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Correlation between carriers of Methicillin-resistant *Staphylococcus aureus* and the incidence of MRSA surgical site infections in orthopedic surgery patients

M.P. JOHAN[1,2], F. ARDEN[1], M.A. USMAN[1,2], M. SAKTI[1,2], J. ARIFIN[1,2], R. SJAHRIL[3,4], A.M. ILHAMJAYA[3,5], I. PATELLONGI[6], M. MUHAMMAD[7], A. SEWENG[8], N. RAHMANSYAH[1,9], M.A. ABIDIN[1,10], R. ARAFAT[11], A.A. PANGERAN[12]

[1]Department of Orthopedics and Traumatology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[2]Department of Orthopedics and Traumatology, Dr. Wahidin Sudirohusodo General Hospital, Makassar, Indonesia
[3]Department of Microbiology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[4]Microbiology Laboratory, Hasanuddin University Hospital, Makassar, Indonesia
[5]Department of Microbiology, Faculty of Medicine, Alkhairaat University, Palu, Indonesia
[6]Department of Physiology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[7]Department of Pharmacology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[8]Department of Public Health, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[9]Faculty of Medicine, Bosowa University, Makassar, Indonesia
[10]Faculty of Medicine, Muhammadiyah University, Makassar, Indonesia
[11]Faculty of Nursing, Hasanuddin University, Makassar, Indonesia
[12]Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

Abstract. – OBJECTIVE: Surgical site infection (SSI) is a devastating complication in orthopedic surgery. Methicillin-resistant *Staphylococcus aureus* (MRSA) is a notorious organism in SSI, especially in orthopedic patients. We aimed to understand the association between MRSA carriers and the rate of SSI caused by MRSA in orthopedic patients.

PATIENTS AND METHODS: **We prospectively performed a cohort investigation on patients admitted to the Department of Orthopedic between April and August 2023. Samples were taken preoperatively from the nose and post-operatively in surgical wounds. All samples were grown in MeReSa Agar and defined as positive with MRSA characteristics. Data analysis was performed using SPSS Statistics. A significant difference between groups was assessed using either the Chi-square test or Fisher's exact test. Statistical significance was set at $p<0.05$.**

RESULTS: **We obtained 526 nasal swabs of patients, and 140 (26.6%) samples were positive for MRSA. Our study revealed significant associations between MRSA carriers and the following factors: history of recent hospitalization (OR: 1.81; 95% CI: 1.172-2.795; $p=0.007$), smoking history (OR: 1.55; 95% CI: 1.011-2.383; $p=0.044$), and antibiotic exposures (OR: 2.19; 95% CI: 1.305-3.703; $p=0.003$). Our findings showed a significant association between SSI and the following factors: history of antibiotic exposures (OR: 2.89; 95% CI: 1.264-6.566; $p=0.003$), blood loss volume >500 ml (OR: 2.522; 95% CI: 1.245-5.108; $p=0.008$) and contaminated surgical wounds (OR: 5.97; 95% CI: 2.907-12.266; $p=0.001$). Patients with MRSA carriers tended to have an increased risk of having an MRSA SSI with an odds ratio of 3.44 (95% CI: 1.13-10.48; $p=0.047$).**

CONCLUSIONS: **Our study highlights the increased risk of MRSA carriage in patients with a history of smoking, recent hospital admission, or antibiotic exposure. Our reports also identify potential risk factors for SSI, such as previous antibiotic exposure, blood loss, and contaminated wounds. Furthermore, our research establishes an association between MRSA colonization and MRSA SSI, which emphasizes the criticality of decolonization strategies. A further prospective multicenter study is needed to elaborate on our study findings.**

Key Words:
MRSA Carrier, Orthopedic patients, Surgical site infection, MRSA SSI.

Introduction

Surgical site infection (SSI) is a devastating complication in operative procedures that significantly affects the hospital cost, length of stay, and quality of life. SSI is a preventable complication

Corresponding Author: Muhammad Phetrus Johan, MD, Ph.D; e-mail: muhpjo@gmail.com; johanmp@med.unhas.ac.id

that occurs around 10-20% globally, with more cases underestimated in low and middle-income countries Indonesia[1].

