Evaluation of the BBL Crystal MRSA ID System for detection of oxacillin resistance in Staphylococcus aureus

Günther Kampf, Christoph Lecke, Ann-Katrin Cimbal, Klaus Weist, Henning Rüden

Abstract
Aims—To evaluate the BBL® Crystal™ MRSA ID System for detection of oxacillin resistance in Staphylococcus aureus.

Methods—52 methicillin resistant S aureus (MRSA) from five different countries and 85 methicillin susceptible S aureus (MSSA) were included. The species was confirmed by tube coagulation and detection of the clumping factor using the Staphaurex Plus. Clonal non-identity of the MRSA isolates was shown by pulsed field gel electrophoresis. MIC values (oxacillin) were determined using the Etest. Polymerase chain reaction was carried out to detect the mecA gene. The BBL Crystal MRSA ID System was carried out according to the manufacturer’s instructions.

Results—The BBL Crystal MRSA ID System showed fluorescence in 45 of 52 MRSA (sensitivity 86.5%; negative predictive value 92.2%), and the specificity was 97.6% (positive predictive value 95.7%). Two of seven MRSA that failed to show fluorescence had MIC values (oxacillin) of 4 mg/litre.

Conclusions—The BBL Crystal MRSA ID System is a valuable test for detecting oxacillin resistance in S aureus. Its major advantage is the short time (4–5 hours) required to perform the test when organisms are grown on tryptic soy agar or sheep blood agar. Difficulties may arise in borderline resistant isolates.

Keywords: oxacillin resistance; Staphylococcus aureus; screening; BBL Crystal MRSA ID system

Methicillin resistant Staphylococcus aureus (MRSA) continues to be a prominent problem in hospitals in the USA and Europe. Rapid identification is essential to limit the spread within a hospital. Conventional methods to detect resistance to oxacillin such as disc diffusion or agar dilution require up to 24 hours of incubation, depending on the guideline. In addition, they may fail to detect oxacillin resistance when phenotypic expression of an isolate is heterogeneous. Detection of the mecA gene by polymerase chain reaction (PCR) is regarded as the reference method, but it requires special equipment which is not yet available in most routine medical microbiology laboratories. The BBL® Crystal™ MRSA ID System has been designed to allow detection of oxacillin resistance in S aureus within four to five hours when organisms are cultured on tryptic soy agar or sheep blood agar, allowing earlier treatment and more rapid implementation of infection control measures. In this study we evaluated the system using 52 non-identical MRSA isolates from five countries and 85 methicillin susceptible S aureus (MSSA) isolates.
of Sperber and Tatini. Any isolate with a positive agglutination reaction and a coagulation reaction $\geq 1$ was regarded as S. aureus. Six isolates without agglutination or visible plasma coagulation were excluded from further analyses.

**POLYMERASE CHAIN REACTION FOR DETECTION OF THE mecA GENE**

All isolates were investigated for the presence of the mecA gene (PCR product, 533 bp) by PCR. The amplification was carried out with the following primers which are highly specific:

- $\text{mecA}_1$: 5’-AAA ATC GAT GGT AAA GGT TGG C;
- $\text{mecA}_2$: 5’-AGT TCT GCA GTA CCG GAT TTG C.

The cycle for mecA gene determination was 94°C for one minute; 60°C for 30 seconds; 72°C for 30 seconds; 29 cycles at 94°C for 30 seconds, 60°C for 30 seconds, and 72°C for 30 seconds; 94°C for 30 seconds; 60°C for 30 seconds; and 72°C for four minutes. The amplification products were stained with ethidium bromide after separation on gel electrophoresis (agarose 2%), illuminated under ultraviolet light, and photographed.

**E-TEST FOR DETERMINATION OF MINIMUM INHIBITORY CONCENTRATION**

Minimum inhibitory concentration (MIC) was determined using the E-test, carried out according to the manufacturer’s instructions. Mueller–Hinton agar supplemented with 2% NaCl was used.

**THE BBL CRYSTAL MRSA ID SYSTEM**

The BBL Crystal MRSA ID System was employed according to the manufacturer’s instructions (Becton Dickinson, Heidelberg, Germany). All trays with little fluorescence after four hours were incubated for another hour and reassessed. Fluorescence in the oxacillin containing well was regarded as evidence for oxacillin resistance when the positive growth control showed fluorescence and the negative growth control did not.

