Middle-East Journal of Scientific Research 15 (10): 1440-1449, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.15.10.11588

Clinical and Microbiological Effect of Linezolid on Methicillin-Resistant *Staphylococcus aureus* (MRSA) Colonization in Healthcare Workers in Egypt

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Abstract: Colonization is an important step in the pathogenesis of methicillin-resistant *Staphylococcus aureus* (MRSA) infection. Both patients and healthcare workers (HCWs) colonized by MRSA playing important role in MRSA transmission. Linezolid is the first antibiotic of the oxazolidinones class approved for clinical use by the FDA as a response to the rising incidence of MRSA. Investigation of the clinical (*in vivo)* and microbiological laboratory (*in vitro)* effect of linezolid on nasal and throat colonization with MRSA. A prospective cohort, opened, controlled and randomized study was conducted, where nasal and throat swabs were obtained from the healthcare workers (HCWs) in different hospital departments to investigate for methicillin-resistant *Staphylococcus aureus* (MRSA) carriers. Eligible personnel colonized with MRSA were randomized into linezolid group received (linezolid) 600 mg every 12 hours in form of oral tablet for 10 days. The quantitative assay for minimum inhibitory concentrations (MICs) of linezolid against MRSA was determined by using the Epsilon test (E-test) strips. Overall 134 healthcare workers screened, 43 (32%) were found to be MRSA carriers; 41 (95%) were nasal carriers and 2(5%) were nasal plus throat carriers. The MRSA carriages were found as following; (35.7%) between doctors, (32%) between nursing staff and (27.8%) between cleaning workers. From 30 HCWs received linezolid oral tablet 19 (63.3%) cleared from MRSA colonization while no one in the control group who did not receive linezolid was able to clear MRSA with (P = 0.002). Out of 28 nasal carriers 17 (60.7%) cleared from MRSA colonization and all 2 (100%) nasal plus throat carriers cleared from MRSA without significant difference between both carriers. Linezolid was responsible for nausea (P = 0.04) which was observed only in the first day of starting the treatment and bad taste (P = 0.01). Linezolid showed excellent (100%) *in vitro* activity against MRSA strains before and after treatment and the minimum inhibitory concentrations (MICs) range of linezolid for MRSA isolates obtained from HCWs before treatment was (0.38-2 µg/ml). The decolonization rate of linezolid E-test strips was (100%) compared to (63.3%) for the oral tablet of linezolid, therapy failure was not likely to be due to linezolid resistance, all the HCWs that showed therapy failure 11 (36.7%) were still susceptible for linezolid. The use of linezolid is considered to be promising regarding MRSA eradication. Linezolid is effective in eradication of both nasal and nasal plus throat colonization. Linezolid was well tolerated from HCWs.

Key words: Linezolid · MRSA · Colonization · Healthcare workers · Egypt

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INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been a plague of mankind since the dawn of history, boils which are common *S. aureus* skin infections, are mentioned in the Bible, pathological changes consistent with staphylococcal osteomyelitis are known from Egyptian mummies and other remains of similar antiquity [1, 2].

MRSA is a substantial public health problem worldwide, causing significant morbidity and mortality, longer hospital stays and elevated healthcare costs [3, 4]. MRSA is most often recognized to be a hospital-acquired organism and nosocomial cross-infection occurs frequently [5]. In 2007, a Mediterranean study found that the highest proportions of MRSA were reported by Egypt (52%), Cyprus (55%) and Jordan (56%), in comparison to other Mediterranean countries such as Lebanon (12%), Tunisia (18%), Morocco (19%), Algeria (45%) and Malta (50%) [6].

Healthcare workers (HCWs) are likely to be important in the transmission of MRSA. Eradication of MRSA from HCWs to limit transmission of MRSA in healthcare setting can be accomplished by topical or systemic antimicrobial agents. According to *Albrich WC and Harbarth (2008)* review the prevalence of MRSA in healthcare workers was found to be 6.1% and 15.5% in the Middle East and Africa respectively [7, 8].

