The prevalence of icaADBC Genes among Clindamycin Inducible Resistant Staphylococcus aureus Isolates

Abdolmajid Ghasemian, Shahin Najar Peerayeh*, Bita Bakhshi, Mohsen Mirzaee

Department of Bacteriology, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, IR Iran

*Corresponding author: Shahin Najar Peerayeh, Department of Bacteriology, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, IR Iran. Tel: +98-92182883780, E-mail: najarp_s@modares.ac.ir

Submitted: May 29, 2014; Revised: September 25, 2014; Accepted: September 28, 2014

1. Background

Staphylococcus aureus isolates including nosocomial and community associated pathogens colonize on the surface and epithelium of the body (1-3). Clindamycin (as a lincosamide) and erythromycin (as a macrolide) have remained among the few efficient antibacterial drugs against S. aureus strains. Clindamycin has excellent pharmacokinetic properties and can penetrate into various tissues (4). Resistance to these antibiotics has gradually become widespread among the countries (5), due to the differences in the consumption of antibiotics and various regional factors. Clindamycin is a proper antibiotic for the treatment of staphylococcal infections as an alternative after vancomycin (6). Resistance to these antibiotics occurs via methylation of ribosomal drugs target. This alteration is called macrolide-lincosamide-streptogramine (MLSB) resistance (7).

The icaADBC genes play an important role in the biofilm formation among both isolates of S. aureus and S. epidermidis. In this operon, ica genes, icaA encodes the major enzyme essential for PIA synthesis. Likewise, this enzyme might require icaD gene product (called IcaD) for efficient activity (8). Co-expression of icaA with icaD provokes induction of higher enzymatic activity (9). The other genes within ica operon are icaB (polysaccharide deacetylase), icaC (transporter of PIA) and icaR (the inhibitor gene). In a study by Akiyama (2003), all S. aureus strains studied in the skin lesions of impetigo, atopic dermatitis and pemphigus had capability to produce glycopealys and formed microcolonies (10). Most strains of S. aureus contained all four genes of ica operon, however several reports have detected some of these genes (11).

2. Objectives

The aim of this study was to detect the icaADBC genes among S. aureus with inducible resistance to clindamycin.

3. Materials and methods

3.1. Bacterial isolates

A total of 209 S. aureus isolates were collected from various clinical origins of infection in hospitalized patients, including blood, trachea, wound and sputum from July 2012 to January 2013. Biochemical tests were conducted for the identification of the isolates, including mannitol fermentation on Mannitol Salt Agar (MSA) medium, coagulase (including slide and tube) and DNase tests, and colony morphology on blood agar medium.

3.2. Clindamycin inducible resistance

The Double disk/D test was performed on Mueller Hinton Agar medium (similar to disk diffusion test) using clindamycin (2µg) and erythromycin (15µg) antibiotics according to Clinical and Laboratory Standards Institute (CLSI) guidelines (version of 2012).

3.3. Detection of MRSA strains

Oxacillin (1µg) was used in phenotypic test for the detection of MRSA strains with the antibiotic susceptibility test. Moreover, PCR assay was performed to detect meca gene with specific primers, Table 1.

3.4. Extraction of genomic DNA

One or two colony of each bacterial isolate was suspended in 200 µl of TE buffer, and then the enzyme lysostaphin was added (a total of 200 µl of TE buffer and 20 µl of 2 µg/ml lysostaphin). Genomic DNA was isolated as described in the method described by Gey and colleagues (13).

