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Prevalence and antimicrobial susceptibility profile of methicillin-resistant *Staphylococcus aureus* among patients in various intensive care units

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The incidence of Methicillin-resistant *Staphylococcus aureus* (MRSA) infection poses significant challenges to epidemiology, infection control, and therapeutic management, particularly within intensive care units (ICUs). This study aimed to monitor MRSA infection rates among patients in various ICUs at Luxor International Hospital (LIH), one of the largest healthcare facilities in Upper Egypt. Mannitol Salt Agar (MSA), Cefoxitin disk (*mecA*-mediated Oxacillin resistance), Oxacillin Resistance Screening Agar Base (ORSAB), and VITEK2 COMPACT system were used for the isolation and identification of the bacterial isolates from various biological specimens. 69.6% of the staphylococcal isolates obtained from ICUs were identified as MRSA strains. Infection rates were 69.8% and 31.2% in males and females, respectively. The isolation rates of MRSA from the collected samples were as follows: blood (77.9%), sputum (11.3%), pus (9.0%), and urine (1.8%). MRSA infection was very prevalent in Moderate intensive care unit (MCU) and Neurological intensive care unit (NECU) compared to other ICUs. Antimicrobial susceptibility testing shows that the isolated MRSA strains are highly sensitive to Tigecycline, Linezolid, Vancomycin, Teicoplanin, and Rifampicin while they are highly resistant to Cefoxitin and Penicillin. Collectively, this study suggests that the prevalence of MRSA infection is high among ICUs patients, particularly MCU and NEICU patients. Findings from this study have important implications for future epidemiology, and infection control studies to develop an effective protocol to manage MRSA infection within settings.

Keywords: Intensive care, antimicrobials susceptibility pattern, Methicillin-resistant *Staphylococcus aureus*, MRSA, Nosocomial infection, ORSAB, VITEK2

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INTRODUCTION

Hospital-acquired infections are a major global concern as they have a significant impact on clinical outcomes in hospitalized patients (Tsalik *et al*., 2016). The inappropriate use and excessive use of antibiotics in medicine have resulted in the emergence of multidrug-resistant bacteria (MDR), which is now considered a major cause of hospital-acquired infection. Apart from the high risk of unfavorable clinical results and mortality, Multidrug-resistant bacterial infections also impose an increased economic burden on patients (Antony and Parija, 2016, Arenz and Wilson, 2016, Sikora and Zahra, 2022). On the other hand, nosocomial infections predominantly caused by multidrug-resistant bacteria are more common in ICUs than in other departments (Vincent *et al*., 1995). Limited or even ineffective treatment options make clinical management of multidrug-resistant bacterial infections particularly difficult (Voidazan *et al*., 2020, Souli *et al*., 2008, Karaiskos and Giamarellou, 2014).

Staphylococcus aureus is a pathogenic bacterium that can colonize mammals and cause a range of diseases, including skin infections and more severe conditions such as endocarditis, osteomyelitis, and severe sepsis. After appearing of semisynthetic penicillin and methicillin antibiotics, methicillin-resistant *Staphylococcus aureus* was reported in 1961(David and Daum, 2010). Prior to the 1990s, Methicillin-resistant Staphylococcus aureus (MRSA) strains are mainly linked to hospitals and patients who had contact with the healthcare industry, thus the term healthcare-associated methicillin-resistant Staphylococcus aureus was coined. These strains were typically resistant to multi antimicrobials and carried large *Staphylococcal* cassette chromosome *mecA* (David *et al*., 2008, Shimizu *et al*., 2022).
Methicillin-resistant *Staphylococcus aureus* (MRSA) is a well-known pathogen causing large numbers of different nosocomial infections each year around the world (Turner *et al*., 2019). MRSA is known as one of the most important causes of hospital-acquired infection outbreaks with morbidity and mortality significant. That is why many national and international infection control guidelines are provided to assist infection control personnel when encountering such an infection (Mizuno *et al*., 2018, Liu *et al*., 2011). Compared to other African countries, southern and eastern Mediterranean countries, the rates of Methicillin-resistant *Staphylococcus aureus* (MRSA) among *S. aureus* which was isolated from health care were highest in Egypt. (Falagas *et al*., 2013, Borg *et al*., 2007)