Once the β-lactam fails, the mainstay against MRSA infections is the use of parenteral vancomycin has been the standard of therapy for infected patients however, despite the relative efficacy of vancomycin for treating serious MRSA infections its heavy use has led to the emergence of vancomycin intermediately sensitive *S. aureus* (VISA) which have been reported in Europe, Asia and the US in the late 1990s and vancomycin resistant *S. aureus* (VRSA) which have been reported in the US since 2002 [9, 10, 11]. Agents such as teicoplanin and quinupristin-dalfopristin are available in some countries but only in parenteral formulations, which may necessitate prolonged hospitalizations or costly and inconvenient home healthcare arrangements.

Linezolid, in contrast to other anti-MRSA agents, is 100% bioavailable after oral administration [12, 13]. Linezolid is the first antibiotic of the oxazolidinones class; it was developed in the 1990s and approved for clinical use by the FDA in April 2000 as a response to the rising incidence of MRSA which lead to the increased use and emerging resistance to vancomycin [14]. Linezolid has excellent *in vitro* activity against all of the major Gram-positive bacteria such as *Enterococcus faecium (*vancomycin-resistant strains only), *Staphylococcus aureus* (including MRSA), *Streptococcus pneumoniae* (including multi-drug resistant pathogens MDRSP), *Streptococcus agalactiae* and *Streptococcus pyogenes* [15].

So there was a need for reliable and safe oral regimens for those with less serious infections and, in some cases, for the eradication of MRSA colonization in order to reduce the hospital reservoir. Hence, the present work was conducted to investigate the clinical (*in vivo)* and microbiological laboratory (*in vitro)* effect of linezolid on nasal and throat colonization with MRSA between HCWs in an Egyptian educational hospital.

Patient and Method

Hospital Setting: The present work is a prospective cohort, opened, controlled and randomized study. This study was conducted in Misr University for Science and Technology (MUST) educational hospital between (June 2011 and January 2012).

Patient Population: An informed consent and patient profile were obtained from the participants. All HCWs were subjected to complete personal history and medical history. Eligible patients were selected according to the following inclusion and exclusion criteria:

Inclusion Criteria: Healthy healthcare workers, Age 20-50 years and Laboratory findings (e.g. five serial nasal and or throat swabs showing culture growth obtained, gram stain positive cocci, positive coagulase and positive catalase test) consistent with MRSA persistent colonization.

Exclusion Criteria: Hypertension, cardiac diseases, kidney diseases, liver diseases, epilepsy, usage of antidepressants, pregnancy and lactation, usage of other antibiotics 24 hour before the start of the study and cancer patients.

Study Design: Nasal and throat swabs were obtained from 134 healthcare workers (HCWs); physicians, nurses and cleaning workers in different hospital departments; intensive care unit (ICU), coronary care unit (CCU), emergency room (ER), operation room (OR), kidney

dialysis unit, urology clinic, obstetrics/gynecology clinic, dentistry clinic and inpatient hospital wards to investigate for methicillin-resistant *Staphylococcus aureus* (MRSA) carriers. About five nasal and throat swabs were taken from HCWs before the start of hospital shift to make sure they were all persistent carriers. Eligible personnel colonized with MRSA were randomized according to medication intake into two groups;

Group I (Linezolid Group): received Averozolid® (linezolid) 600 mg every 12 hours in form of oral tablet for 10 days. This therapy was accompanied by hygienic instructions for daily life at home (showering after finishing hospital shift, changing bed linen every day washing bed linen, clothes and towels with boiling water) and attention to hospital infection control measures.

Group Ii (Control Group): comprised 10 HCWs did not receive linezolid eradication therap.

The drug has been used in the study is linezolid in the form of Averozolid® 600 mg oral tablets supplied from (Averroes Pharma, Al-Menofya, Egypt).

Clinical Outcome: The clinical outcome of linezolid was defined as:

Effective: Eradication of MRSA (no colonies on a plate of MRSA) from all sites immediately after 10 days of treatment.

Failure: presence of MRSA (colonies on a plate of MRSA) in nose or throat immediately after 10 days of treatment.

Also the adverse effects of linezolid were reported during and after the therapy.

