocomial infections[1,2]. Clinically, this bacterium induces cellulitis, carbuncles, papules, boils, infected bedsores, impetigo and surgical site infections. Its enterotoxin causes the most common food poisonings. The methicillin-resistant *Staphylococcus aureus* (MRSA) clinically induces septicemia, pneumonia, osteomyelitis and endocarditis, ending in prolonged hospital stays and higher patient mortality, causing waste of medical care resources and manpower. MRSA also induces nosocomial infections in neo-natal ICU's, burn units and nurseries. Outbreaks are hard to control; in these units, the contacts between patients and care providers are frequent and more antibiotics are used. These antibiotics will not have any inhibitive effect on most MRSAs. MRSA, therefore, is a challenging headache to both patients and the medical care personnel.

To understand the infection of patients by Staphylococcus aureus in this Hospital and the trend of infection, related data collected over the past nine years were tabulated and analyzed to review the effectiveness of current nosocomial infection control measures.

2. Materials and Methods

The survey was begun in 1985, when trained infection control nurses, on routine weekly visits to wards, would check records of all hospitalized patients, including medical care records of doctors and nurses, chest X-ray examination and microbiological isolation reports of the laboratory culture of specimens. They would then decide if a case were nosocomially infected, following the definitions for such infections. A nosocomial infection record would be established for any case meeting the definition; more information about the case, relevant risk factors of infection, date of infection, site and strain of infection would also be noted. All pertinent information was then entered into the computer and analyzed regularly.

Suspicious cases or cases of unusual infections would be discussed at weekly infection control team meetings with doctors working in the Infectious Disease Section. All nosocomially-infected patients would be reviewed and so verified by the physician-in-charge. Reports were presented monthly and annually at the Infection Control Committee meetings. Special issues concerning nosocomial infection and their management were also presented and reviewed.

The 1982 US CDC definitions of nosocomial infection were applied[3], with some modification to meet the special conditions of the Hospital concerned. Some major criteria were:

"Nosocomial blood stream infection" refers to a patient whose blood c admission was either negative or in whom-though not given blood culture hours after, admission, micro-organisms could be isolated, with or witho of any part of the body. To avoid false positive reaction from contamina bacteria isolated were one of the normal flora commonly found on skin, the be so recorded only either after isolation of the same strain upon two consec cultures, or if the clinical doctor considered the infection to be a significant blood stream infection.

"Nosocomial urinary tract infection" refers to a patient whose urine urine culture upon admission was negative, and who developed pyuria missions, un-centrifugated fresh urine, when placed under high-power micı examination, showed 10 or more white blood cells in one visual field; or that is, the number of colonies per cc in urine culture was 100,000 or mo kinds of micro-organisms cultured did not exceed two. The patient, with any urinary tract infection, would then be considered to have a nosocomi infection.

"Nosocomial surgical site infection" refers to a patient showing any pus-lik around wounds after operation, with or without microbiological culture respiratory tract nosocomial infection" refers to a patient showing no syı pneumonia upon admission who, however, developed 48 hours after admission such as coughing, fever and sputum, and has thus been diagnosed by a clinica as having pneumonia. Such a patient is considered to have a lower respir nosocomial infection with or without either sputum culture or chest X-ray ex "Upper respiratory tract nosocomial infection" refers to infections of the ear throat, often by viruses. Special consideration should be given to incubatic to eliminate any latent infections prior to admission.

"Nosocomial skin infection" includes skin infections of newborns such as of the umbilicus, impetigo and bedsore. "Gastro-intestinal tract infection" refe diarrhea after admission or, over a period of more than 12 hours, a watery c occurred, a discharge not likely to have been caused by a non-infection agent. agents are often either bacteria or viruses; special consideration should be gi incubation period. Other nosocomial infections include all infections acquir hospital stay, excluding latent infections prior to admission.