3.5. Polymerase Chain Reaction (PCR)

Simplex PCR was conducted to determine meca gene in MRSA and the icaADBC genes with specific primers, Table 1.
PCR for mecA gene was performed with the mixture of 9.5 µl distilled water (DW), 1 µl primer (100pm), 1.5 µl MgCl2 (50 mM), 3 µl 10x buffer, 2 µl dNTPs (10 mM), 2 µl Taq polymerase (500 U) and 5 µl DNA template. PCR conditions were as 94 °C (5 min), followed by 30 cycles of 94 °C (30 s), 55 °C (30 s), 72 °C (30 s) and then 72 °C for 5 min. PCR for icaADBC genes was performed with mixture of 9.5 µl DW, 1 µl primer, 1.5 µl MgCl2, 3 µl 10x buffer, 2.5 µl dNTPs, 2µl Taq polymerase and 5 µl DNA template. PCR conditions were partially different for these genes. For example for icaADBC genes, 30 cycles were set. For these genes, 94 °C for 5min was conducted and was followed by 94 °C for 1min, except for icaD (30 s). Then the annealing temperature for icaA (55 °C for 1min), icaB (52 °C for 30 s), icaC (55 °C for 30 s) and icaD (55 °C for 30 s) was set up. The extension step of 72 °C included: icaA (1min), icaB (1.5min), icaC (30 s) and icaD (1 min).

### Table 1. Sequence of the icaA, icaB, icaC and icaD primers used in this study.

| Primer | Sequence (5’ to 3’) | Product size (bp) | Reference |
|--------|---------------------|-------------------|-----------|
| mecA   | F: GTG AAG ATA TAC CAA GTG AT | 147 | 12 |
|        | R: ATG GCC TAT AGT TGA AAG GGA | | |
| icaA   | F: ACAGTTGCAGCGCAGCTCAA | 188 | 15 |
|        | R: TCTGGAACCAACATCCAACA | | |
| icaB   | F: AGGATCTGGAAGTATGAAATT | 900 | 15 |
|        | R: TCTAATTTTTC ATGAGTCTG | | |
| icaC   | F: ATGGGAGCGATCTGATGAAAGA | 1100 | 15 |
|        | R: TAATAGAATTTAATGTTCAAT | | |
| icaD   | F: ATGTCAAGCCGACAGACAGAG | 198 | 15 |
|        | R: AGATTTTCAATGTTAAGCCA | | |

#### 3.6. Statistical Analysis

Pearson Chi-Square was used for data analysis using SPSS software version 19. The P-value less than 0.05 were considered as significant.

### 4. Results

#### 4.1. The phenotypic tests

All the isolates with inducible resistance to clindamycin (equal to 8) were susceptible to methicillin (MSSA) (Figure 1). Moreover, all the isolates were susceptible to vancomycin and linezolid. Six isolates (75%) were resistant to amoxicillin. Resistance to tetracycline, ciprofloxacin, gentamicin and trimethoprim-sulfamethoxazole were observed in 4 (50%), 3 (37.5%), 3 (37.5%) and 2 (25%) isolates, respectively.

![Figure 1](image1.png)

**Figure 1.** Clindamycin inducible resistance; the distortion of the susceptibility zone indicates this phenomenon. CD: clindamycin; E: erythromycin.

#### 4.2. The presence of mecA and icaADBC genes

The mecA gene was not detected in clindamycin inducible resistant isolates. Four (50%) isolates contained all the icaADBC genes. The frequency of icaA, icaB, icaC and icaD genes were: 62.5% (n=5), 50% (n=4), 75% (n=6) and 62.5% (n=5), respectively. Among the total of 209 isolates, there was no significant difference between MSSA and MRSA strains regarding the presence of icaADBC genes (P-value = 0.14). Two blood isolates with inducible resistance harbored all icaADBC genes (Fig. 2).

![Figure 2](image2.png)

**Figure 2.** The icaADBC genes. M: DNA size marker; Lanes 1 and 2: positive control for mecA and icaA genes, respectively; lanes 3 and 4 indicate icaA gene (188bp); lanes 5 and 6 indicate icaD gene with 198bp size; lanes 4 and 5 also show icaB (900bp) and icaC (1100bp), respectively.

