Optimizing screening procedures for *Staphylococcus aureus* nasal carriage in patients on haemodialysis

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**Abstract**

**Background.** So far it remains unclear what the optimal screening method for detection of *S. aureus* nasal carriage in patients on haemodialysis is with regard to number of cultures performed, culture interval, and necessity of a broth-enrichment procedure.

**Methods.** A prospective, uncontrolled study was performed at the renal unit of a tertiary care centre, including all haemodialysis patients \((n = 91)\) attending the unit during the study period. The purpose was to determine the optimal screening method for *S. aureus* nasal carriage in patients on haemodialysis.

**Results.** When compared to the conventional culture method, inclusion of a broth-enrichment procedure increased the number of cultures positive for *S. aureus* significantly \((31 \% \text{ vs } 24 \%, P < 0.0001)\). Of 91 patients 37\% were *S. aureus* carriers (defined as at least 1 of 5 cultures positive), 33\% were stable carriers (defined as at least 2 of 5 cultures positive). Fourth and 5th cultures, taken at subsequent dialysis sessions, captured only two additional carriers (6\% of all carriers). With respect to culture results and identification of carrier status a short (1-h) and a long (>24-h) sampling procedure showed no significantly different results.

**Conclusions.** *S. aureus* nasal carriage in haemodialysis patients can be conveniently established with three nasal cultures taken with 1-h intervals, and the inclusion of a broth-enrichment procedure.

**Key words:** enrichment procedure; haemodialysis; nasal carriage; screening interval; *Staphylococcus aureus*

**Introduction**

Infection is one of the leading causes of morbidity and mortality in patients treated by haemodialysis and within this category *Staphylococcus aureus* constitutes the major pathogen, accounting for 70–96\% of bacterial infections [1–4]. The anterior nares are the main reservoir for *S. aureus* and nasal carriage can maintain skin infections and thus contribute to the risk for subsequent invasive infections [5,6]. Measures to eradicate nasal carriage by means of topical bactericidal ointments or antibiotics to prevent these infectious complications have been shown to be effective in haemodialysis patients [1,7]. Hence, adequate establishment of *S. aureus* nasal carrier status is essential in these patients. True-negative cultures can be found in non-carriers, but also in patients who intermittently carry *S. aureus*. False-negative culture results may arise from sampling errors or insensitive culture methods. Van Ogtrop reported that exclusion of a broth-enrichment procedure may affect the ability to detect *S. aureus* carriage, causing false-negative culture rates up to 44.6\% [8]. Fast and reliable procedures to identify all patients that carry *S. aureus* also will allow identification of meticillin-resistant *S. aureus* (MRSA)-carriers. Such a procedure may reduce the time during which potential MRSA carriers have to be isolated in order to prevent transmission of MRSA.

The aim of this study was to optimize the method for assessment of the *S. aureus* nasal carrier status in the patients on haemodialysis at our unit.

**Subjects and methods**

**Patients, sampling, and definition of carrier status**

All 91 patients on haemodialysis at our centre (49 male, 42 female) gave their informed consent to participate in the study. Cultures were taken by instructed dialysis nurses. One swab was used for culturing both nares. From each patient five cultures of both nares were taken. The first three cultures were taken on day one, with 1-h intervals. Cultures four and five were taken at subsequent dialysis sessions, each interdialysis interval spanning at least 2 days. *S. aureus* nasal carriage was defined by a positive culture. Stable nasal carriage was defined by at least two positive cultures.
Microbiology

For the preparation of nasal cultures, a swab moistened in sterile 0.9% sodium chloride solution was rotated in both nares, placed into modified Amies charcoal transport medium (Eurotub, Barcelona) and processed in the laboratory within 12 h. Swabs were plated onto blood-agar plates (BBL 811–037) and mannitol–salt agar plates (Merck, art. no 5404). For the broth-enrichment procedure the swab was put into a tube containing 5 ml of tryptic soy broth (BBL) supplemented with 6.5% sodium chloride for the enrichment procedure. For the standard procedure plates were incubated for 48 h at 37°C in air and examined thereafter. For the broth-enrichment procedure the swabs were subcultured by plating them onto blood agar plates and mannitol–salt agar plates after 48 h of preincubation at 37°C in the broth and they were examined after another 48 h. Identification of S. aureus was based on colony morphology, DNase production and latex agglutination by Staphaurex Plus (Murex ZL 34, Weesp).

Statistical analysis

The  $\chi^2$ test was used for analysis of categorical variables. Statistical significance was set at the 0.05 level.

