ORIGINAL ARTICLE

Molecular characteristics and carriage rate of Methicillin-Resistant *Staphylococcus aureus* (MRSA) in pediatric hepatology unit

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ABSTRACT

Background*: Methicillin Resistant Staphylococcus aureus (MRSA) is a serious pathogen in hospitals leading to failure of treatment. MRSA colonization in pediatric patients increases the risk of severe invasive infections, while in the hospital and once they leave.* ***Objectives****: We aimed to study the molecular characters of MRSA and its prevalence among pediatric patients and healthcare workers (HCWs) in National Liver Institute (NLI), also the risk factors and mupirocin efficiency in MRSA decolonization were evaluated.* ***Methodology****: Nasal and hand swab specimens were obtained from patients and HCWs in pediatric department of NLI. MRSA detection was achieved by phenotypic methods such as cefoxitin diffusion test, VITEK2 compact system and chromogenic media, then confirmed by PCR. Susceptibility of S. aureus to different antibiotics was done by VITEK2 compact system. All isolated MRSA were subjected to SCCmec typing by multiplex PCR.* ***Results****: MRSA prevalence among HCWs was 18.9%, and among ward patients, PICU and NICU was 24.2 %, 16.7 % and 36.4 % respectively. Skin infections and less hygiene training were significant risk factors for colonization with MRSA among HCWs. Regarding antibiogram, high resistance rate was detected among MRSA isolates. Sensitivity and specificity of cefoxitin disc diffusion and VITEK2 were 97.8% and 93.3%, while that of CHROM agar was 91.3% and 80%. According to SCCmec typing, the most predominant SCCmec genotypes in the studied subjects was type III followed by type I then type IV, and the least prevalent was type V in both patients and HCWs. So, hospital acquired MRSA (36 /46) was more than community acquired MRSA strains (10/46 samples). When apply intranasal mupirocin ointment 2% regimen, a high successful decolonization rate was achieved.* ***Conclusion****: The most predominant type of SCCmec gene was type III followed by type I, which is linked to hospital acquired strains. Implementation of urgent antibiotic policy and strict infection control programs, in addition to mupirocin decolonization measures will decrease the transmission and spread of these multi drug resistant pathogens.*

INTRODUCTION

Staphylococcus aureus (*S. aureus*) is one of the commonest causes of healthcare and community-acquired infections and it responsible for various diseases, from skin infections to serious life-threatening infections[1]. Methicillin Resistant *Staphylococcus aureus* (MRSA) is a serious pathogen leading to failure of treatment in hospitalized patients [2]. The mec-A gene is responsible for methicillin resistance in MRSA, which encodes low affinity penicillin binding protein (PBP)-2. Detection of MRSA can be achieved by conventional methods as cefoxitin disc diffusion test and automated VITEK 2 system and by molecular detection of mec-A gene by PCR[3]**.** The mecA gene is located on the staphylococcal cassette chromosome mec (SCCmec) island. Till now, we can recognize at least 13 types of SCCmec elements. The SCCmec type I, II, and III are associated with healthcare-acquired MRSA (HA-MRSA) and type IV and type V are distributed in the community-acquired MRSA (CA-MRSA) [1]. Health care workers **(**HCWs) can transmit MRSA via their hands, clothes, or equipment[4]. MRSA colonization in hospitalized children has a great risk for invasive infections, both during hospitalization and once they leave. [5]. Hence, our aim is to study the molecular types of MRSA and its prevalence among HCWs and patients in Pediatric hepatology department, National liver institute and to investigate mupirocin decolonization regimen in HCWs.

METHOEDOLOGY

Study plan and participants

This cross-sectional study was done at National Liver Institute, Menoufia University from May 2020 to

May 2021.The study included 79 members of the medical staff in pediatric hepatology department (21 doctors, 46 nurses, and 12 cleaning workers), and 114 patients in pediatric department of NLI (91 inpatients from wards, 12 patients in PICU and 11 patients in NICU). The study was done after approval of NLI Ethical Committee No:00311/2022 and obtaining an informed written consent from all participants.

Data collection by self-administered questionnaire

Questions included: age, sex, occupation, working in ICU, history of previous MRSA carriage, hospitalization in the last 6 months, history of recurrent skin lesions or history of chronic diseases.