Specimen Collection Methods: Nasal and throat specimens were collected before and after linezolid therapy; nasal specimen collected by swabbing circularly both anterior nares five times and throat specimen collected by repeatedly swabbing the tonsillar arches without touching the sides of the mouth, all specimens were collected by using sterile cotton swabs and were inserted into a transport plastic tube labeled with the subject's name, age, occupation and date of collection then transported within 24 to the lab. Facial mask and new pairs of sterile gloves were worn for each specimen collection to avoid cross contamination.

Microbiological Investigations

Mrsa Isolation and Identification: All nasal and throat swabs specimens were inoculated and streaked on a selective media for detection of methicillin-resistant *Staphylococcus aureus* (MRSA) directly from routine swab samples; oxacillin-resistance screening agar base (ORSAB), obtained from Oxoid Basingstoke, UK [16]. The ORSAB plates were incubated for 24 hours at 37°C, after which the plates were observed for any growth of denim blue coloured colonies characteristic for MRSA growth. All bacteria have grown on the ORSAB plate were considered MRSA. Laboratory procedure for ORSAB preparation and use was according to manufacturer (Oxoid Basingstoke, UK) instruction for use.

Staphylococcus Aureus Confirmation: Gram-positive blue/violet non-motile cocci in tetrads and grape-like clusters, coagulase-positive and catalase-positive indicate *S. aureus* [17].

Antimicrobial Susceptibility Testing: Determination of susceptibility to antibiotics was performed by modified Kirby-Bauer disk diffusion method and results were performed and interpreted according to clinical laboratory standards institute guidelines [18]. The antibiotics discs that has been tested were; cefoxitin (30µg), linezolid (30 µg), vancomycin (30 µg), ticoplanin (30 µg), trimethoprim/sulfamethoxazole (1.25/23.75 µg) and fusidic acid (10 µg). Methicillin-resistance for *Staphylococcus aureus* was confirmed by being resistant to ceforxitin discs. All antibiotics discs were obtained from (Oxoid Basingstoke, UK).

Minimum Inhibitory Concentrations (MICs) of Linezolid: In order to determine the *in vitro* activities of linezolid for MRSA isolated from all HCWs in linezolid group before starting eradication therapy The quantitative assay for minimum inhibitory concentrations (MICs) of linezolid against MRSA was determined by using the Epsilon test (E-test) strips (obtained from Liofilchem, Italy) containing linezolid (range 0.016-256 mg/l) were applied onto the surface of Mueller-Hinton agar, test procedure according to the manufacturer's (Liofilchem, Italy) recommendations included in the package insert.

Resistance to Linezolid: MRSA isolated from HCWs after treatment for those who failed therapy were investigated for linezolid resistance using Epsilon test (E-test) strips.

The MIC =4 µg/ml is considered susceptible to linezolid and MIC = 8 µg/ml is considered resistant [19, 20].

Statistical Analysis: The data were analyzed statistically using SSPS Clementine statistics standard package (V.12, SSPS Inc., USA, 2008). Results were presented as; mean ± standard deviation for description of quantitative continuous variables, numbers and percentages for description of qualitative variables. The following tests were used; Student unpaired t-test for comparison between the mean of independent quantitative parametric data and Chi-Square test to study the association between each two variables or comparison between two groups as regard the categorized data of qualitative variables. All the previously mentioned statistical tests were performed at probability ($P \leq 0.05$).

RESULT

Percentage and Distribution of Mrsa Between HCWs: During the study period (June 2011 to January 2012), 134 healthcare workers were screened for nasal and throat carriage of MRSA, 43 (32%) were found to be MRSA carriers the results is shown in Figure (1).

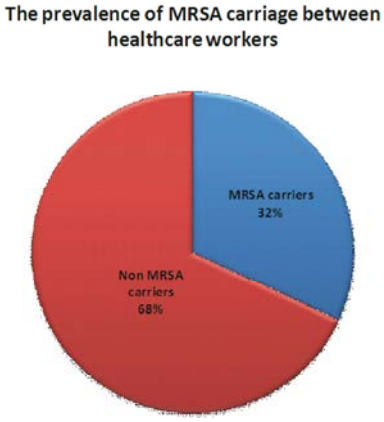

Fig. 1: Pie chart represents the percentage of MRSA carriage
MRSA = Methicillin-resistant *staphylococcus aureus*