During the past twenty years, Vancomycin has been the backbone for treating patients with Hospital-acquired MRSA infection (Thati *et al*., 2011). It is conceivable that treatment failure in cases of Methicillin-resistant *Staphylococcus aureus* (MRSA)

infections is mainly attributed to phenotypes with low sensitivity to vancomycin which has called the utility of vancomycin into question (Hiramatsu *et al*., 1997). Tigecycline is a new class of antimicrobial agents known as bacteriostatic glycylcyclines, that has a broad spectrum against Gram-negative and Gram-positive bacteria and has a strong effect against MRSA (Shariati *et al*., 2020). Linezolid is an antibacterial and protein-synthetic agent that shows excellent activity against the biofilms of staphylococci (Butler *et al*., 2013). Although linezolid has an antibacterial effect *in vitro*, some authors have noted that it may act as a bactericidal antibiotic *in vivo*, by inhibiting the production of staphylococcal and streptococcal toxins (De Rosa *et al*., 2018). Linezolid was the first commercially available oxazolidinone licensed by the Food and Drug Administration in 2000 in the United States (Khan *et al*., 2019). Oxazolidinones bind to ribosomal RNA 23S of ribosomal subunit 50S, inhibiting the formation of the ribosome module 70S and the translation initiation phase, which inhibits the protein synthesis of bacteria (De Rosa *et al*., 2018). Clindamycin, a member of the macrolide antibiotics, has emerged as an effective alternative to MRSA infections due to its pharmacokinetic properties, especially for penicillin-allergic patients (Hiramatsu *et al*., 1997, Chavez-Bueno *et al*., 2005). There are different resistance mechanisms that induce macrolide (e.g., Erythromycin) resistance in *Staphylococci*. (1) *erm* gene codes for methylation of the 23S rRNA, which leads to resistance to erythromycin and either inducible or constitutive resistance to clindamycin. (2) *msr*A gene is encoded for an efflux mechanism, which lead to resistance to erythromycin but susceptibility to Clindamycin (Uma Maheswari, 2019), (3) enzymatic inactivation, but only the first two are important in the development of resistance in *Staphylococcus aureus* (Feßler *et al*., 2018).

In this work, we monitored the prevalence rate of Methicillin-resistant *Staphylococcus aureus* (MRSA) infections at the different intensive care units at the Luxor International Hospital (LIH); one of the largest hospitals in Upper Egypt.

MATERIAL AND METHODS

Specimen collection and processing

From January 2018 to December 2018, clinical specimens were collected from different ICUs including Moderate intensive care unit (MCU), Abdominal intensive care unit (ABCU), Neonate intensive care unit (NICU), Isolation intensive care unit (ISICU), Burns intensive care unit (BICU), Neurological intensive care unit (NECU), Cardiac intensive care unit (CCU) and Pediatric intensive care unit (PICU). Samples were collected from different body sources, including blood, sputum, pus, and urine. Collection and handling were conducted according to Egypt's technical guidelines for the prevention and control of hospital-acquired infections caused by multidrug-resistant (MDR) bacteria. All samples were transported to microbiology labs in the hospital for culture and sensitivity tests.

Bacterial isolation

Clinical specimens were inoculated onto blood agar base (Oxoid ™ Ltd, Basingstoke, Hants, UK) with 5% sheep blood was added and Mannitol salt agar (Oxoid ™ Ltd, Basingstoke, Hants, UK) by streaking method. The inoculated plates were incubated at 35 to 37 ° C for 18 to 24 H in aerobic condition. Bacterial colonies showing a typical characteristic of *Staphylococcus aureus* (i.e., beta hemolytic on blood agar and colonies with yellow pigmentation on Mannitol salt agar) were subjected to subculture on to basic media, staining by gram and other biochemical tests catalase and coagulase and confirmed by Vitek2 automated identification (Junkins *et al*., 2009, Miller *et al*., 2018).