Sample collection and *S. aureus* identification

Two swabs (nasal and hand) were taken from all subjects using sterile disposable cotton swabs. The swabs were transferred to clinical Microbiology and Immunology Department, National Liver Institute within one hour to be processed.

Nasal and hand swabs were cultivated on mannitol salt agar (Oxoid, UK) and blood agar (Oxoid, UK) and incubated at 37◦C for 24 hours. Identification of *S. aureus* was done according to morphological and biochemical tests as catalase, coagulase, DNase, and fermentation of mannitol according to the standard microbiological techniques and confirmed by VITEK 2 compact system [6].

Isolated *S. aureus* were stored in nutrient broth supplemented with 16% glycerol and kept frozen at −80°C.

Antibiotic sensitivity of all isolated *S. aureus* was done by VITEK 2 compact System (Biomeruex, France)[7].

MRSA and MSSA definitions

MRSA were considered when *S. aureus* isolates exhibited a zone diameter ≤ 21 mm against 30µg cefoxitin disc. While, methicillin sensitive *S. aureus* (MSSA) were considered if the zone diameter against cefoxitin disc was ≥ 22 mm [8].

Fig 1: Cefoxitin resistant *S. aureus* (MRSA)

All isolated MRSA were further confirmed by cultivation on CHROMagar™ MRSA plates from CHROMagar (Paris, France), a selective chromogenic media for MRSA identification. The growth of pink colonies on the selective plates after 18 to 28 h incubation at 37°C, was indicative of MRSA [9]

Fig 2: Culture of MRSA on CHROMagar™ MRSA media.

Genotypic confirmation of MRSA

All isolated *S. aureus* with a zone diameter ≤21 mm against 30µg cefoxitin disc were tested for the occurrence of *mecA* gene by conventional PCR.

Table I: Primers specific for detection of *mecA gene* [10] and Sccmec typing [11].

Primers	Sequence (5`-3`)	Product Size(bp)	Region/Sccmec type
mecA gene - Forward primer - Reverse primer	TCCAGATTACAACTTCACCAGG CCACTTCATATCTTGTAACG	162	
β α3	ATTGCCTTGATAATAGCCTTCT TAAAGGCATCAATGCACAAACACT	937	II , IV
ccrCF ccrCR	CGTCTATTACAAGATGTTAAGGATAAT CCTTTATAGACTGGATTATTCAAAATAT	518	III , V
1272F1 1272R1	GCCACTCATAACATATGGAA CATCCGAGTGAAACCCAAA	415	I , IV
5RmecA 5R431	TATACCAAACCCGACAACTAC CGGCTACAGTGATAACATCC	359	V

The amplification of mecA gene was performed via the pre denaturation of the reaction mixture for 3 min at 94°C, then followed by 30 cycles at 94°C for 1 min, 1 min for annealing at 54°C, then the PCR reaction was completed at 72°C for 1 min, and a final elongation for 7 min at 72°C.The the amplified products were visulized by gel electrophoresis using 50 bp ladder [10].

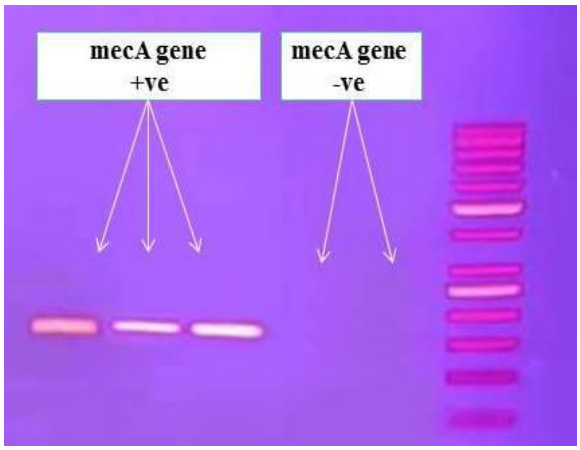

Fig 3: Gel electrophoresis of PCR amplification product of mecA gene among *S. aureus* isolates.