3. Results

In the period between 1985 and 1994, there were altogether 321,380 per of discharges in this hospital. Of those, 12,635 person-times were ider nosocomial infections by infection control nurses through routine reviews of records, thus establishing an infection rate of around 3 to 5% per year, or a average infection rate of 3.92% (see Table 1). The infection rate is the of infections per 100 patient discharges, using the number of discharge denominator

Table 1. Incidence of Nosocomial Infections in a Medical Center, 1985-1994

Year	No. Discharged	No. Infected	Infection Rate
1985	31,241	1,219	3.90%
1986	31,942	1,344	4.20%
1987	33,442	1,526	4.56%
1988	33,091	1,226	3.70%
1989	31,587	1,179	3.73%
1990	31,926	1,261	3.94%
1991	31,930	1,179	3.69%
1992	31,337	1,320	4.21%
1993	34,302	1,320	3.84%
1994	30,582	1,061	3.47%
Average	32,138	1,253	3.92%

Survey findings show that the proportion of *Staphylococcus aureus* to all clinically isolated bacteria had increased from 6.9% in 1985 to 13.9% in 1994, an increase of 101%. The proportion of *Staphylococcus aureus* to all pathogenic bacteria of nosocomial infections had increased sharply from 9.8% to 16.7% in the same period, an increase of 70% (see Table 2). The proportion of *Staphylococcus aureus* to all clinically-isolated bacteria had declined from 8.9% in 1985 to 4.8% in 1990, and from the fourth to the seventh cause of infection. This proportion has shown a dramatic increase since 1991, doubling in the three years from 4.8% in 1990 to 15.1% in 1993, to become the second cause of infection. The proportion of *Staphylococcus aureus* to all pathogenic bacteria of nosocomial infections also declined from 9.8% in 1985 to 6.0% in 1990, and from the third to the eighth cause of infection. Since 1991, the proportion has increased sharply by 2.5 times at 5% a year to 21.5% in 1993, and had been the first cause of infection for the last two years (see Table 2).

By site of infection, more *Staphylococcus aureus* nosocomial infections are skin infections (40.1%), blood stream infections (23.9%), respiratory tract infections (13.2%) and surgical site infections (10.8%). Survey findings also show that there has been a more-than-average increase of respiratory tract infections in the last three years, and that skin and blood stream infections have always remained high. From Table 3, of all the nosocomial skin infections, *Staphylococcus aureus* can be seen to occupy about 22.5%. It went down to 10.9% in 1989; went up again after 1990 to more than 30% in 1994. That the proportions of respiratory tract, surgical wound and blood infections have all exceeded 20%, much higher than the annual average, deserves further study. By location, more cases are found in ICUs, Internal Medicine, Nurseries and Surgical Departments. Statistics also show that the number of nosocomial infections caused by *Staphylococcus aureus* in these four Departments,

Table 2. Percentage of *Staphylococcus aureus* to Total Isolated Bacte Pathogenic Bacteria of Nosocomial Infections in a Medical Center, 19

Year	Total No. of Isolated Bacteria	*Staphylococcus aureus* (%)	Pathogenic Bacteria of Nosocomial Infections	Noso *Staphy au*
1985	7,933	557 (6.9%)	1,255	124
1986	11,441	670 (5.9%)	1,147	127
1987	15,431	723 (4.3%)	1,820	129
1988	10,426	559 (5.4%)	1,435	110
1989	11,029	474 (4.3%)	1,447	81
1990	11,091	527 (4.8%)	1,353	81
1991	10,177	945 (9.3%)	1,350	156
1992	11,596	1,514 (13.1%)	1,588	266 (1
1993	14,877	2,246 (15.1%)	1,557	335 (2
1994	14,412	2,000 (13.9%)	1,291	216 (1