Methicillin-resistant *Staphylococcus aureus* (MRSA) is known for its multidrug resistance against beta-lactams, including penicillin and methicillin. MRSA can infect patients without any apparent symptoms, with colonies growing up around the skin, particularly in the anterior part of the nose and inguinal folds. Due to asymptomatic infection, these patients could easily spread the disease to other people. These patients are known as MRSA carriers[2].

In orthopedic SSIs, the primary pathogen found in the culture is MRSA[3]. The higher incidence of MRSA carriers and SSI has also been shown in multiple studies in Southeast Asia, with high variability of MRSA prevalence between these studies (2-80%)[4]. Indonesia, one of the largest countries in Southeast Asia, has scarce data on MRSA carriers and surgical site infections, with the latest publication reporting around an 8% rate of MRSA carriers in one of the largest hospitals in Indonesia[5]. MRSA infection in orthopedic SSI (MRSA SSI) warrants special attention due to the pathogen's ability to produce glycocalyx biofilm, rendering antibiotic penetration almost impossible[6].

Patients and Methods

This is a prospective cohort study performed on all consecutive patients admitted to the orthopedic department between April and August 2023. The inclusion criteria were the following: patients of all ages with planned orthopedic procedures. The exclusion criteria were patients with active surgical site infection and those with preceding orthopedic surgery procedures in the same area within three months. Nasal swabs were taken at either the emergency department upon hospital admission or at the outpatient clinic preoperatively. Informed consent was taken before any sample was obtained. There was no decolonization process on patients performed before surgery. All patients were followed up for at least one month after the procedure in the outpatient clinic to monitor the probable surgical site infection with MRSA. The surgical site sample swab was obtained in the outpatient clinic. During the screening period, several patients underwent several surgeries. Determining each patient's carrier status was counted as a single screening event because these patients were only counted once. The ethical committee of our institution, the University of Hasanuddin Ethics Board, approved this prospective data collection and analysis study.

Assessment of Swab Samples

All samples were obtained preoperatively and transported using Amies transport medium. They were then directly cultured on mannitol salt agar and later subcultured on HiChrome MeReSa Salt Agar (M1674 HiMedia Laboratories Private Limited, India), both incubated at the aerobic condition at 37°C for 24-48 hours. The growth of bluish-green colonies on HiChrome MeReSa Salt Agar plates defined positive samples. Our microbiology analysis complied with Leber's screening guidelines[7].

Patient Characteristics

Orthopedic surgeons obtained data collection for each patient. Primary demographic data were obtained, including gender, age, trauma history, admission status, recent hospitalization, smoking history, diabetes mellitus history, and antibiotic exposure history. Trauma history was classified into two groups (trauma cases and non-trauma cases). Admission status was divided into two groups (outpatient department and emergency department). Recent hospitalization was defined as hospitalization for a fixed period of time within three months prior to admission. Smoking history was classified into active-smoker and non-smoker. An active smoker was defined as a person who had smoked more than 100 cigarettes in their lifetime and was still smoking in the past three months. Antibiotic exposure history was defined as antimicrobial medication within three months preceding the screening examination.

Surgical Site Infection

Surgical site infection (SSI) was defined according to the CDC by the presence of pus, wound dehiscence, or abscess found in the surgical site, along with a positive culture on wound swab within 30 days postoperatively[8]. Aside from demographics, the following data were obtained in patients with surgical site infection, including implantation, surgery location, operation duration, blood loss volume, and surgical wounds. Implantation was classified into patients using orthopedic implants and patients without orthopedic implants. The surgery location was divided into the lower limb, upper limb, and spine. Operation duration was categorized into before 75th percentile (180 minutes) and more than the 75th percentile[9]. Blood loss volume was grouped into less than 500 cc and more than 500 cc. The surgical wound was divided into

three groups (clean incision, minimally contaminated, and severely contaminated). Clean incision was defined as a patient with intact skin without any contamination. A minimally contaminated wound was defined as non-intact skin with minimal contamination (open, fresh, accidental wound, open fracture grade I or II, a wound with suspected infection process without evident pus found intraoperatively). A severely contaminated wound was defined as gross contamination or severe open wound, such as open fractures grade III.

Statistical Analysis

The significance of differences between groups was assessed using either the Chi-square test or the Wilcoxon rank sum test. Fisher's exact test was used when applicable as well. A study was conducted to estimate adjusted odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) *via* multiple logistic regression analysis. Every statistical analysis was conducted utilizing SPSS Statistics (Statistical Package for the Social Sciences, version 25.0; IBM Corp., Armonk, NY, USA). Statistical significance was set at $p<0.05$.