SCCmec typing by multiplex PCR

PCR program was achieved in a thermal cycler to detect the SCCmec type of the isolates. Amplification reaction included denaturation at 94 C for 4 mins, 30 cycles of 94 C for 30s, 55 C for 60 s, 72 C for 60 s, and finally extension at 72 C for 4 mins. The amplified products of SCCmec gene were visualized using gel electrophoresis and 50bp ladder[12].

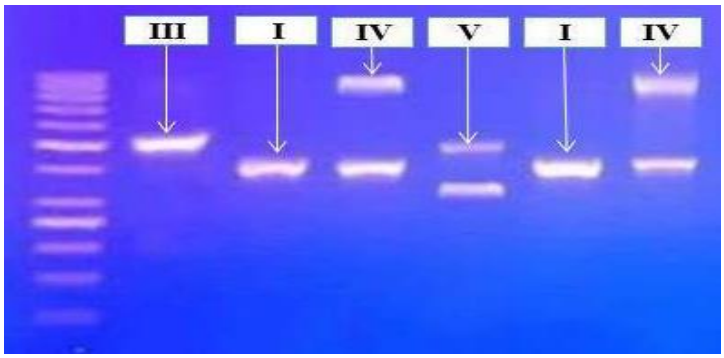

Fig 4: Gel electrophoresis of multiplex PCR amplification products of SCCmec gene typing among MRSA isolates.

Mupirocin eradication regimen

The MRSA colonized HCWs were informed to use intranasal mupirocin ointment (2%) twice daily for one week. Then nasal swabs were taken and subsequently cultured on CHROMagar™ MRSA plates after cessation of treatment and at intervals of 1, 3, and 6 months, to assess the eradication rate and the recolonization. Cure/success outcome achieved when no *S. aureus* (negative culture) was recovered after the end of treatment and during the follow-up [13].

Statistical Analysis

The collected data were tabularized and analyzed by SPSS program (statistical package for the social science software, SPSS Inc. Chicago, IL, USA) statistical package version 20 on an IBM compatible computer.

RESULTS

A total of 79 HCWs (62 female and 17 male) in pediatric hepatology department, NLI, and 114 patients in pediatric department of NLI (91 inpatients from wards, 12 patients in PICU and 11 patients in NICU) were enrolled in our study.

The screening tests identified 19 *S. aureus* isolates among HCWs (24.1%), of which 15 isolates confirmed to be MRSA by PCR (*mecA*-positive). MRSA colonization incidence among HCWs was 18.9%.

S. aureus prevalence among ward patients, NICU and PICU was 33 %, 54.5 % and 25 % respectively and MRSA prevalence among ward patients, NICU and PICU was 24.2 %, 36.4 % and 16.7% respectively**. (table 2).**

Table 2: Demographic data of staphylococcal carriage status of the studied HCWs (No=79) and pediatric patients (No=114).

Item	HCWs (no=79)	Ward patients (no=91)	PICU (no=12)	NICU (no=11)
Gender				
-Males	17(21.5%)	44 (48.4 %)	6 (50 %)	6 (54.5 %)
-Females	62(78.5%)	47 (51.6 %)	6 (50 %)	5 (45.5 %)
Age in years				Age in days
- Mean ±SD	28.5±7.1	5.6±5.7	2.9±4.6	25.5±22.3
-Min-Max	18-54	0.08-17	0.25-17	3-71
***S. aureus* colonization**				
- Nasal	12	21	3	4
- Hand	7	9	0	2
- Total	19 (24.1%)	30 (33%)	3 (25%)	6 (54.5 %)
MRSA prevalence				
-MRSA	15 (18.9%)	22 (24.2 %)	2 (16.7 %)	4 (36.4 %)
-MSSA	4 (5.1%)	8 (8.8 %)	1 (8.3 %)	2 (18.2 %)
-No MRSA	64 (81.1%)	69 (75.8 %)	10 (83.3 %)	7 (63.6 %)

X^2 chi square test, FE fissure exact test

A significant difference was noticed between MRSA and non-MRSA carriers as regard skin lesions and hygiene training ($p<0.05$). Also, MRSA prevalence was higher in nurses than doctors and cleaning workers (no 9 ,3, 3 respectively) and in medical staffs who worked in ICU **(table 3).**