Table 3. Nosocomial Infections by Site in a Medical Center, 1986-1

Year	Surgical Site	Urinary Tract	Respiratory Tract	Skin	Blood Stream	Others	
1986	22 (12.2)*	5 (0.9)	11 (7.3)	53 (29.9)	28 (9.1)	8 (13.6)	12
1987	14 (5.5)	5 (0.9)	6 (3.9)	77 (26.3)	19 (3.7)	8 (12.1)	12
1988	10 (5.2)	2 (0.6)	12 (6.4)	48 (21.4)	26 (6.2)	12 (16.9)	11
1989	8 (5.8)	5 (1.4)	8 (3.9)	28 (10.9)	29 (6.6)	3 (6.4)	8
1990	12 (8.8)	1 (0.3)	2 (1.2)	35 (13.1)	23 (5.6)	8 (14.0)	8
1991	23 (14.2)	8 (3.0)	27 (16.2)	55 (18.5)	38 (9.0)	5 (13.2)	15
1992	22 (13.3)	13 (5.5)	33 (17.0)	111 (22.3)	76 (16.5)	11 (34.4)	26
1993	30 (21.0)	15 (6.4)	55 (21.3)	148 (28.5)	77 (21.0)	10 (27.0)	33
1994	19 (16.1)	14 (5.3)	44 (23.0)	50 (31.3)	53 (14.9)	36 (17.9)	21
Average	18 (11.2)	8 (2.7)	22 (11.1)	67 (22.5)	40 (10.3)	11 (17.3)	16

* Percentage of nosocomial *Staphylococcus aureus* infection strains is calcu holding the total number of all bacterial strains as denominator.

particularly in Nurseries, has increased significantly.

Drug-resistance of *Staphylococcus aureus* to various antibiotics, with the exception of vancomycin thus far, has increased year by year, particularly to oxacillin, the antibiotic most commonly used for the treatment of *Staphylococcus aureus* infections. Resistance increased from 18% in 1989 to 81% in 1994, an increase of 63% in the last six years (see Table 4). Resistance to other antibiotics, amoxicillinclavalanic acid (76%), cephalothin (79%), gentamicin (79%), erythromycin (85%), tetracycline (88%), penicillin (99%) and ampicillin (99%), has also increased by more than 70%. A fact to note from Table 4 is that, in the one-year period between 1990 and 1991, resistance to oxacillin, cephalothin, gentamicin, clindamycin and chloramphenical had increased by 20%. Survey findings show that of all *Staphylococcus aureus* nosocomial infections in the last four years, on the average 68% were caused by oxacillin-resistant *Staphylococcus aureus* strains (see Table 5).

Table 4. Sensitivity test of *Staphylococcus aureus* to Various Antibiotics in a Medical Center, 1985-1994

Year	No. of Strains Isolated	P	AMP	OX	AMC	CF	VA	GM	CC	TE	E	C
1985	557	3*	3	74	—	94	—	73	88	28	57	80
1986	670	2	2	76	—	91	—	77	88	27	55	76
1987	723	1	1	80	—	92	—	76	89	32	51	80
1988	559	3	3	75	—	86	100	73	77	38	49	79
1989	474	4	4	82	—	88	100	73	76	41	55	74
1990	527	3	3	67	—	72	100	66	77	37	47	67
1991	945	1	2	42	—	43	100	41	50	26	29	46
1992	1,514	1	1	30	—	32	100	27	44	16	20	34
1993	2,371	1	1	25	30	27	100	25	32	13	19	32
1994	2,000	1	1	19	24	21	100	21	24	12	15	32

* indicates percentage of antibiotic sensitivity. Where P = penicillin; AMP = ampicillin; OX = oxacillin; AMC = amoxicillin/clavalanic acid; CF = cephalothin; VA = vancomycin; GM = gentamicin; CC = clindamycin; TE = tetracycline; E = erythromycin; C = chloramphenical. —: not done.

4. Discussion

Infections by *Staphylococcus aureus*, particularly nosocomial infections, have been increasing. The proportions of Staphylococcus to either clinically-isolated bacteria or

Table 5. Nosocomial Infections Due to MRSA in a Medical Center, 19

Year	Nosocomial Infection	
	Staphylococcus aureus Strains	MRSA Strains
1990	80	53 (66.3%)
1991	154	136 (88.3%)
1992	266	154 (57.9%)
1993	335	207 (61.8%)

pathogenic bacteria from nosocomial infections have increased significantly by 5% a year in the last three years (see Table 2). Since 1992, *Staphylococcu* has replaced *Pseudomonus aeruginosa* as the first cause of nosocomial in occupying about 21.5% of all such infections. Authorities and individuals c should be more alert to this problem. After all, nosocomial infections prolong hospitalization, cause waste of money and manpower and are a major re increased infection rates and mortality.