### 5. Discussion

In our study, eight (4%) isolates had inducible resistance to clindamycin. In our previous survey, we depicted that several previous surveys had reported a variety of results. Morbidity and mortality rates due to a variety of S. aureus infections have been reported continuously from several areas (14). In our previous study, we determined that the majority of the isolates belonged to accessory gene regulator (agr) group I (15), but in inducible resistant isolates agrII was more frequent than agrI. Besides this, we observed no relationship between virulence genes and agr groups. The agr locus in S. aureus isolates, works as a global regulator of virulence genes, including secreted virulence components and surface proteins. We also observed that half of the inducible resistant isolates harbored the whole four icaADBC, showing an inevitable role of this operon in biofilm production. To our knowledge, there is no previous study regarding the presence of these genes in clindamycin inducible resistant strains of S.aureus. However, several surveys have displayed that icaAD genes are present in a majority of isolates of S.aureus; especially when producing biofilm phenotypically (16, 17). Furthermore, most of the previous studies have conducted surveys on the icaAD genes that encode PIA. For instance, Nasra and colleagues (2012) reported that the icaAD genes were present in 32% of blood and catheter isolates (18). In the study by Szveda and colleagues (2012), 36 of 46 Staphylococcal isolates harbored icaA and icaB genes; however, Grinholc and colleagues did not detect icaD, however, all strains contained icaA (19). In the study by Kara Terki and colleagues (2013), the icaAD genes have been detected in 17(38.5%) of the 44 Staphylococcal isolates from urinary tract (20). Moreover, in the present study, two blood isolates with inducible resistance contained all the icaADBC genes, suggesting that more studies are required for the relationship between clinical infections and presence of these genes. It is suggested that
Prevalence of icaADBC in Staphylococcus aureus

several factors, such as epidemiological aspects, the strains and origins should be included in studies on the frequency of icaADBC genes.

6. Conclusion
In this study, half of the isolates with inducible resistance to clindamycin harbored all the icaADBC genes, suggesting that the presence of these genes is important for biofilm production.

Conflict of Interests
The authors declare they have no conflict of interests.

Acknowledgments
The authors appreciate the help of Staff of Loghman Hospital of Tehran and their contribution for the collection of clinical isolates

Authors’ Contributions
Abdolmajid Ghasemian performed the laboratory work. Dr. Shahin Najer Peerayeh guided the process, Dr. Bita Bakhshi advised the study. Mohsen Mirzaee helped the laboratory work.

Funding/Support
This study was supported by Faculty of Medical Sciences, Tarbiat Modares University.