Table 3: Risk factors for MRSA carriage among HCWs

Items	MRSA positive (No=15)		MRSA negative (No=64)		Test of sig. p-value
	No	%	No	%	
Gender					
- Male	2	13.3	15	23.4	**FE= 0.735**
- Female	13	86.7	49	76.6	**P =0.503 (>0.05)**
Age in years					
- Mean SD	27.1±4.9		28.8±7.5		**Mann Whitney =0.382**
- Min-Max	18-35		20-54		**P=0.702 (>0.05)**
profession					
- Doctors	3	20	18	28.1	**X^2= 0.594**
- Nurses	9	60	37	57.8	**P =0.743 (>0.05)**
- Cleaning Workers	3	20	9	14.1	
Previous MRSA carrier					
- Yes	0	0	0	0	**X^2= ---**
- No	15	100	64	100	**P ----**
Working in the ICU					
- Yes	12	80	45	70.3	**FE= 0.568**
- No	3	20	19	29.7	**P =0.342 (>0.05)**
Hygiene training					
- Yes	11	73.3	59	92.2%	**X^2= 4.2793**
- No	4	26.7	5	7.8%	**P=0.038(<0.05)**
Contact with MRSA patients at home					
- Yes	0	0	0	0	**X^2= ---**
- No	15	100	64	100	**P ----**
Recurrent skin lesions					
- -Yes	10	66.7	15	23.4	**FE=10.5**
- -No	5	33.3	49	76.6	**P=0.004*(≤0.05)**
Upper respiratory tract infection					
- Yes	8	53.3	27	42.2	**X2= 0.612**
- No	7	46.7	37	57.8	**P =0.434 (>0.05)**
D.M & other chronic diseases					
- Yes	1	6.7	5	7.8	**FE = 0.023**
- No	14	93.3	59	92.2	**P =0.99 (>0.05)**
Contact with animals					
- Yes	6	40	11	17.2	**FE= 3.7**
- No	9	90	53	82.8	**P =0.079(>0.05)**
Hospitalization for more than 24 hours in the last 6 months					
- Yes	0	0	3	4.7	**FE= 0.731**
- No	15	100	61	95.3	**P =0.618 (>0.05)**
Antibiotic use					
- Yes	5	33.3	14	21.9	**FE= 0.873**
- No	10	66.7	50	78.1	**P =0.350 (>0.05)**

X^2 chi square test, FE fissure exact test

Regarding antimicrobial resistant profile, all isolated MRSA were 100% resistant to oxacillin and benzylpenicillin. The resistance levels to cefoxitin, erythromycin, Moxifloxacin, ciprofloxacin, clindamycin, gentamycin, rifampicin, tetracycline, trimethoprim sulfamethoxazole and teicoplanin were 97.8%, 73.9%, 69.6%, 60.3%, 52.2%, 52.2%, 47.8%, 39.1% 28.3% and 23.9% respectively. Vancomycin resistance was detected in 26.1% (12/46). All isolated MRSA revealed no resistance to linezolid and tigecycline, however 26.1% revealed resistance to vancomycin.

The resistance patterns of MSSA isolates when compared to MRSA resistant pattern, there was highly significant difference regarding resistance to cefoxitin, oxacillin, benzylpenicillin, vancomycin and fusidic acid. **(table 4)**

Table 4: Antibiotic sensitivity and resistance pattern in MRSA (mecA gene positive) versus MSSA isolates (no=61)