Many hospitals have already set up Nosocomial Infection Control Commit individual nosocomial infection surveillance systems to apply epidemiological a statistical methods to collect and analyze data, and to further understand the likel organisms, departments and sites of infections of the hospital concerned and development and changes in resistance to antibiotics for early detection and control of any unusual infections. Most nosocomial infections caused by *Staphy aureus* are still non-clustered or opportunistic. However, with increased resis antibiotics in recent years, particularly MRSA nosocomial outbreaks often c clusters[4-6]. A report in 1992 by US CDC of a 17-year survey of US hospital that the proportion of MRSA to all *Staphylococcus aureus* had increased fro in 1975 to 29% in 1991, with the increase logarithmic after 1985[7]. The rep shows that larger hospitals (more than 500 beds) show significantly more inc MRSA infections than smaller hospitals (fewer than 500 beds). In Taiwan, the been reports that the proportion of MRSA-induced infections has also increased 25-30% in medical centers[8]. The present survey shows that, between 1985 an the proportion of MRSA to all Staphylococcus aureus (clinically isolated) wa a proportion fairly close to that of medical centers[8]. However, this proporti up from 33% in 1990 to 70% in 1992, and to 81% in 1994. In the past thre the proportion of MRSA-induced nosocomial infections to all *Staphylococcus* infections in this Hospital was an the average of 70.8%, particularly high nosocomial blood stream infections, and even more in ICU's.

The increase in MRSA-induced respiratory tract, skin, surgical site and blood infections in recent years is probably associated with more invasive proced treatment, more use of high-powered anti-cancer chemotherapy and antibiot

more serious contamination of the environment by MRSA[9]. Furthermore, patients often are hosts with lower resistance or sufferers from latent illnesses, and thus are more prone to MRSA infections. Continuing treatment to improve a patient's resistance may help, although care should be taken to carefully select appropriate and effective antibiotics for the treatment. In addition, infection control measures should be applied to the patients themselves, to medical care personnel and to the environment as well. Measures which can be practiced by hospitals for the surveillance and control of MRSA infections are: careful review of the findings of micro-biological culture of hospitalized patients; isolation of patients with MRSA colonies, with special labeling on medical records; the wearing of gloves by medical care personnel who handle patients, and scrupulous hand-washing after handling any patient's body discharges; isolation of MRSA patients in single rooms and special wards; early discharge of patients requiring no further treatment[10-12]. As MRSA infections are relatively serious in this Hospital, in addition to the above-mentioned measures, medical personnel likely to be exposed to MRSA patients and environment should be given micro-biological cultures. If test results are positive, nasal cavities of carriers should be swabbed with mupirocin[13]. The environment and equipment should also be disinfected, and admission to hospital wards should be strictly monitored. Through these measures, MRSA infections can be brought under control.

Abuse of antibiotics brings about drug resistance. *Staphylococcus aureus* has developed resistance to most antibiotics and drastically so, particularly after 1990. By last year, resistance to the antibiotic oxacillin most commonly used for the treatment of *Staphylococcus aureus* infections had reached 81%. At present, vancomycin is used clinically for the treatment of MRSA infections, since vancomycin, as shown in Table 4, is still 100% effective against *Staphylococcus aureus* infections. With the increase in MRSA infections year by year locally and internationally, the use of vancomycin has also increased, resulting in the early development of resistance to vancomycin by some enterococci and coagulase-negative staphylococci[14,15]. By 1991, US CDC had not yet received reports from hospitals of resistance to vancomycin by *Staphylococcus aureus* cases. No new medicine is yet available for treatment, even in the States, once this situation does occur. Therefore, MRSA infections must be placed under strict surveillance and control; once they have spread in hospitals, it will be difficult to treat them effectively.