Results

During the investigation, 526 patients were enrolled in total. Of these, 218 (41.4%) were female, while 308 (58.6%) were male. The mean age of the patients was 37.7 years. Following admittance, a total of 231 patients (44%) underwent testing within the ward, whereas 295 (56%) were evaluated in the outpatient department. Ultimately, it was determined that 140 patients were colonized with MRSA, representing a prevalence of 26.6% for nasal MRSA colonization. Of the 140 colonized samples, 69 (49.2%) were collected in the outpatient department, and 71 (50.8%) were collected after admission. The analysis was conducted on specific variables of interest (Table I). The uni-

Table I. Descriptive logistic regression analysis from data obtained at admission (risk factor for MRSA carrier).

Variables	Number of patients n=526	MRSA carrier (+) (140 patients) n (%)	MRSA carrier (-) (386 patients) n (%)	*p*-value	Univariable analysis OR (CI 95%)
Gender					
Male	308 (58.5%)	82 (26.6%)	226 (73.4%)	0.535	0.76 (0.58-0.99)
Female	218 (41.5%)	58 (26.6%)	160 (73.4%)		
Age					
Pediatric (<18 years)	143 (27.2%)	38 (26.5%)	105 (73.5%)		
Adult (18-55 years)	248 (47.1%)	62 (25%)	186 (75%)	0.619	0.97 (0.7-1.2)
Elderly (≥55 years)	135 (25.7%)	40 (29.6%)	95 (70.4%)		
Trauma history					
Trauma cases	148 (28.1%)	44 (29.7%)	104 (70.3%)	0.284	1.25 (0.82-1.92)
Non trauma cases	378 (71.9%)	96 (25.4%)	282 (74.6%)		
Admission status					
Emergency Department	231 (43.9%)	71 (30.7%)	160 (69.3%)	0.058	1.45 (0.98-2.14)
Outpatient Department	295 (56.1%)	69 (23.4%)	226 (76.6%)		
Recent hospitalization					
Yes	122 (23.2%)	44 (31.4%)	78 (68.6%)	0.007*	1.81 (1.172-2.795)
No	404 (76.8%)	96 (20.2%)	308 (79.8%)		
Smoking history					
Active smoker	140 (26.6%)	44 (31.4%)	88 (22.8%)	0.044*	1.55 (1.011-2.383)
Non-smoker	386 (73.4%)	96 (68.6%)	298 (77.2%)		
Diabetes mellitus					
Yes	31 (6.8%)	10 (7.1%)	26 (6.7%)	0.870	1.06 (0.5-2.26)
No	490 (92.2%)	130 (92.9%)	360 (93.3%)		
Antibiotic exposures history					
Yes	70 (13.3%)	29 (41.4%)	41 (58.6%)	0.003*	2.19 (1.305-3.703)
No	456 (86.7%)	111 (24.3%)	345 (75.7%)		

*: $p<0.05$. Methicillin-resistant *Staphylococcus aureus* (MRSA).

variate logistic regression analysis revealed significant associations between MRSA colonization at the time of hospital admission and the following patient characteristics: recent hospitalization, smoking history, and antibiotic exposures. Individuals with a history of recent hospitalization had risks of being MRSA carriers that were 1.81 (95% CI: 1.172-2.795; p=0.007) times greater than those without a history of recent hospitalization. Active smokers had 1.55 (95% CI: 1.011-2.383; p=0.044) times the risk of being an MRSA carrier than non-smokers. Furthermore, an odds ratio of 2.19 (95% CI: 1.305-3.703; p=0.003) revealed that individuals who had recently received antibiotic treatment demonstrated a substantially increased probability of being MRSA carriers. In contrast, no significant correlation was found between MRSA carriage and gender, age, trauma history, admission status, or diabetes mellitus.

Out of 526 patients, we obtained 412 wound samples eligible for follow-up; 239 (58%) were males, and 173 (42%) were females. The average age of the population is 38.2 years. The average time of operation is 180 minutes (range 60-540 minutes). Of the 412 patients in whom we were able to assess SSI, 36 (8.7%) developed infections. Out of all surgical wound samples, 13 (3%) were found to be colonized by MRSA.