Items	MRSA (No=46)		MSSA (No=15)		Test of sig. p-value
	No	%	No	%	
Cefoxitin					
- Resistant	45	97.8	1	6.7	**X2= 50.7**
- Intermediate	0	0	0	0	**P =0.00** (≤0.001)**
- Sensitive	1	2.2	14	93.3	
Benzylpencillin					
- Resistant	46	100	11	73.3	**X2= 13.1**
- Intermediate	0	0	0	0	**P =0.00** (≤0.001)**
- Sensitive	0	0	4	26.7	
Oxacillin					
- Resistant	46	100	0	0	**X2= 61**
- Intermediate	0	0	0	0	**P =0.00** (≤0.001)**
- Sensitive	0	0	15	100	
Gentamycin					
- Resistant	24	52.2	3	20	**X2= 4.8**
- Intermediate	2	4.3	1	6.7	**P =0.93 (>0.05)**
- Sensitive	20	43.5	11	73.3	
Ciprofloxacin					
- Resistant	28	60.9	5	33.3	**X2= 3.5**
- Intermediate	2	4.3	1	6.7	**P =0.177 (>0.05)**
- sensitive	16	34.8	9	60	
Moxifloxacin					
- Resistant	32	69.6	6	40	**X2= 4.2**
- Intermediate	0	0	0	0	**P =0.040* (≤0.05)**
- Sensitive	14	30.4	9	60	
Erythromycin					
- Resistant	34	73.9	4	26.7	**X2= 16.8**
- Intermediate	1	2.2	3	20	**P =0.00** (≤0.001)**
- Sensitive	11	23.9	8	53.3	
Clindamycin					
- Resistant	24	52.2	4	26.6	**X2= 5.4**
- intermediate	0	0	1	6.7	**P =0.066 (>0.05)**
- Sensitive	22	47.8	10	66.7	
Linezolid					
- Resistant	0	0	0	0	**X2= --**
- Intermediate	0	0	0	0	**P =---**
- Sensitive	46	100	15	100	
Teicoplanin					
- Resistant	11	23.9	0	0	**X2= 4.4**
- Intermediate	0	0	0	0	**P =0.036* (≤0.05)**
- Sensitive	35	76.1	15	100	

Items	MRSA (No=46)		MSSA (No=15)		Test of sig. p-value
	No	%	No	%	
Vancomycin					
- Resistant	12	26.1	0	0	**X2= 4.8**
- Intermediate	0	0	0	0	**P =0.027* (≤0.05)**
- Sensitive	34	73.9	15	100	
Tetracycline					
- Resistant	18	39.1	2	13.3	**X2= 3.8**
- Intermediate	1	2.2	1	6.7	**P =0.150 (>0.05)**
- Sensitive	27	58.7	12	80	
Tigecycline					
- Resistant	0	0	0	0	**X2= --**
- Intermediate	0	0	0	0	**P =---**
- Sensitive	46	100	15	100	
Fusidic acid					**X2= 25.3**
- Resistant	43	93.5	5	33.3	**P =0.00** (≤0.001)**
- Intermediate	1	2.2	1	6.7	
- Sensitive	2	4.3	9	60	
Rifampicin					**X2= 5.6**
- Resistant	22	47.8	2	13.3	**P =0.018* (≤0.05)**
- Intermediate	0	0	0	0	
- Sensitive	24	52.2	13	86.7	
Trimethoprim/sulfamethoxazole					
- Resistant	13	28.3	2	13.3	**X2= 1.9**
- Intermediate	1	2.2	1	6.7	**P =0.388 (>0.05)**
- Sensitive	32	69.6	12	80	

Table 5 showed that, among the 61 isolates of ***S. aureus***, 46 were positive for mecA gene by PCR and were regarded as MRSA, while 15 isolates were negative for mecA gene and were regarded as MSSA. Cefoxitin disk method and VITEK 2 system were able to detect 45 out of 46 *mecA*-positive ***S. aureus***; and their sensitivity, specificity, and diagnostic accuracy were 97.8%, 93.3%, and 95.6%, respectively. The chromogenic MRSA agar was able to detect 42 out of 46 *mecA*-positive ***S. aureus***; and its sensitivity, specificity, and diagnostic accuracy were 91.3%, 80%, and 85.7% respectively. **Figure 5.** So cefoxitin disc diffusion and VITEK 2 system have higher diagnostic performance than chromogenic media.

Table 5: Comparison between phenotypic & genotypic methods (PCR as a gold standard) of detection of MRSA.