5. Conclusion

MRSA infections, either in community or nosocomial situations, bring about serious consequences, and may even raise the infection rate and mortality of hospitalized patients. Literature both abroad and in-country shows that the proportion of MRSA to either the clinically isolated bacteria or pathogenic bacteria of nosocomial infections has increased drastically. Resistance of MRSA to antibiotics has also increased. Therefore, hospitals should set up a surveillance system as soon as possible for the early detection of MRSA infections and for prompt control measures. If MRSA carriers or infected persons can be detected earlier, with adequate control measures taken and treatment given immediately, cross infections between departments of the hospital can be

minimized, and both infection rate and mortality from MRSA can be reduced. departments concerned should also control the use of antibiotics, particularly va Once vancomycin develops resistance to various *Staphylococcus aureus* strains, rate and mortality can be expected to increase. Hospitals and health care give be alert to this fact.

Prepared by: K.S. Lin[1], C.K. Yang[1], Y.W. Chen[1], C.H. Li[2].

1. Nosocomial Infection Control Committee, Tri-Service Hospital
2. Department of Clinical Pathology. Tri-Service General Hc

References:

1. Thompson RL, Cabezudo I, Wenzel RP. Epidemiology of nosocomial caused by methicillin-resistant *Staphylococcus aureus*. Ann Intern Med 1 309-317.
2. Schaberg DR, Culver DH, Gayners RP. Major trends in the microbial et nosocomial infection. Am J Med 1991; 91:[Suppl 3B] 72-75.
3. Springfield VA, National Technical Information Service Distributor. Guid the prevention and control of nosocomial infection. Atlanta, Ga: US De of Health and Human Services, Public Health Service, Centers for Disease 1982, IV.
4. Craven DE, Reed C, Kollisch N, et al. A large outbreak of infections c a strain of *Staphylococcus aureus* resistant to oxacillin and aminoglycosi J Med 1981; 71: 53-58.
5. Saravolatz LD, Pohlod DJ, Arking LM. Community-acquired methicillin *Staphylococcus aureus* infections: a new source for nosocomial outbreaks. A Med 1982; 97: 325-329.
6. Goetz MB, Mulligan ME, Kwok R, et al. Management and epidemiologic of an outbreak due to methicillin-resistant *Staphylococcus aureus*. Am J M 92: 607-614.
7. Panililo AL, Culver DH, Gaynes RP, et al. Methicillin-resistant *Staphy aureus* in US hospitals, 1975-1991. Infect Control Hosp Epidemiol 1 582-586.
8. Ho LJ, Wu HH, Chu ML. Plasmid profiles of methicillin-resistant *Staphy aureus* isolated in Taiwan. Annual Meeting Chin Soc Microbiol 1988, Taip CM-10:16.
9. Bitar CM. Outbreak due to methicillin- and rifampin-resistant *Staphylococcus* epidemiology and eradication of the resistant strain from the hospital. Infect 1987; 8: 15-23.
10. Boyce JM. Should we vigorously try to contain and control methicillin- *Staphylococcus aureus*. Infect Control Hosp Epidemiol 1991; 12: 46-54.
11. Neu HC. The use of mupirocin in controlling methicillin-resistant *Staphy aureus*. Infect Control Hosp Epidemiol 1990; 11: 11-12.
12. Murray-Leisure KA, Geib S, Graceley D, et al. Control of epidemic me resistant *Staphylococcus aureus*. Infect Control Hosp Epidemiol 1990; 11:

13. Cederna JE, Terpenning MS, Ensberg M. et al. *Staphylococcus aureus* nasal colonization in a nursing home: eradication with mupirocin. Infect Control Hosp Epidemiol 1990; 11: 13-16.
14. Schwalbe RS, Stapleton JT, Gilligan PH. Emergence of vancomycin-resistant in coagulase-negative staphylococci. N Eng J Med 1987; 316: 927-928.
15. Goldmann DA. Vancomycin-resistant *Enterococcus faecium*: headline news. Infect Control Hosp Epidemiol 1992; 13: 695-699.