Detection of MRSA

Cluster-shaped gram-positive isolates thar are positive for catalase and coagulase reactions were inoculated in Mannitol salt Agar (MSA) and Oxacillin Resistance Screening Agar Base (ORSAB) (Oxoid ™ Ltd, Basingstoke, Hants, UK). The identification of *S. aureus* strains was done through the detection of yellow colonies on mannitol salt agar. ORSAB contains Oxacillin to inhibit Methicillin sensitive *Staphylococcus aureus* and Polymyxin B for the suppression of other bacteria that are able to grow at such a high salt concentration (Ibrahim *et al*., 2020). All inoculated plates were incubated at 35 to 37 °C overnight. Bacterial strains were confirmed by VITEK 2 compact system (BioMerieux SA, USA) (Junkins *et al*., 2009). Methicillin resistant *Staphylococcus aureus* (MRSA) species also detected by *mecA*- mediated Oxacillin resistance by using Cefoxitin disk (30 µg) on Mueller Hinton Agar (MHA) plates after spreading the strain on it as in standard disk diffusion method recommendation and incubated at 35 to 37 ° C for 16 to 18 h. Inhibited zone ≤ 21mm by Cefoxitin disk was interpreted as *mecA* – mediated positive according to Clinical Laboratory Standard Institute guidelines (CLSI, 2018). Cefoxitin disk is used as other marker for

mecA – mediated Oxacillin resistance (Sawhney *et al*., 2022). Also, automated susceptibility testing by VITEK 2 compact system uses Cefoxitin to enhance the detection of Methicillin resistant *Staphylococcus aureus* (MRSA) (Coombs *et al*., 2019).

Antimicrobial susceptibility testing

Kirby Bauer or disc diffusion method is one of the antimicrobial susceptibility tests as per Clinical Laboratory Standard Institute guidelines (CLSI, 2018) was carried out on Muller Hinton agar (Oxoid ™ Ltd, Basingstoke, Hants, UK) by 12 discs for different antimicrobial agents. Suspension from bacterial growth was prepared in 0.5 ml of the same broth medium, and turbidity was adjusted to correspond to that of 0.5 McFarland standard to obtain approximately the organism number of 1.5×10^8 colony forming units (CFU/ml). A sterile swab was dipped into the suspension and the excess of inoculum was removed by pressing it on the side of the tube. Then the swab was applied to the center of Muller Hinton agar plate and evenly spread on the agar or medium. Through 15 minutes, antibiotics disks were placed on Muller Hinton agar seeded with each isolate and were incubated for 24 h at 35-37 °C. The diameter of the zone of inhibition around the disc was measured using a sliding metal caliper. The antibiotics tested in this study included Cefoxitin (FOX) (30µg), penicillin (P) (10µg), Gentamicin (GN) (10µg), Ciprofloxacin (CIP) (5µg), Norfloxacin (NOR)(10µg), Azithromycin (AZM) (15µg), Erythromycin (E) (15µg), Clindamycin (DA) (2µg), Linezolid (LZD) (30µg), Doxycycline (DO) (30µg), Rifampicin (RD) (5µg), Trimethoprim/ Sulfamethoxazole (SXT) (25µg) (Oxoid ™ Ltd, Basingstoke, Hants, UK). Suspension of bacterial growth equivalent to 0.5 McFarland standard was prepared and plated on Muller Hinton agar (Oxoid ™ Ltd, Basingstoke, Hants, UK). Then the media were incubated for 18-24 h at 35-37 °C. The results were confirmed by minimum inhibitory concentration (MIC) method by using VITEK 2 compact system (BioMerieux SA, USA).