Based on types of surgical procedures in our study (Figure 1), the infection rate was 5.6% (1/18) in arthroscopy, 4% (2/50) in arthroplasty, 8.6% (8/93) in spinal surgery, 12.2% (7/57) in oncology surgery, 22.2% (8/36) in soft tissue procedures, 0% (0/93) in internal fixation of closed long bone fracture, 0% (0/26) in implant removal, 35% (7/20) in debridement and 15.7% (3/19) in other surgical procedures (Table II).

Our finding shows that patients with a history of antibiotic exposure had risks of having an SSI that was 2.89 (95% CI: 1.264-6.566; p=0.015) times greater than those without a history of antibiotic exposure. Patients with blood loss volume >500 ml had a 2.522 (95% CI: 1.245-5.108; p=0.008) times the risk of having an SSI than those with blood loss volume <500 ml. Furthermore, those with contaminated surgical wounds tended to have an increased chance of having an SSI, with an odds ratio of 5.97 (95% CI: 2.907-12.266; p=0.001). Meanwhile, we found no significant association between SSI and age, trauma history, admission status, recent hospitalization, smoking history, diabetes status, operation duration, implantation, and surgery location (Table III).

Out of 412 followed-up patients, we found that 108 (26.1%) were MRSA carriers and 304 (73.9%) were non- MRSA carriers. Seven out of 108 (6.5%)

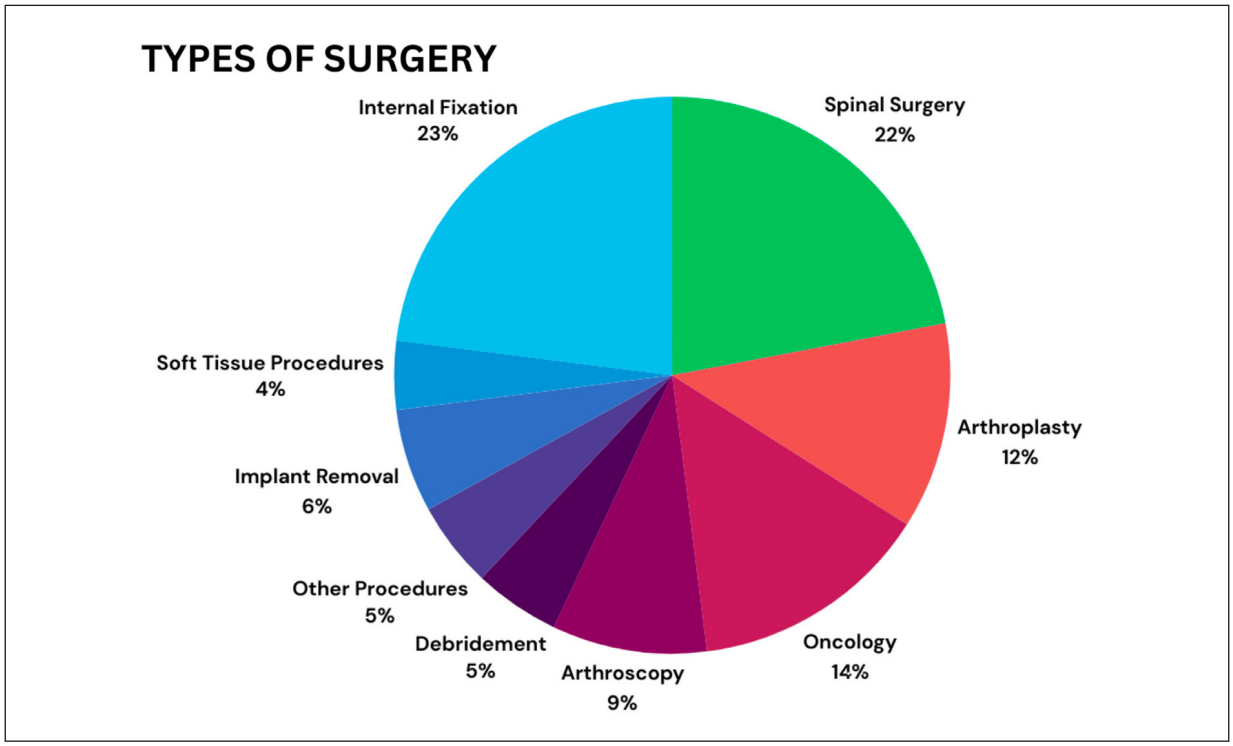

Figure 1. Types of surgery

Table II. Types of surgery related to surgical site infection (SSI).