References
1. Tarek Z, Bochra K, Hanene M, Mahdouani K, Bakhrouf A, Amina B. A micro titer plate assay for Staphylococcus aureus biofilm quantification at various pH levels and hydrogen peroxide supplementation. New Microbiol. 2010; 33(2):137-45.
2. Christopher W, Christine G, Christiane W. Staphylococcus aureus determinants for nasal colonisation. Trends in Microbiol. 2012; 20(5):243-50.
3. Ajao AO, Harris AD, Roghmann MC, Johnson JK, Zhan M, Mc Gregor JC. Systematic review of measurement and adjustment for colonization pressure in studies of methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, and clostridium difficile acquisition. Infect Control Hosp Epidemiol. 2011; 32(5):481-9
4. Dardi CK, Khare AS. Inducible clindamycin resistance in Staphylococcus aureus in a tertiary care rural hospital. Indian J Basic Appl Med Res. 2013; 7(2):686-93.
5. Mohammad A. Incidence of macrolide-lincosamide-streptogramin-B resistance phenotypes of methicillin resistance Staphylococcus aureus and methicillin sensitive Staphylococcus aureus among animals in Saudi Arabia. Res J Microbiol. 2012; 7(5):256-62.
6. James SL, James HJ. Inducible clindamycin resistance in staphylococci. Should clinicians and microbiologists be concerned? Antimicrob resist. 2005; 40(2):280-5.
7. Cetin ES, Gunes H, Kaya S, Aridogan BC, Demirci M. Macrolide-lincosamide-streptogramin B resistance phenotypes in clinical Staphylococcal isolates. Int J Antimicrob Agents. 2008; 31(4):364-8.
8. Gerke C, Kraft A, Sittsoum R, Schweitzer O, Goes F. Characterization of the N-acetylglucosaminyltransferase activity involved in the biosynthesis of the Staphylococcus epidermidis polysaccharide intercellular adhesion. J Biol Chem. 1998; 273(29):18586-93.
9. Liberto MC, Matra G, Quirino A, Lamberti AG, Capicotto R, Paccio R, et al. Phenotypic and genotypic evaluation of slime production by conventional and molecular microbiological techniques. Microbiol Res. 2009;164(5):522-8.
10. Akiyama H. Confocal laser scanning microscopic observation of glycocalyx production by Staphylococcus aureus in skin lesions of bullous impetigo, atopic dermatitis and pemphigus foliaceus. Br J Dermatol. 2003; 148(3):326-32.
11. Eltekhah F, Daidea T. Biofilm formation and detection of icaAB genes in clinical isolates of methicillin resistant Staphylococcus aureus. Iran J Basic Med Sci. 2011; 14(2):132-6.
12. Zhang K, Sparling, J, Chow B, Elsayed S, Hussain Z, Church DL, et al. New quadruplex PCR assay for detection of methicillin and mupirocin resistance and simultaneous discrimination of Staphylococcus aureus from Coagulase-negative staphylococci. J Clin Microbiol. 2004; 42(11): 4957-55.
13. Gey A, Werckenthiin C, Poppert S, Straubinger RK. Identification of pathogens in mastitis milk samples with fluorescence in situ hybridization. J Vet Diagn Invest. 2013; 25(3):386-94.
14. Faghir J, Shabazzadeh D, Pooshang Bagheri K, Moghim S, Ghaseimian Safaei H, Nast Eslahani B, et al. Two Dimensional Structural Analysis and Expression of a New Staphylococcus aureus Adhesin Based Fusion Protein. Iran J Basic Med Sci. 2012; 15(2):725-38.
15. Ghasemian A, Najer Peerayeh Sh, Bakhshi B, Mirzae M. Accessory Gene Regulator Specificity Groups Among Staphylococcus aureus Isolated From Hospitalized Children. Arch Pediatr Infect Dis. 2014; 2(2):e16096.
16. Atshah SS, Nor Shamsudin M, Leslie SZ, Lung TT, Karunanidhi A, Alheshidi MA, et al. Prevalence of adhesion and regulation of biofilm-related genes in different clones of Staphylococcus aureus. J Biomed Biotechnol. 2012; 2012:976972.
17. Mirzaee M, Najer Peerayeh Sh, Ghaseimian A. Detection of icaABCD Genes and Biofilm Formation in Clinical Isolates of Methicillin Resistant Staphylococcus aureus. Iran J Pathol. 2014; 9(4):257-262.
18. Nasra RA, AbulShadyb HM, Hussein SH. Biofilm formation and presence of icaAD gene in clinical isolates of staphylococci. The Egypt J Med Hum Gen. 2012; 13(3):269-74.
19. Skreseda P, Schielmann M, Milewski S, Frankowska A, Jakabczak A. Biofilm Production and Presence of ica and hap genes in Staphylococcus aureus strains isolated from cows with mastitis in the eastern Poland. Polish J Microbiol. 2012; 61(1):65-9.
20. Kara Terki J, Hassaine H, Oufid S, Bellifa S, Mhamedi I, Lachachi M, et al. Detection of icaA and icaD genes and biofilm formation in Staphylococcus spp isolated from urinary catheters at the University Hospital of Tlemcen (Algeria). Afr J Microbiol Res. 2013; 7(47):5350-7.

How to cite this article: Ghasemian A, Najer Peerayeh Sh, Bakhshi B, Mirzae M. The prevalence of icaADBC Genes among Clindamycin Inducible Resistant Staphylococcus aureus Isolates. Infection Epidemiology and Medicine. 2016; 2(1): 15-17.