The characteristics of the HCWs carriers for MRSA in Table (1) revealed that the anterior nares is the predominant site of MRSA colonization (95%) between HCWs while only (5%) were nasal plus throat carriers, there was a significant relation between MRSA carriage and previous exposure for antibiotics (P<0.0001),

Table 1: The general characteristics of the HCWs screened

Characteristics	MRSA carriers N (%) Total no.= 43	Non MRSA carriers N (%) Total no.= 91	*P* value*
Age (years) mean ± SD	31.1 ± 3.7	32 ± 4	> 0.05**
Sex			
Male	17 (39.5%)	38 (41.8%)	0.9
Female	26 (60.5%)	53 (58.2%)	
Colonization site			
Nasal	41 (95%)	-	-
Nasal plus throat	2 (5%)		
Diabetes mellitus	3 (7%)	6 (6.6%)	0.9
Chronic Sinusitis	6 (14%)	2 (2.2%)	0.02 [a]
Previous antibiotic use (past 1 mo) [a]	13 (30.2%)	68 (74.7%)	< 0.0001
Hospital department			
Operation room	11 (25.6%)	22 (24.1%)	0.06
Inpatient rooms	13 (30.2%)	21 (23%)	
NICU	6 (14%)	5 (5.5%)	
ICU	6 (14%)	9 (10%)	
Cleaning workers	5 (11.6%)	13 (14.3%)	
ER	0 (0%)	6 (6.6%)	
Renal dialysis unit	0 (0%)	6 (6.6%)	
CCU	0 (0%)	4 (4.4%)	
Urology clinic	1 (2.3%)	0 (0%)	
Obstetrics/Gynecology	1 (2.3%)	0 (0%)	
Dentistry clinic	0 (0%)	5 (5.5%)	

CCU=cardiac care unit; ER, emergency room; HCWs, health care workers; HS, highly significant; ICU, intensive care unit; MRSA= methicillin-resistant *Staphylococcus aureus;* NICU, neonatal intensive care unit; NS, non significant; SD, standard deviation.

*Using Chi-Square test.

** Using unpaired student t-test.

[a] Statistically significant (*P*-value).

Table 2: Distribution of MRSA between healthcare workers

Healthcare workers Total no. = 134	Doctors Total no. = 14	Nursing staff Total no.= 102	Cleaning workers Total no.= 18
MRSA colonization N (%)	5 (35.7%)	33 (32%)	5 (27.8%)

MRSA= methicillin-resistant *Staphylococcus aureus.*

Table 3: The characteristics of healthcare workers in linezolid and control group

Characteristics	Linezolid group N (%) Total no.= 30	Control group N (%) Total no.= 10	*P* value*
Age (years) mean± SD	32.1 ± 8	31.5 ± 6.7	> 0.8**
Sex			
Male	13 (43.3%)	4 (40%)	0.8
Female	17 (56.7%)	6 (60%)	
Colonization site			
Nasal	28 (93.3%)	10 (100%)	0.4
Nasal plus throat	2 (6.7%)	0 (0%)	
Prior antibiotics	9 (30%)	4 (40%)	0.8
Diabetes mellitus	2 (6.7%)	1 (10%)	0.7
Chronic Sinusitis	4 (3.3%)	2 (%)	0.6
Hospital department			
Operation room	10 (33.3%)	1 (10%)	0.06
Inpatient	7 (23.3%)	3 (30%)	
NICU	4 (13.3%)	2 (20%)	
ICU	3 (10%)	3 (30%)	
Cleaning workers	4 (13.3%)	1 (10%)	
Urology clinic	1 (3.3%)	0 (0%)	
Obstetrics/Gynecology	1 (3.3%)	0 (0%)	
Physicians	3 (10%)	2 (20%)	0.7
Nurses [a]	23 (76.7)	7 (70%)	
Cleaning workers	4 (13.3%)	1 (10%)	

CCU=cardiac care unit; ER, emergency room; HS, highly significant; ICU, intensive care unit; NICU, neonatal intensive care unit ; NS, non significant; SD, standard deviation.

*Using Chi-Square test.