Variable	Number of patients n=412	SSI (+) n=36 (8.7%)	SSI (-) n=376 (91.3%)
Types of surgical procedure			
Arthroscopy	18	1 (5.6%)	17 (94.6%)
Arthroplasty	50	2 (4%)	48 (96%)
Spinal surgery	93	8 (8.6%)	85 (91.4%)
Oncology	57	7 (12.2%)	50 (87.8%)
Soft tissue procedures	36	8 (22.2%)	28 (77.8%)
Internal fixation	93	0 (0%)	93 (100%)
Implant removal	26	0 (0%)	26 (100%)
Debridement	20	7 (35%)	13 (65%)
Other procedures	19	3 (15.7%)	16 (84.3%)

MRSA carriers developed MRSA SSI, and 6 out of 304 (2%) non-MRSA carriers developed MRSA SSI. Patients with MRSA carriers tended to have an increased risk of having an SSI compared with non-MRSA carriers, with an odds ratio of 3.44 (95% CI: 1.13-10.48; p=0.047) (Table IV).

According to our demographics, 13 patients (3%) developed MRSA SSI, with seven individuals having positive preoperative nasal swabs for MRSA carriers. Five cases formed in the lower extremities, three in the upper extremities, and five in the spine, according to the location. Eight cases were admitted from the outpatient department, and five cases from the emergency room. Six patients did not have implants, whereas seven cases included implants. The majority of cases (12 out of 13) had not taken antibiotics before the operation, which took an average of 170 minutes (range 60-450 minutes) and 258 cc (range 10-750 cc) of blood loss.

Discussion

We found that recent hospitalization has a significant relation with MRSA carriers. Our findings were synergistic with those of other published journals, where the rate of MRSA carriers was higher in patients with recent hospitalizations[10,11]. As shown in the results, a history of antibiotic exposure was a significant risk factor for MRSA carriers and infection. This finding was consistent with many published journals' results that antibiotic exposure was a significant risk factor for MRSA carriers and infection. From our results, smoking was also identified as a significant risk factor. This could be due to decreased immunity in the upper respiratory airway in smokers, which predisposes them to MRSA colonization[12,13].

Our study has a higher incidence of infection than other studies, in which the author reported around 2% of the infection rate in arthroplasty surgery compared to our 4.3%[14]. This raises awareness that arthroplasty, particularly in hip and knee surgery with metal implants, could develop infection due to complex factors between the host, bacterial virulence, prosthesis, and the presence of metallic implants. Even low-level virulence bacteria, such as *Staphylococcus epidermidis* and *Staphylococcus aureus*, could replicate and avoid the host immune system and eventually infect the prosthetic joint along with the tissue surrounding it. This complex of host and bacterial virulence was also mentioned in a study[15] in which it was stated that host factors such as the presence of systemic or local infection elsewhere, previous surgery in the same location, decompensated diabetes malnutrition, obesity (BMI>30), alcohol abuse, drug addiction, chronic renal failure, chronic hepatitis B or C, HIV, immunosuppression, previous prolonged hospitalization or hospitalization in a nursing home, can increase the risk of the development of prosthetic joint infection. A staging system is also applicable in host conditions where systemic host status is graded as A (uncompromised), B (compromised), or C (significant compromise), in which there is a significant correlation between host condition with prosthetic joint infection (PJI) and complication following the PJI. Due to significant morbidities caused by PJI, several organizations have already made preoperative prevention guidelines by optimizing the patient's condition (blood glucose control in diabetic, smoking cessation,

Table III. Descriptive logistic regression analysis of the risk factors associated with surgical site infection.