Phenotypic methods	PCR			Sensitivity	Specificity	PPV	NPV	Accuracy
	+ve (n=46)		-ve (n=15)					
Cefoxitin	+ve	45	1	97.8%	93.3%	97.8%	93.3%	95.6%
	-ve	1	14					
VITEK 2	+ve	45	1	97.8%	93.3%	97.8%	93.3%	95.6%
	-ve	1	14					
Chrome agar	+ve	42	3	91.3%	80.0%	93.3%	75.0%	85.7%
	-ve	4	12					

NPV: Negative predictive value **PPV: Positive predictive value**

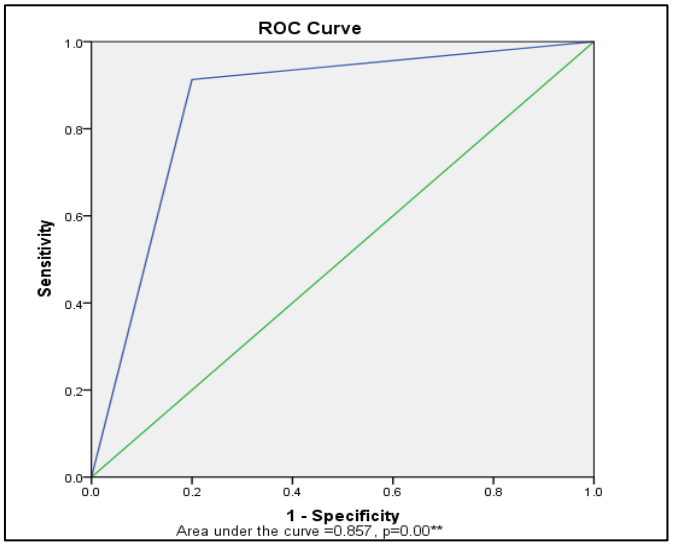

Fig 5: Chrome agar in diagnosis of MRSA in *S. aureus* carriers in relation to PCR.

Table 6 showed the distribution of different SCCmec genotypes among the studied subjects. The most predominant SCCmec genotypes in the studied subjects was type III followed by type I and type IV, and the least prevalent was type V.

Table 6: Distribution of SCCmec genotypes among the studied subjects

Category	Type I (no=13)	Type II (no=6)	Type III (no=17)	Type IV (no=8)	Type V (no=2)	P-value
HCWs						
Physicians	0 (0 %)	1 (16.7 %)	2 (11.8 %)	0 (0 %)	0 (0 %)	
Nurses	2 (15.4 %)	0 (0 %)	4 (23.5 %)	2 (25 %)	1 (50 %)	
Workers	2 (15.4 %)	0 (0 %)	1 (5.9 %)	0 (0 %)	0 (0 %)	
Total no	**5**	1	**7**	**2**	**1**	X^2=27.2 P=0.131
Patients						
Wards	8 (61.5 %)	4 (66.6 %)	9 (52.9 %)	2 (25 %)	1 (50 %)	
PICU	0 (0 %)	1 (16.7 %)	1 (5.9 %)	0 (0 %)	0 (0 %)	
NICU	1 (7.7 %)	0 (0 %)	0 (0 %)	4 (50 %)	0 (0%)	
Total no	**9**	**5**	**10**	**6**	**1**	

SCCmec types I and III were the most detected genotypes in both HCWs and patients, which referred to the hospital acquired source of these MRSA isolates.

When comparing the HCWs and patients regarding distribution of SCCmec genotypes, no significant difference was observed. **(table 7)**

Table 7: Comparison between HCWs & pediatric patients as regard SCCmec genotypes.

Items	HCWs (No=15)		Patients (No=31)		Test of sig. p-value
	No	%	No	%	
SCCmec genotype					
- I	4	26.7	9	29	
- II	1	6.7	5	16.1	X^2= 1.8
- III	7	46.6	10	32.3	P =0.778(>.001)
- IV	2	13.3	6	19.4	
- V	1	6.7	1	3.2	
Source					
- Hospital acquired	12	80	24	77.4	X^2= 0.040
- Community acquired	3	20	7	22.6	P =0.842 (>0.001)

Ten subjects of HCWs with nasal colonization of MRSA applied intranasal mupirocin ointment 2% and followed by culture after one week, one month and six months. Topical mupirocin has a rate of successful decolonization reached 80% after 1 week, 100% after 1 month and 20% showed relapse / recolonization during follow up cultures after 6 months. **(Figure 6)**