**Using unpaired student t-test.

[a] Three nurses were excluded (2 pregnant females, 1 epileptic patient).

ciprofloxacin was the only one that showed high statistical significant relation with MRSA colonization (P = 0.02), while there was no relation has been found between penicillin agents, cefotriaxone and erythromycin with MRSA colonization, also there was a relation between chronic sinusitis and MRSA carriage (P = 0.02). There was no statistical significant difference in the age and sex between MRSA and non MRSA carriers. MRSA carriage varied for different hospital departments; 25.6% of colonized HCWs were working in operation room, 30.2% were in inpatient, 14% in neonatal intensive care unit, 14% in intensive care unit, 11.6% cleaning workers, 2.3% in urology clinic and 2.3% in obstetrics and gynecology clinic. While MRSA was absent in emergency room, renal dialysis unit, coronary care unit (CCU) and dentistry clinic. The highest rate of MRSA carriage was found to be: between doctors: (35.7%) than (32%) nursing staff and cleaning workers (27.8%) as shown in Table (2).

Forty eligible HCWs out of 43 MRSA carriers (3 (7%) nurses were excluded two of them were pregnant and one was epileptic patient) were divided randomly into two groups: linezolid group contained 30 HCWs received linezolid eradication therapy and control group contained 10 HCWs did not receive any treatment. Both groups were similar with respect to age, sex, chronic diseases (diabetes mellitus, sinusitis) and prior antibiotic use one month before the study and hospital department that indicate randomization in both groups and neither of these parameters affected the final results as shown in Table (3).

Clinical (In Vivo) Effect of Linezolid: The clinical effect of linezolid as presented in Table (4) showing that; 19/30 (63%) HCWs who received linezolid 600 mg oral tablet every 12 hour for 10 days cleared from MRSA, while no one of HCWs in control group was able to clear from

Table 4: Clinical therapeutic *(in vivo)* effect of linezolid

Effect	Linezolid groupN (%) Total no.= 30	Control group N (%) Total no.= 10	*P* value
Total clearance	19 (63%)	0	0.002*
Still carriers	11 (37%)	10 (100%)	
Nasal clearance Total no.=28	17 (60.7%)	-	0.7
Nasal plus throat clearance Total no.=2	2(100%)	-	

* Statistically significant (p-value) using chi-square test.

Table 5: The MICs of linezolid for MRSA nasal and throat specimens

MIC(µg/ml) of linezolid E-test strips	0.38 (µg/ml)	0.5 (µg/ml)	0.75 (µg/ml)	1 (µg/ml)	1.5 (µg/ml)	2 (µg/ml)
Nasal N (%) Total no. = 30	5 (16.7%)	4 (13.3%)	10 (33.3%)	5 (16.7%)	4 (13.3%)	2 (6.6%)
Throat N (%) Total no. =2	-	-	-	-	2 (100%)	-

MICs= minimum inhibitory concentrations; E-test, epsilon test.