Variables	Number of patients n=412	SSI (+) (36 patients) n (%)	SSI (–) (36 patients) n (%)	*p*-value	Univariable analysis OR (CI 95%)
Gender					
Male	239 (58%)	18 (7.5%)	221 (92.5%)	0.308	0.71 (0.35-1.39)
Female	173 (42%)	18 (10.4%)	155 (89.6%)		
Age					
Pediatric (<18 years)	111 (26.9%)	8 (7.2%)	103 (92.8%)		
Adult (18-55 years)	192 (46.6%)	23 (12.0%)	169 (88.0%)	0.074	1.23 (0.76-1.99)
Elderly (≥55 years)	110 (26.7%)	5 (4.6%)	105 (95.4%)		
Trauma history					
Trauma (+)	125 (30.3%)	14 (11.2%)	111 (88.8%)	0.165	1.51 (0.75-3.07)
Trauma (–)	287 (69.7%)	22 (7.7%)	265 (92.3%)		
Admission status					
Emergency Department	184 (44.7%)	21 (11.4%)	163 (88.6%)	0.840	1.82 (0.91-3.65)
Outpatient Department	228 (55.3%)	15 (6.6%)	213 (93.4%)		
Referral status					
Referral (+)	102 (24.8%)	12 (11.8%)	90 (88.2%)	0.212	1.58 (0.76-3.3)
Referral (–)	310 (75.2%)	24 (7.7%)	286 (92.3%)		
Smoking history					
Active smoker	100 (24.3%)	10 (10%)	90 (90%)	0.608	1.22 (0.56-2.63)
Non smoker	312 (75.7%)	26 (8.3%)	286 (91.7%)		
Diabetes history					
Diabetes (+)	26 (6.3%)	2 (7.7%)	24 (92.3%)	0.845	0.83 (0.19-3.8)
Diabetes (–)	386 (92.7%)	34 (8.8%)	352 (91.2%)		
Antibiotic					
Exposure (+)	48 (11.7%)	9 (18.8%)	39 (81.3%)	0.015*	2.89 (1.264-6.566)
Exposure (–)	364 (88.3%)	27 (7.4%)	337 (92.6%)		
Blood loss (Vol)					
<500 mL	309 (75%)	21 (6.8%)	288 (93.2)	0.008*	2.522 (1.245-5.108)
>500 ml	103 (25%)	15 (14.6%)	88 (85.4%)		
Operation duration					
<180 minutes	284 (68.9%)	20 (7%)	264 (93%)	0.069	0.53 (0.26-1.06)
≥180 minutes	128 (31.1%)	16 (12.5%)	112 (87.5%)		
Wound status					
Clean	347 (84.2%)	19 (5.5%)	328 (94.5%)		
Mild contaminated	49 (11.9%)	8 (14.3%)	41 (85.7%)	0.001*	5.97 (2.907 -12.266)
Severely contaminated	16 (3.9%)	9 (56.3%)	7 (43.8%)		
Implantation					
(+)	273 (66.3%)	19 (7%)	254 (93%)	0.073	0.53 (0.27-1.06)
(–)	139 (33.7%)	17 (12.2%)	122 (87.8%)		
Location					
Lower limb	216 (52.4%)	23 (10.6%)	193 (89.4%)		
Upper limb	96 (23.3%)	6 (6.3%)	90 (93.8%)	0.348	1.35 (0.86-2.12)
Spine	100 (24.3%)	7 (7%)	93 (93%)		

*: $p<0.05$.

management of other infections in the body area). Other possible preventions were also mentioned, such as decreasing the body flora by bathing using a chlorhexidine bath for 5 days, using the laminar airflow and bodysuits in the operating theatre, using preoperative antibiotics with vancomycin, and using antibiotic-loaded polymethyl methacrylate (PMMA) at prosthesis implantation[16].

Table IV. Univariable analysis of the nasal carrier for MRSA SSI.

Variables	Number of patients n=412	MRSA SSI (+) n (%)	MRSA SSI (–) n (%)	*p*-value	Univariable analysis OR (CI 95%)
Carrier Status					
MRSA carrier (+)	108	7 (6.5%)	101 (93.5.%)	0.047*	3.44 (1.13-10.48)
MRSA carrier (–)	304	6 (2%)	298 (98%)		

MRSA SSI=surgical site infection colonized by MRSA.*: $p<0.05$.

Another study[17] of spinal surgery reported a 0.9% rate of surgical site infection compared to 8.6% in our study. The tropical conditions in Indonesia might contribute to the risk of infection in this study. A study[18] from the Caribbean holds similar results to ours, with a 7.7% infection rate in spinal surgery compared to our 8.6%. A publication[19] also highlighted that surgical site infection rate would be higher in warm weather compared to cold weather due to increased humidity and temperature.