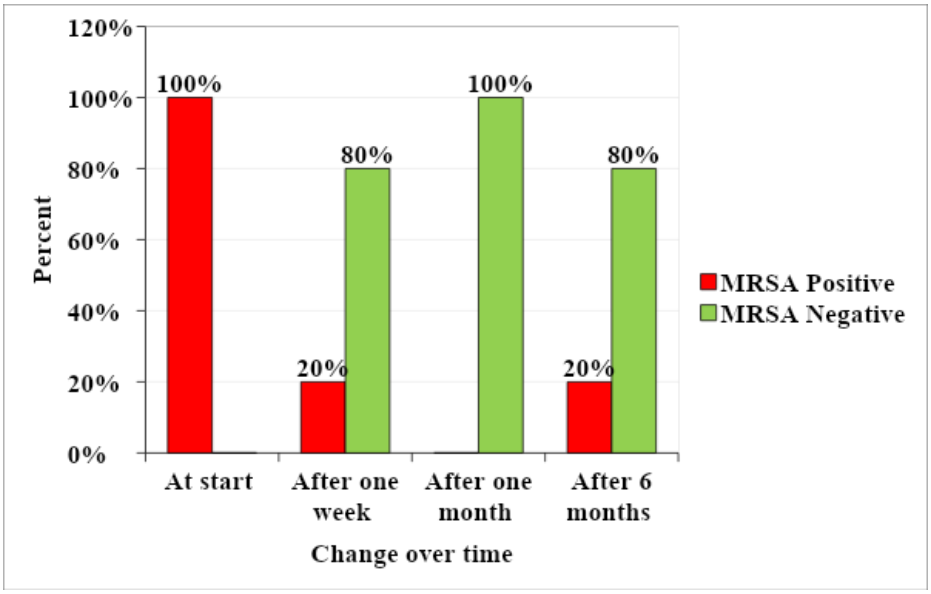

Fig. 6. Evaluation of topical mupirocin as nasal decolonization of MRSA among HCWs (NO=15)

DISCUSSION

HCWs can transmit MRSA as they are situated at the interface between hospital and the community. MRSA spread in the hospitals is usually by contact between patients via hands, clothes or equipment of HCWs [11]. Hospitalized children colonized with MRSA have a great risk for invasive and severe infections[5]. MRSA problem is present all over the world, MRSA prevalence is high in developing countries, is about 16% to 55% in utmost of the African countries. In Egypt, MRSA prevalence ranges from 45% -52% [14].

Thus we aimed to study the molecular characters of MRSA and its prevalence among pediatric patients and healthcare workers (HCWs) in National Liver Institute (NLI), also the risk factors and mupirocin efficiency in MRSA decolonization were evaluated.

The study was conducted over one year from May 2020 to May 2021. The study comprised 193 subjects in pediatric department (79 HCWs and 114 pediatric patients) (120 females and 73 males).

In our study, 79 HCWs were sampled. 19 out of 79 (24.1%) were carried the *S. aureus* and MRSA prevalence among HCWs was 18.9% (15 of 79). Our results were nearly similar to many previous studies. [15, 16, 17] Relatively low carriage rate if compared with *Gomes et al.* [18] and *Elzorkany et al.* [19] who found that frequency was 33%, 37.2% among HCWs and higher than *Baroja et al.* [15] who observed that MRSA carriage rate among HCWs was 5%. These variances in MRSA prevalence may be due to differences in measures of infection control applied in each hospital, frequency of antibiotic use, the method of MRSA detection and its sensitivity, and the characters of the studied population *Jaradat et al.* [20].

In our study, *S. aureus* and MRSA prevalence among patients were 34.2% and 24.6%. These results agreed with *Tuta et al.* [21]] and *Rodrigues et al.* [22] who found that colonization with S. *aureus* was detected in 36.7% and 15.7% of the sick children respectively.

In the current study, *S. aureus* and MRSA prevalence among NICU were 54.5 and 36.4 % respectively. Our result was higher than *Akinboyo et al.* [23] and *Giuffrè et al.* [24] who observed that MRSA prevalence among NICU was 13% and 22.8% respectively.

In this study, *S. aureus* and MRSA prevalence among PICU was 25% and 16.7% respectively. This result was higher than previous USA study. [25]

According to risk factors among HCWs which might predispose to MRSA colonization, there was a significant difference as regard skin lesions and hygiene training. While no significant difference was detected as regard the other factors ($p>0.05$).