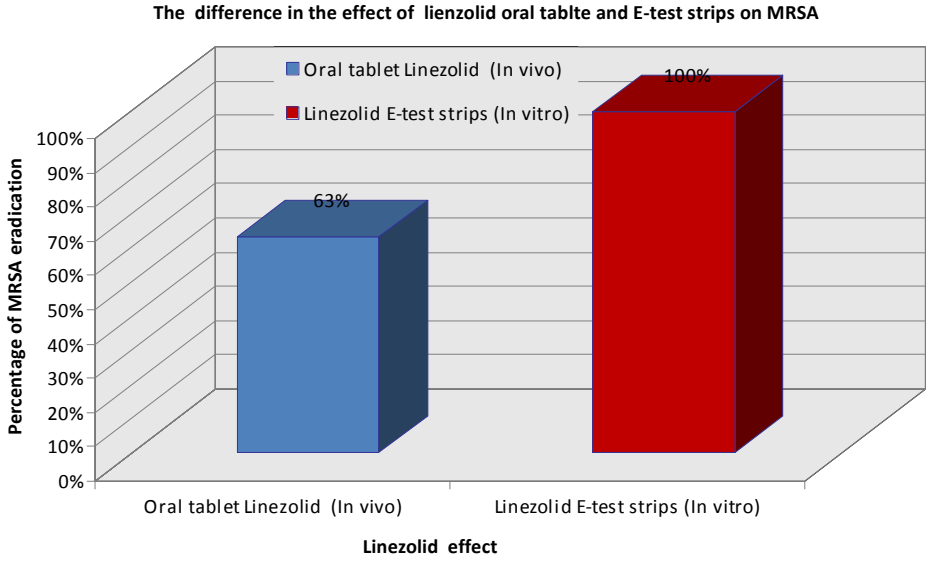

Fig. 2: Bar chart represents the difference in the effect of oral linezolid tablet *(in vivo)* and test strips *(in vitro)* on MRSA

MRSA colonization with ($P = 0.002$). Linezolid was also able to clear nasal MRSA colonization as well as nasal plus throat colonization without presence of statistically significant difference. It was observed that linezolid was responsible for nausea ($P = 0.04$) which was observed only in the first day of starting the treatment and bad taste ($P = 0.01$) between HCWs in linezolid group.

Microbiological Laboratory (In Vitro) Effect of Linezolid Antimicrobial Susceptibility Testing: All (100%) nasal and throat MRSA isolates were sensitive to linezolid and vancomycin, about (7%) of nasal MRSA isolates showed intermediate resistance and (11.6%) of nasal isolate were resistant for ticoplanin, about (62.8%) of nasal isolates and one (50%) of throat isolates were resistant for trimethoprim-sulfamethoxazole, about (74.4%) of nasal isolates and one (50%) of throat isolates were resistant for fusidic acid, all (100%) nasal and throat isolates were resistant for cefoxitin.

Minimum Inhibitory Concentrations Before Linezolid Oral Therapy: All the nasal 30 (100%) and the two throat (100%) isolates were sensitive for linezolid E- test strips. The MIC range of linezolid on MRSA strains was ranged from (0.38-2 µg/ml), MIC_{50}= 0.75 µg/ml, MIC_{90} = 1.5 µg/ml. The results are represented in Table (5).

Resistance to Linezolid: The decolonization rate of linezolid E-test strips (*in vitro*) was (100%) compared to (63.3%) for the oral tablet (*in vivo*) as shown in Figure (2). Out of 30 HCWs who received oral linezolid therapy 11 were still nasal carriers for MRSA so we investigated if they acquired resistance for linezolid after therapy; it was found that all of the 11 isolates were still sensitive for linezolid Table (6).

Table 6: The MICs of linezolid before and after oral therapy on MRSA strains that showed treatment failure

Isolates	MICs before oral linezolid	MICs after oral linezolid
1	2 µg/ml	1.5 µg/ml
2	0.5 µg/ml	1 µg/ml
3	0.75 µg/ml	0.75 µg/ml
4	0.75 µg/ml	1 µg/ml
5	1 µg/ml	1.5 µg/ml
6	1.5 µg/ml	2 µg/ml
7	0.38 µg/ml	0.5 µg/ml
8	1 µg/ml	0.75 µg/ml
9	1.5 µg/ml	2 µg/ml
10	0.75 µg/m	2 µg/ml
11	0.38 µg/ml	0.75µg/ml

MICs= Minimum inhibitory concentrations.

DISCUSSION

Our result showed that linezolid is a promising agent for eradication of methicillin-resistant *Staphylococcus aureus* (MRSA) nasal and throat colonization. It was found that linezolid was able to clear MRSA from nasal and nasal plus throat colonization from 63% HCWs while no one in control group cleared from MRSA colonization. Compared to previous studies used combination of systemic oral therapy; novobicin and rifampin was able to clear MRSA colonization from all body sites; nasal and extranasal in 67% of patients while co-trimoxazole plus rifampin achieved 53% eradication rate [9]. In a study for Muder *et al*. [21] showed that 70% eradication for MRSA colonization in long-term care patients has been achieved with rifampin, 50% with rifampin plus minocycline, while minocyline alone failed in MRSA eradication showed eradication in only 38%. In another investigation oral fusidic acid failed to eradicate MRSA colonization and results in emergence of fusidic acid-resistant strains [22]. The use of topical agents such as mupirocin ointment was effective in MRSA nasal eradication plus chlorhexidine bath lead to a significant decrease in the colonization/infection rate by 52% [23].