### Table 1 BBL Crystal MRSA ID System with methicillin resistant (MRSA) and susceptible (MSSA) S aureus isolates from five different countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Oxacillin resistant S. aureus (n)</th>
<th>BBL Crystal MRSA ID System positive (n)</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>4</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>Canada</td>
<td>17</td>
<td>13</td>
<td>76.5%</td>
</tr>
<tr>
<td>Germany</td>
<td>19</td>
<td>17</td>
<td>89.5%</td>
</tr>
<tr>
<td>Belgium</td>
<td>6</td>
<td>6</td>
<td>100%</td>
</tr>
<tr>
<td>Argentina</td>
<td>5</td>
<td>5</td>
<td>100%</td>
</tr>
<tr>
<td>All countries</td>
<td>52</td>
<td>45</td>
<td>83%</td>
</tr>
</tbody>
</table>

**STATISTICAL ANALYSIS**

The sensitivity, specificity, positive predictive value, and negative predictive value were calculated.

**Results**

All 139 S. aureus isolates were classified as resistant or susceptible to oxacillin by the oxacillin MIC values according to the National Committee for Clinical Laboratory Standards (NCCLS). Fifty two isolates were oxacillin resistant (MIC value $\geq$ 4 mg/litre; 51 mecA positive), 85 isolates were oxacillin susceptible (MIC value $\leq$ 2 mg/litre; 83 mecA negative). Two isolates were found to have MIC values of 3 mg/litre (both mecA positive) and were excluded from further analysis. There were 136 isolates that achieved sufficient growth in the control well within five hours (99.3%).

Of the MRSA, 86.5% were correctly identified as oxacillin resistant, with a negative predictive value of 92.2% (table 1). Four of the seven MRSA which failed to show fluorescence came from Canada (oxacillin MIC values: 4, 12, 48, and 256 mg/litre; all mecA positive), two came from Germany (oxacillin MIC values: 4 and 256 mg/litre; one mecA positive), and one came from Switzerland (oxacillin MIC value: 24 mg/litre; mecA positive; table 2). Of the MSSA, 97.6% were found to be oxacillin susceptible by the BBL Crystal MRSA ID System, with a positive predictive value of 95.7%.

**Discussion**

Rapid detection of resistance to oxacillin in S. aureus is very important for the clinical management of an infection and to implement appropriate infection control measures. It is claimed that the BBL Crystal MRSA ID System detects resistance to oxacillin within four to five hours when organisms are cultured on tryptic soy agar or sheep blood agar. The use of screening cultures such as mannitol salt agar cancels out any speed advantage intrinsic to the kit because subcultures on tryptic soy agar or sheep blood agar would be necessary. The kit uses a fluorescent indicator which is sensitive to the presence of oxygen dissolved in the broth. When oxygen is present no fluorescence can be detected; when oxygen is removed (for example, by respiration of the bacteria in the presence of oxacillin) fluorescence is easily detected. In our study we found that the BBL Crystal MRSA ID System had a low sensitivity (86.5%) but a high specificity (96.7%). Other investigators have also found the system to be highly specific, but our sensitivity rate is the lowest ever reported. A sensitivity of 100% was reported for 142 MRSA isolates from a hospital in Saudi Arabia, while Knapp et al reported 95% sensitivity in 69 mecA positive isolates. A sensitivity of 92.9% among 170 mecA positive isolates was described in a European multicentre study, and a sensitivity of 92.6% was reported from France among 27 mecA positive S. aureus isolates. Dutka-Malen et al found a sensitivity and a specificity of 100% among 13 MRSA and 11 MSSA isolates. Willey et al found an accurate classi-
fication by the BBL Crystal MRSA ID System in 25 mecA positive and 18 mecA negative S. aureus isolates.\textsuperscript{19} In another report, difficulties with the test system were only observed in borderline resistant strains.\textsuperscript{20}

Apart from our own study, no other investigator has proved clonal non-identity of the isolates. Retesting of copy strains cannot therefore be excluded. In our selection of MRSA isolates from five different countries, four of the seven MRSA without fluorescence in the test kit came from Canada, two from Germany, and one from Switzerland. An explanation for this could be the lack of oxacillin phenotypic resistance despite the presence of the mecA gene. Up to 16.7\% of all oxacillin susceptible S. aureus isolates may carry the mecA gene.\textsuperscript{21} Of the seven isolates that failed to show fluorescence in the BBL Crystal MRSA ID System, two were found with MIC values of 4 mg/litre\textsuperscript{12} and the remaining five isolates had MIC values $\geq$ 12 mg/litre. It has been shown previously that borderline resistant isolates are difficult to identify accurately.\textsuperscript{20} It remains unclear why some highly resistant isolates apparently do not utilise oxygen in the presence of 2 mg/litre oxacillin. This observation might be most important for microbiological laboratories in Canada—the origin of the isolates giving the lowest test sensitivity in our study.

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