This study also shows a good result on our patient undergoing open reduction with internal fixation (ORIF) for closed fractures and implant removal, with 0% infection rates in both cases. Lower incidence of blood loss ≥500 cc in these two groups (13.9% in the ORIF Group and 0% in the implant removal group, compared to 31.06% incidence in all operative procedures) might have given this positive result in our study. We conclude that patients with internal fixation for closed fractures and implant removal have clean incision sites with less soft tissue trauma compared to other groups, which results in a lower infection rate in the closed fracture with internal fixation group and implant removal group. This finding also correlates with other studies[20] from India that found a lower incidence of infection, with 1.6% in closed fractures treated with ORIF compared to 2.9 in overall orthopedic procedures.

With respect to our findings concerning antibiotic exposure and surgical site infection, our research aligns with a prior publication[11] that identified antibiotic exposure as the sole risk factor for infection. This correlation stems from the likelihood of antibiotic resistance resulting from inappropriate antibiotic indications and the fact that patients with a history of antibiotic exposure had to treat contaminated wounds or had another condition that suggested antibiotic usage prior to the operation, such as a history of urinary tract infection, pneumonia or skin infection. Another study[21] also reports findings that reinforce our conclusions: blood loss also correlates with transfusion and hypotension intraoperatively, thus increasing the SSI risk factor.

Our study discovered that there is no statistically significant risk of surgical site infection (SSI) associated with procedures lasting longer than 180 minutes compared to those lasting less than 180 minutes ($p=0.069$). This contradicts the findings of other studies[14], which found a direct correlation between operation time and surgical site infection rate. This result could potentially be attributed to the reduced operative times for the most severely contaminated wound cases in our study (17 severely contaminated wound operations completed in less than 180 minutes, compared to 4 severely contaminated wounds with operative times exceeding 180 minutes). While the finding in our study is not statistically significant, we acknowledge that an extended operative time may lead to an increased risk of surgical site infection.

An additional significant discovery in our research was that patients with diabetes mellitus did not exhibit any notable distinctions in the development of surgical site infections compared to those without diabetes. This finding contradicts the results of another study[22], which found a significant correlation between hyperglycemia and surgical site infections, with higher blood glucose levels associated with a greater risk of developing such infections. This contradictory result may have been caused by the limited proportion of diabetic patients included in this study (n=31 patients, 6.8%). Current guidelines[23] advise that postoperative glucose levels remain within the range of 180 mg/dL and propose delaying surgery for patients who exhibit inadequate preoperative glycemic control. Compared to conventional protocols (220 mg/dL), intensive protocols with more stringent blood glucose targets (150 mg/dL) have been associated[22,23] with a reduction in SSI cases. However, there are no relevant diabetes control

guidelines for the prevention of postoperative SSI in cases of acute fracture fixation that require immediate operation.

Our results concerning the relationship between carrier status and the incidence of MRSA SSI are consistent with those of other studies[24,25] that have found a significant correlation between MRSA carrier status and MRSA SSI. MRSA colonization in the nostril would have a substantial impact on the likelihood that a patient with an infected MRSA lesion would develop SSI. Additional evidence[26] suggests that the rate of surgical site infections caused by MRSA could be positively impacted by the efficacy of decolonization from MRSA carriers. Consequently, eliminating MRSA colonies from nasal carriers would have a positive effect on the rate of surgical site infections. The World Health Organization[27] recommends 2% Mupirocin for MRSA decolonization; however, a study[26] on Chinese patients demonstrated that povidone-iodine also significantly reduced MRSA colonization[26,28].

Our research is consistent with our previous pilot study[29] on MRSA in Makassar, which yielded comparable results regarding risk factors for MRSA carriers. Specifically, both studies identify recent hospitalization status as a statistically significant factor, as observed in our pilot study and our longer-period cohort study (p=0.007 in this investigation *vs.* p=0.043 in the former analysis). Similar results were observed in this analysis: 140 positive MRSA carriers out of 526 patients (26.6%), compared to 69 positive MRSA carriers out of 184 patients (37.5%) in the pilot study. Consequently, the results of this cohort study regarding the history of recent hospitalization are statistically significant in relation to MRSA risk factors and are comparable to those of our earlier study[29].