RESULTS

Isolation of MRSA

One hundred and twenty-two Staphylococcus spp. isolates were isolated during this study and Eighty-five (69.6%) of them were successfully identified as Methicillin-resistant Staphylococcus aureus (MRSA) strains. The screening for all isolates (n = 85) of Methicillin-resistant Staphylococcus aureus (MRSA) by Mannitol salt agar (MSA) appear 100% growth (yellow colonies and a surrounding by yellow medium) (Figure 1A). In Oxacillin Resistance Screening Agar Base (ORSAB) 100% of typical colonies growth of Methicillin-resistant Staphylococcus aureus (MRSA) are intense blue in color on a colorless background to enable the organism to be more easily identified in mixed colonies or culture (Figure 1B).

Isolation rates of MRSA from different types of ICUs and samples

The rates of MRSA isolation vary significantly among various types of ICUs (Table 1 & Figure 2A). Isolations rates of MRSA were 32.9 %, 18.8 %, 14.1 %, 11.7 %, 11.7 %,4.7 %, 3.5 %, and 2.3 % from MCU, NEICU, ABICU, NICU, ISICU, PICU, BICU, and CCU, respectively (Figure 2A). Interestingly, the isolation rate was very high in males (60.8 %) compared to females (39.2 %) (Figure 2B). Isolation of MRSA was very high in blood samples (77.9 %), compared to Sputum samples (11.3 %), Pus samples (9.0 %), and urine samples (1.8 %) (Figure 2C).

Antimicrobial susceptibility pattern of *S. aureus* MRSA strains

Disk diffusion method

Susceptibility tests for Methicillin-resistant *Staphylococcus aureus* (MRSA) were performed by using disk diffusion method on the Muller Hinton agar plate according to CLSI guideline. All isolated MRSA species are highly resistant to Cefoxitin (Table 2 and Figure 3). This indicates that Penicillin, Cephalosporins, Carbapenems, β-lactam, and β-lactamase inhibitor combination would not be effective in controlling infections of MRSA. On the other hand, 80% of the isolated MRSA strains were sensitive to Linezolid (Oxazolidinones Bs), and Ciprofloxacin (Quinolones). Similarly, Azithromycin and Erythromycin (Macrolides), Clindamycin (Lincosamides Bs), Doxycycline (Tetracyclines Bs) and Trimethoprim/Sulfamethoxazole (Sulfonamides) were effective against 40% of the total MRSA isolates. Gentamycin (Aminoglycosides) and Rifampicin were effective against 30% and 20% of the total isolates, respectively (Table 2). The susceptibility rates of antibiotics showed significant variations, but Ciprofloxacin and Linezolid had higher susceptibility rates compared to other antibiotics (Figure 3).

MIC method

MIC methods by VITEK 2 COMPACT (Table 3) were used to monitor the antibiotic sensitivity of the isolation of MRSA species. Compared to disc diffusion,