This in agreement with Allam et al.[14] who observed no statistically significant relation between of MSSA or

MRSA colonization and either age, sex, years of working and working in ICU. Also similar to *Sassmannshausen et al.* [4] who found that acne was significant factor between MRSA and non MRSA.

The resistance patterns of all detected MRSA to various antibiotics were studied. All detected MRSA were highly resistant to various antibiotics. Resistance to vancomycin was noticed in 26.1% (12/46) of isolated MRSA. However, all isolates were sensitive to linezolid and tigecycline. Our findings agreed with Abbasian et al. [26] who observed nearly similar antibiogram results, in contrary, Lee et al. [27] reported lower resistant rate of MRSA to different antibiotics.

Proper detection of MRSA is essential not only to select the proper antimicrobial agent but also to control its spread. MRSA can be detected by phenotypic methods or PCR. But use of PCR for routine practice is not affordable to laboratories, because of its high cost and greater technical requirement [28]. So, the use of highly sensitive phenotypic method with low cost is very essential. [29]

In our study, a new chromogenic media (CHROMagar™ MRSA), cefoxitin disk diffusion and VITEK 2 were used for detection of MRSA to observe their sensitivity and specificity in relation to PCR (gold standard test).

In the current study, among the 61 isolates of *S. aureus*, 46 (75.4%) were positive for mec- A gene by PCR. Remaining 15 isolates (24.6%) were negative for mec-A gene. This result was in agreement with *Madhavan et al.* [3] who revealed that prevalence of MRSA was 72% and 28% was MSSA. Our results were lower than that was observed by *Deniz et al.*[30] and *Aziz & Hassan,* [31] who revealed that presence of mecA gene in all *S. aureus* was 98%, 89.9% respectively.

This study revealed that, cefoxitin disc diffusion and VITEK 2 system correctly identify 45 out of 46 as MRSA with sensitivity of 97.8%, specificity of 93.3% and accuracy of 95.6%, which in agreement with previous studies. [4, 5, 32] The benefit of VITEK 2 over disc diffusion test is that disc diffusion test requires less incubation time. CHROM agar correctly identify 42 out of 46 as MRSA with 91.3% sensitivity, 80% specificity and 85.7% accuracy, which was lower than that reported by *Madhavan et al.* [3] who showed that chrome agar sensitivity was 100 % and near its specificity which was 78.6% and similar *to Elzorkany et al.* [19] and *Bhoi et al.* [32]

In the present study, SCCmec typing by PCR revealed that the most predominant type (in both patients and HCWs) was type III and I, and the less prevalent types was II and V. So, hospital acquired MRSA (36 out of 46 sample) was more than community acquired MRSA (10 out of 46 samples). Our findings were nearly similar to the results achieved by *Abbasian et al.* [26] and *Rezashateri et al.* [33]. So, we can conclude from this prevalence that the patients we studied might have acquired the infection from the hospital environment and/or HCWs.

According to MRSA decolonization, topical mupirocin ointment 2% had a rate of successful decolonization reached 80% after 1 week, 100% after 1 month, but, 20% showed relapse / recolonization during follow up cultures after 6 months. This in agreement with *Elzorkany et al.*[19] and *Rai et al.* [34] who found nearly similar observations. The appearance of mupirocin resistance due to plasmid-mediated mupA gene and poor patient compliance may lessen the efficiency of mupirocin regimen.[35]

CONCLUSION

Most of the isolated *S. aureus* were MRSA and they were multi- resistant to different antimicrobials. The most common type of SCCmec gene was type III and I followed by type IV, II and V respectively in pediatric department. These findings call for urgent antibiotic policy and strict infection control measures to prevent MRSA spread and transmission. Knowledge of the risk factors of MRSA colonization and its prevalence in HCWs orders continuous surveillance and will aid in reduction of MRSA spread. The phenotypic identification of methicillin resistance has high diagnostic performance in agreement with PCR, in addition they are simple, rapid, sensitive, specific and easy so we can use them in screening of HCWs and patients. Topical mupirocin ointment 2% high successful decolonization rate.

This manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other reviewed media. I have contributed sufficiently to the project to be included as author. To the best of my knowledge, no conflict of interest, financial or others exist. All authors have participated in the concept and design, analysis, and interpretation of data, drafting and revising of the manuscript, and that they have approved the manuscript as submitted.

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