In this study it was found that linezolid was effective in elimination of MRSA from throat colonization 2 (100%) as well as from nasal colonization 17 (60.7%). In contrast to other studies where topical eradication therapy was used for eradication of MRSA from nasal and extranasal sites, failed in eradication of MRSA from extranasal sites [24]. While the use of combination of systemic oral therapy such as trimoxazole plus topical fusidic acid succeeded in MRSA eradication by 74% from extranasal sites [8].

In this work we studied the microbiological laboratory (*in vitro)* activity of linezolid using E-test for MRSA and it was found that all the nasal 30 (100%) and throat strains 2 (100%) were sensitive for linezolid test strips, the MIC range of linezolid on MRSA strains was ranged from (0.38-2 µg/ml), MIC50 = 0.75µg/ml, MIC90 = 1.5µg/ml. The results obtained in our study were similar to those described by other investigators, where linezolid also showed excellent *in vitro* activity against MRSA isolates with MIC range lower than obtained in our study (0.023- 0.75µg/ml) [25, 26]. Compared to other agents; rifampin and novobiocin showed excellent *in vitro* activities against MRSA [27]. Also fusidic acid showed 100% eradication of MRSA isolates, while mupirocin was able to eradicate only 60% of MRSA isolates [28].

Therapy failure was not likely to be due to linezolid resistance, we found that the 11 MRSA isolates obtained from HCWs who were still carriers after linezolid treatment were found to be sensitive for linezolid with MIC range (0.5-2 µg/ml). In contrast to another studies 32% of therapy failure was due to emergence of antibiotic resistance [9]. This therapeutic failure may be due to household and environmental contamination [29, 30], colonization of extranasal sites such as perineum, pharynx, rectum, wounds or catheter exit sites and skin [31, 32, 33], comorbidities: cutaneous lesions/conditions [34, 35].

In the current study we found that linezolid was well tolerated by the HCWs who received the treatment, where no one had to be excluded from the study due to linezolid side effects or noncompliance; it was observed that 19 (63.3%) who received experienced nausea, also 15 (50%) HCWs in linezolid group said they experienced bad taste however these side effects were mild and with limited duration, while no one in the control group complaint from bad taste. This finding is agreed with previous studies used linezolid for MRSA treatment [36].

The present study was done in an educational hospital, 134 HCWs were screened; doctors, nurses and cleaning workers in different hospital departments found that MRSA prevalence was (32%) between HCWs, the highest rate of MRSA carriage was found to be between doctors (35.7%) than (32%) nursing staff and cleaning workers (27.8%). In contrast to a study conducted in a tertiary-care hospital in France found an overall MRSA prevalence of (6.2%) in hospital employees. Nursing staff were more likely to test positive than medical staff (9.6% vs 6.3%) [37]. We found a statistically high significant relation between prior use of antibiotics one month before

the study and colonization with MRSA, between the antibiotics previously used, ciprofloxacin was the only one that showed a statistical significant relation with MRSA colonization while there was no relation has been found between penicillin agents, cefotriaxone and erythromycin and MRSA colonization. This result coincided with those reported by previous studies that the risk of acquiring MRSA was increased after exposure to antibiotics, where quinolone exposure considered as independent risk factor for healthcare-associated MRSA bacteraemia [38]. While other studies identified fluoroquinolones, cephalosporins, penicillin agents, carbapenems and macrolides as risk factor for MRSA carriage [39]. There was a relation between HCWs who have sinusitis and MRSA carriage ($P = 0.02$), this finding agreed with previous investigations [40]. In our work out of 43 HCWs showed MRSA colonization, 41 (95%) were nasal carriers only and 2 (5%) were both nasal plus throat carriers while in contrast to other investigations the colonization of the throat was more frequently than that of the nares [41, 42].

CONCLUSION

The present study shows that linezolid is a promising agent for eradication of methicillin-resistant Staphylococcus aureus (MRSA) nasal and throat colonization, however the number of the studied group was small (43 HCWs), thus a larger clinical trials are warranted to address the benefit of linezolid in long-term eradication of MRSA carriage.

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