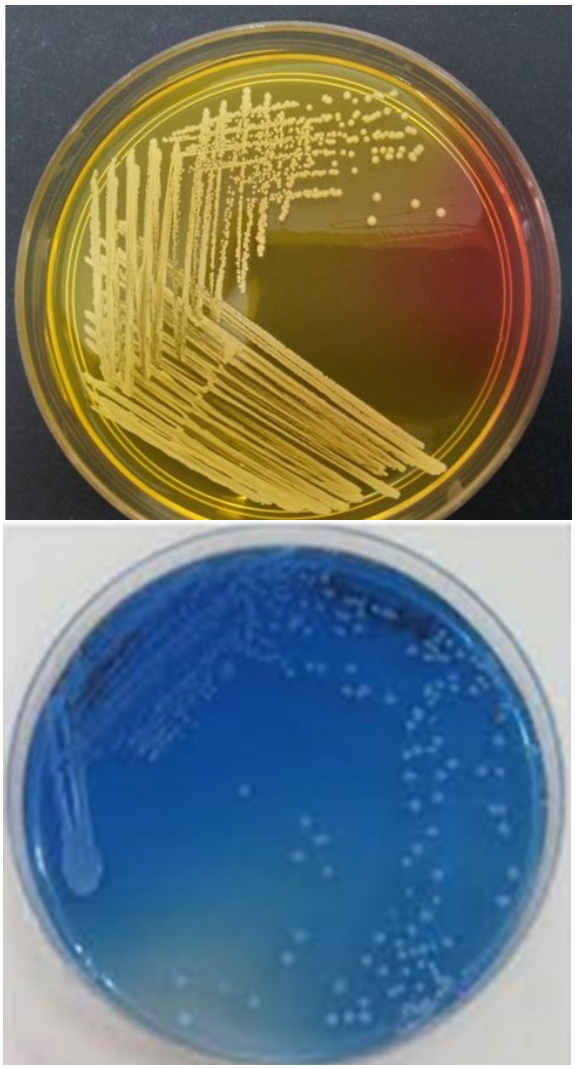

Figure 1. Representative pictures of MRSA isolation and identification. (A) Mannitol Salt Agar (MSA) shows growth. (B) Oxacillin resistant screening Agar Base (ORSAB) shows growth.

Table 1. Isolation rate of MRSA from different types of ICUs and samples.

***Staphylococcus aureus* (MRSA)**			**(*n* = 85)**
		Number of isolates	percentage
Different types of ICU	MCU	28	32.9 %
	NEICU	16	18.8 %
	ABICU	12	14.1%
	NICU	10	11.7 %
	ISICU	10	11.7 %
	PICU	4	4.7 %
	BICU	3	3.5 %
	CCU	2	2.3 %
Type of samples	Blood	65	77.9 %
	Sputum	10	11.3 %
	Urine	2	1.8 %
	Pus	8	9.0 %
Gender	Female	33	39.2 %
	Male	52	60.8 %

MIC methods by VITEK 2 COMPACT system emergence that the isolates of MRSA were more susceptible for Tigecycline by (94.3%), Linezolid by (95.3%), Vancomycin (85.6%), Teicoplanin (83.2%), Rifampicin (83.5%), and less sensitive to the other groups of antibiotics while strongly resistant to Penicillin, Cephalosporins and Carbapenems groups (Table 4).

Inducible Clindamycin Resistance in Staphylococci:

About 40% of MRSA strains showed positive results for inducible Clindamycin resistance and 60% of them have negative results for inducible Clindamycin resistance by VITEK 2 compact system (Table 3).

DISCUSSION

This study aimed to monitor the prevalence and antimicrobial susceptibility profile of Methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from patients in different intensive care units at LIH in Upper Egypt. To isolate and identify MRSA, we used a variety of approaches including VITEK 2, Cefoxitin, and Oxacillin Resistance Screening Agar Base (ORSAB) as previously reported (Boşgelmez-Tinaz *et al*., 2006, Tyasningsih, 2019). Our results revealed a high prevalence rate of *Staphylococcus aureus* (MRSA), at 69.6% among patients in intensive care units. This finding is in consistent with other prospective surveillance studies conducted in Egypt (El Kholy *et al*., 2003, Ahmed *et al*., 2009). Likewise, the occurrence of MRSA observed in our study is comparable to findings reported in studies conducted in other Middle Eastern countries, such as Saudi Arabia (77.5%) (Baddour *et al*., 2006) and in Libya (54–68%) (Ghenghesh *et al*., 2013).

Notably, our study found a significantly higher rate of MRSA prevalence in male patients compared to female patients. This observation is consistent with previous reports from Egypt (Eman S.H. Ibrahim, 2020), Ethiopia (Dilnessa and Bitew, 2016), and other places (Terry Alli *et al*., 2012). Several factors could contribute to this observation, including behavioral and physiological differences between males and females. For instance, gender-related differences in healthcare worker practices, such as hand hygiene behavior, could affect MRSA infection rates and colonization.(Humphreys *et al*., 2015).