To the best of our knowledge, the present study incorporates the greatest number of samples, especially in orthopedic patients in Indonesia (526 samples from nasal biopsies and 412 samples from surgical follow-up). This study is subject to several limitations. Firstly, the incision size and complexity of the surgery performed on our patient have not been considered. Secondly, our patient population is not restricted to individuals with multiple or a single orthopedic injury. Thirdly, obtaining observation for the patient residing far from our hospital was challenging, and the laboratory Hba1c was not utilized to diagnose potential diabetes mellitus, which contributed to the small size of diabetic patients included in this study. As a result of the inherent bias-prone nature of this design, it was ultimately impossible to account for every conceivable lifestyle factor.

Conclusions

Our results underscore the increased susceptibility to MRSA carriage among individuals who have recently been admitted to the hospital, have been exposed to antibiotics, or have a history of smoking. In addition, our reports identify potential SSI risk factors, including a history of prior antibiotic exposure, blood loss, and contaminated wounds. Our research is consistent with previous investigations[26,28] that establish a correlation between MRSA colonization and MRSA SSI, highlighting the importance of decolonization approaches. It is recommended that patients undergoing major surgery who have established risk factors for MRSA carriers use a nasal decolonization protocol consisting of chlorhexidine detergent and mupirocin 2%. We hope this paper contributes to the understanding of MRSA-related risks in orthopedic patients, aiming to pave the way for future investigations and interventions to enhance patient outcomes. A further prospective multicenter study is needed to elaborate on our study findings.

Conflict of Interest

The authors declare that they have no conflict of interest to disclose.

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Authors' Contributions

Conceptualization and design of the study: M.P. Johan, F. Arden, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, I. Patellongi, R. Arafat; acquisition of data: M.P. Johan, F. Arden,

A.M. Ilhamjaya, M. Muhammad, A. Seweng, N. Rahmansyah, M.A. Abidin, A.A. Pangeran; analysis and interpretation of data: M.P. Johan, F. Arden, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, A.M. Ilhamjaya, I. Patellongi, Munawir, A. Seweng, N. Rahmansyah, M.A. Abidin, R. Arafat, A.A. Pangeran; drafting the article or making critical revisions related to relevant intellectual content of the manuscript: M.P. Johan, F. Arden, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, A.M. Ilhamjaya, I. Patellongi, M. Muhammad, A. Seweng, N. Rahmansyah, M.A. Abidin, R. Arafat, A.A. Pangeran; supervision: M.P. Johan, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, I. Patellongi, R. Arafat; validation: M.P. Johan, F. Arden, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, I. Patellongi, R. Arafat; final approval of the version of the article to be published: M.P. Johan, F. Arden, M.A. Usman, M. Sakti, J. Arifin, R. Sjahril, A.M. Ilhamjaya, I. Patellongi, M. Muhammad, A. Seweng, N. Rahmansyah, M.A. Abidin, R. Arafat, A.A. Pangeran. All authors have read and agreed to the published version of the manuscript.

ORCID ID

Muhammad Phetrus Johan: 0000-0002-5567-4710
Ferdinand Arden: 0000-0002-1085-2974
Muhammad Andry Usman: 0000-0002-0287-1737
Muhammad Sakti: 0000-0003-2794-9884
Jainal Arifin: 0009-0004-3458-4574
Rizalinda Sjahril: 0000-0002-4678-9372
Andi Meutiah Ilhamjaya: 0009-0006-9367-5200
Ilhamjaya Patellongi: 0000-0002-1100-4360
Arifin Seweng: 0000-0003-0853-7809
Nur Rahmansyah: 0000-0002-1767-2028
Mohammad Asri Abidin: 0000-0003-2248-5101
Andi Alfiana Pangeran: 0009-0000-8346-3294

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy of patient data; however, they are available from the corresponding author upon reasonable request.

Consent for Publication

Written informed consent was obtained from the patients to publish this paper.

Informed Consent

All subjects provided written informed consent for inclusion before they participated in the study.

Ethics Approval

This study was conducted in accordance with the Declaration of Helsinki of 1975 (as revised in 2013), and the protocol was reviewed and approved by the Institutional Review of the Faculty of Medicine, University of Hasanuddin Ethics Board with number UH23050319.

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