Isolation of MRSA significantly varied among patients of different ICUs. MRSA infection was very prevalent in patients of MCU and NEICU compared to other ICUs. This may be attributed to the fact that these two intensive care units (MCU & NEICU) receive the most

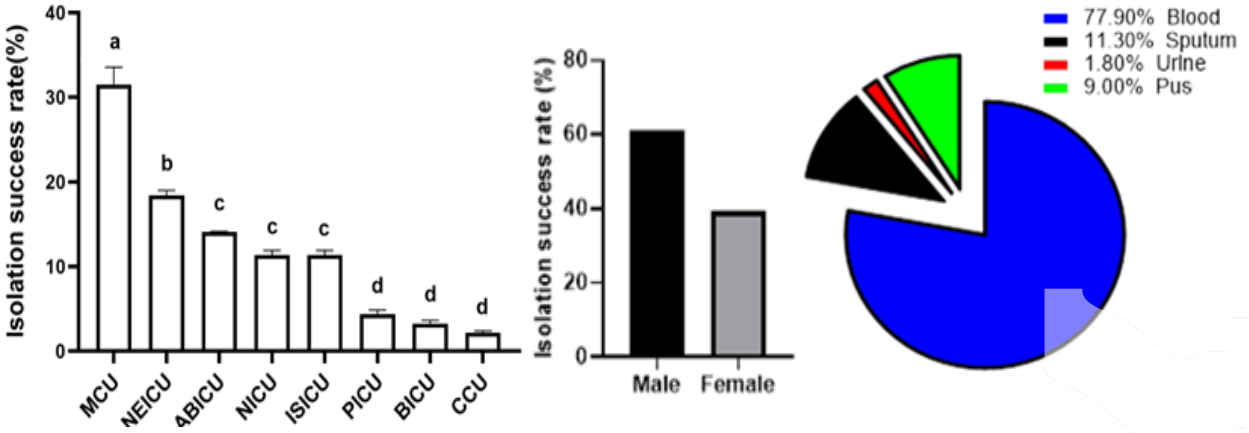

Figure 2: The isolation success rate of MRSA from different ICU's (A), Male and Female (B), and different sample types (C). Columns with different alphabets (panels A) indicate the values to be statistically significant ($p < 0.05$) by Least Significant Difference (LSD).

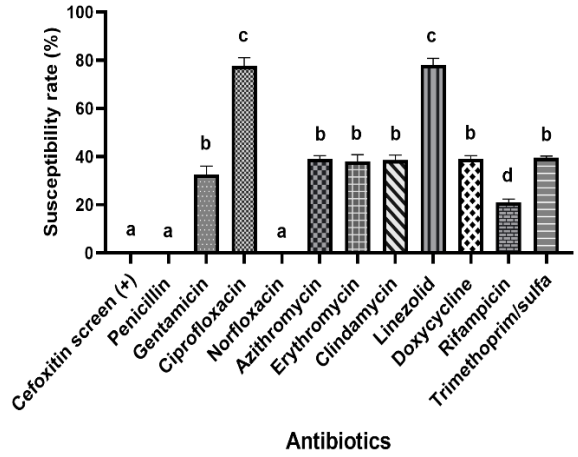

Figure 3. Antibiogram for MRSA by disc diffusion method. Columns with different alphabets indicate the values to be statistically significant ($p < 0.05$) by LSD.

Table 2. Antimicrobial susceptibility pattern of MRSA strains by disc diffusion method.

Antibiotics	MRSA (N= 85)	
	Sensitive N (%)	Resistant N (%)
Cefoxitin screen (+)* (30µg)	0 (0)	85 (100)
Penicillin (P) (10µg)	0 (0)	85 (100)
Gentamicin (GN) (10µg)	25 (30)	60 (70)
Ciprofloxacin (CIP) (5µg)	68 (80)	17 (20)
Norfloxacin (NOR) (10µg)	0 (0)	2 (2.3)
Azithromycin (AZM) (15µg)	34 (40)	51 (60)
Erythromycin (E) (15µg)	34 (40)	51 (60)
Clindamycin (DA) (2µg)	34 (40)	51 (60)
Linezolid (LZD) (30µg)	68 (80)	17 (20)
Doxycycline (Do) (30µg)	34 (40)	51 (60)
Rifampicin (RA) (5µg)	17 (20)	68 (80)
Trimethoprim/sulfamethoxazole (SXT)** (25µg)	34 (40)	51 (60)

*Cefoxitin screen (+) = *S. aureus* MRSA resistant to all Penicillins, Cephalosporins, Carbapenems, β-lactam and β-lactamase inhibitor.
** SXT (25µg) = Trimethoprim/Sulfamethoxazole (1.25/23.75 µg).

serious cases from all hospital departments, and the patient may stay in them for long periods, thus being exposed to many different care devices and different antibiotics doses, and thus a rise in mortality rate. This is in agreement with other previous studies that indicate that other factors such as staying in hospital for a long time and exposure of patient to invasive equipment and presence of other infected or colonized patients in the same area in same time may be exposure to highly antibiotics dose (Graffunder and Venezia, 2002, Gupta *et al*., 2013).

Likewise, the effectiveness of MRSA isolation varies depending on the type of specimen. Blood samples yielded the highest rate of MRSA isolation, followed by sputum, and pus samples. In contrast, MRSA isolation rates from urine samples were notably low. This discrepancy in MRSA isolation rates among different types of specimens has been reported in previous studies (Eman S.H. Ibrahim, 2020, Ahmed *et al*., 2014, Abdel-Maksoud *et al*., 2016) and could be attributed to the fact that a majority of the samples received from intensive care units are related to bacterial infections in the bloodstream, which could explain the higher rate of MRSA isolation from blood samples compared to other types of samples.

The antimicrobial susceptibility test is an important guide for prescribing suitable antibiotics for ICU's patients. The resistance to different types of antibiotics is associated with a long period of hospital staying (hospitalization), high mortality, and increased treatment costs, including a need for alternate medicine (Kim *et al*., 2016). Thus, in our study, a susceptibility test for antibiotics was investigated for all MRSA isolated by using the Kirby Bauer or disk diffusion method and by MIC (VITEK 2).

Table 3. Representative VITEK 2 results of antimicrobial susceptibility pattern for 5 MRSA isolates.

	Staphylococcus aureus (MRSA)									
Bio-number →	050402023761231		050402023763231		070402066763231		010402033763271		070402167763271	
Antimicrobial ↓	MIC	Interpretation	MIC	Interpretation	MIC	Interpretation	MIC	Interpretation	MIC	Interpretation
Cefoxitin Screen	POS	+	POS	+	POS	+	POS	+	POS	+
Benzylpenicillin	>= 0.5	R	>= 0.5	R	>= 0.5	R	>= 0.5	R	>=0.5	R
Oxacillin	>= 4	R	>= 4	R	>= 4	R	>= 4	R	>=4	R
Gentamicin	8	I	>= 16	R	>= 0.5	S	>= 16	R	<=0.5	S
Ciprofloxacin	<= 0.5	S	<= 0.5	S	<= 0.5	S	>= 0.5	S	4	R
Moxifloxacin	<= 0.25	S	<= 0.25	S	<= 0.25	S	<= 0.25	S	2	R
Inducible Clindamycin Resistance	NEG	-	NEG	-	NEG	-	POS	+	POS	+
Erythromycin	<= 0.25	S	<= 0.25	S	<= 0.25	S	>= 8	R	>=8	R
Clindamycin	<=0.25	S	<=0.25	S	<= 0.25	S	<= 0.25	R	<=0.25	R
Linezolid	2	S	2	S	2	S	2	S	2	S
Teicoplanin	<= 0.5	S	<= 0.5	S	1	S	<= 0.5	S	<=0.5	S
Vancomycin	1	S	1	S	1	S	1	S	<=0.5	S
Tetracycline	<=1	S	<=16	R	>= 16	R	>= 16	R	<= 1	S
Tigecycline	<= 0.12	S	<= 0.12	S	<= 0.12	S	<= 0.12	S	<= 12	S
Fusidic acid	8	R	8	R	>= 32	R	8	R	8	R
Rifampicin	<= 0.5	S	<= 0.5	S	<= 0.5	S	<= 0.5	S	<= 0.5	S
Trimethoprim/ Sulfamethoxazole	<= 10	S	<= 10	S	>= 320	R	<= 10	S	160	R
+ = Deduced drug										

Table 4. Antimicrobial susceptibility pattern of MRSA isolates by MIC by VITEK 2 system.

Antibiotics groups	Antibiotics	MIC (µg/ml)	Mean of Sensitive % (n= 85)
Cephalosporins	Cefoxitin	> 8	0
Penicillins	Benzylpenicillin	> 0.5	0
Penicillins	Oxacillin	> 4	0
Aminoglycosides	Gentamicin	<=0.5	23
Quinolones	Ciprofloxacin	<=0.5	64.3
Quinolones	Moxifloxacin	<=0.25	55.7
Macrolides	Erythromycin	<=0.25	41.3
Lincosamides	Clindamycin	<=0.25	44.5
Oxazolidinones	Linezolid	2	95.3
Glycopeptides	Teicoplanin	<=0.5	83.2
Glycopeptides	Vancomycin	<=0.5	85.6
Tetracyclines	Tetracycline	<=1	23.4
Tigecycline	Tigecycline	<=0.12	94.3
Fusidic acid	Fusidic acid	> 8	0
Rifampicin	Rifampicin	<=0.5	83.5
Sulfonamides	Trimethoprim/Sulfa	<=10	62.3

Linezolid (Oxazolidinones Bs) and Tigecyclines were most effective against MRSA at 95.3% and 94.3%, respectively. These results are consistent with another study reported that the effectiveness of Linezolid and Tigecycline against MRSA amount to (99.9%) (Shariati *et al*., 2020). Vancomycin, Teicoplanin, and Rifampicin antibiotics were very efficient at inhibiting the growth of the isolated MRSA. These results are similar to a recent study in Egypt (Metwally and Aamir, 2020).

On the other hand, all MRSA isolates were highly resistant to penicillin and Oxacillin as previously reported in Egypt (Abdel-Maksoud *et al*., 2016), Iran (Saderi H., 2009), and Sudan (Kheder *et al*., 2012). The high rate of resistance can be explained by the response of MRSA species to stress from their persistent exposure to antibiotics used in hospitals and especially in intensive care units (Kheder *et al*., 2012). Interestingly, in this study, MRSA isolated exhibited a low resistance rate to Trimethoprim-sulfamethoxazole and Rifampin. This may be attributed to the limited use of these antibiotics by Egyptian physicians as supported by other studies analyzing the relation between antibiotics used in Egypt. The studies reported that Macrolides, Cephalosporins, and Beta Lactams are the most common specified antibiotics for treating nosocomial infection in Egyptian hospitals (Hassan *et al*., 2011, Kandeel, 2014).

Clindamycin is one of the choices that can be used for treating patients with *Staphylococcus aureus* (MRSA). Our study showed that among the MRSA isolates about (40%) showed inducible Clindamycin resistance, and (60%) from them are constitutive

resistance. Different rates of inducible Clindamycin resistance were reported in other countries including India and USA (Patel *et al*., 2006, Vysakh and Jeya, 2013). So, detection of inducible Clindamycin resistance has a very essential role in clinical labs as it helps to avoid therapeutic failure.

CONCLUSION

This study is the first to monitor the incidence of MRSA infection among ICU's patients in LIH in Upper Egypt area, and it also assessed the susceptibility of isolated MRSA strains to antibiotics. Even though MRSA strains have been successfully isolated from all ICUs, the prevalence of infection was significantly higher in MCU and NEICU patients, especially in male patients. Blood samples were found to be the most reliable specimen type for monitoring the prevalence of MRSA infections among patients in ICUs. Finally, based on the susceptibility patterns of the isolated MRSA strains, this study identified Linezolid, Tigecycline, Rifampicin, Vancomycin, and Teicoplanin to be the most effective antibacterial agents for treating MRSA infections in ICUs,

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This study was approved by Luxor International Hospital in Upper Egypt (03-512LIH-2017)..

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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