Results

From 91 patients 454 cultures were obtained. From one patient only four cultures could be taken because of a kidney transplantation during the study period. Overall 141 cultures (31%) were positive after broth enrichment, whereas 109 (24%) were positive with the standard procedure. All cultures positive in the conventional procedure were also positive with broth enrichment. Of 91 patients 34 (37%) had at least one positive culture and 30 of 91 (33%) patients were stable carriers. After three cultures, 28 stable carriers were identified, and after four and five cultures each, one additional carrier was identified. Table 1 shows the numbers and percentages of patients defined as nasal carriers with increasing culture numbers and according to the culturing procedure. Table 2 shows data of positive cultures; the culture procedure of three cultures with 1-h intervals is compared with three cultures taken with intervals each longer than 24 h. All patients diagnosed as carriers by the $\geq$24-h method were also carriers according to the 1-h method. Table 3 shows the number of carriers identified by both procedures. Table 4 shows the number of stable carriers (at least two positive cultures) found with each method.

Table 1. Number of Staphylococcus aureus nasal carriers (and percentage of total patient numbers) after each culture, according to culture procedure

<table>
<thead>
<tr>
<th>Culture</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>Standard</td>
<td>21 (23%)</td>
<td>26 (29%)</td>
<td>28 (31%)</td>
<td>28 (31%)</td>
<td>28 (31%)</td>
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<tr>
<td>Broth enrichment</td>
<td>26 (29%)</td>
<td>29 (32%)</td>
<td>32 (35%)</td>
<td>33 (36%)</td>
<td>34 (37%)</td>
</tr>
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</table>

All patients diagnosed as stable carriers with the $\geq$24-h method were also stable carriers with the 1-h method. Neither for culture results nor for identification of carrier status was a significant difference comparing the short interval (1 h) with the long interval ($\geq$24 h) found. Twenty-two of 30 stable carriers had five positive cultures, but if results from the broth were not counted, only 14 of 30 stable carriers had five positive cultures.

Discussion

Using an enriched broth significantly more cultures were found positive for S. aureus: 141 positive cultures compared to 109 of 454 ($P < 0.0001$). All cultures using conventional plates were also positive with the enriched broth. In the opinion of some authors, in the assessment of S. aureus nasal carrier status a broth-enrichment procedure should be included [8]. Many studies addressing the risk of S. aureus nasal carriage in dialysis patients with regard to the development of S. aureus infections have not included this procedure [1,7]. However, with a broth enrichment added to the culture procedure, low-level carriers are detected. Possibly low-grade carriers are less at risk of developing infectious complications of S. aureus carriership. Nevertheless our study shows that for evaluation of the risk of S. aureus nasal carriage, the way cultures are processed is important. We defined stable nasal carriage by at least two positive cultures, whereas intermittent carriers had one positive culture. By these criteria 33% of all haemodialysis patients were stable nasal carriers.

Reasons for intermittent nasal carriage may be linked to host factors or sampling error. Our results show that sampling errors may be important, especially when no enrichment procedure is included. Twenty-two of 30 stable carriers had five positive cultures, if enriched cultures were not used only 14 of 30 stable carriers had five positive cultures. Using enriched cultures clearly reduces the rate of intermittent carriership and increases the number of true carriers by reducing sampling errors. Three cultures taken within a short interval (1 h) identified 28 of 30 (93%) stable carriers, compared to 27 (90%) with the long culture ($\geq$24-h) interval. Thus establishment of the S. aureus nasal carrier status with this short-culture regimen yields quick results and is equally adequate compared to culturing with a longer interval. Performing more than three cultures does not contribute significantly to the detection of nasal carriership.

Extra costs involved with the enriched-broth procedure comprise one broth medium and one blood plate, which have to be incubated and examined: this will roughly double the costs of a conventional culture. Taking three instead of one culture will increase expense accordingly. However, laboratory costs should be weighed against costs of mupirocin prophylaxis, reduced infection treatment rates, but also against costs involved with potential emerging mupirocin res-
Table 2. Number of positive cultures comparing broth enrichment with standard procedure and comparing sampling interval of 1 h with an interval of > 24 h

<table>
<thead>
<tr>
<th>Culture</th>
<th>Interval 1 h</th>
<th>Broth</th>
<th>Standard</th>
<th>Interval &gt; 24 h</th>
<th>Broth</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>26</td>
<td>21</td>
<td>29</td>
<td>25</td>
<td>20</td>
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<td>27</td>
<td>20</td>
<td>29</td>
<td>29</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 3. Number of patients with at least one positive culture comparing a 1-h sample interval with intervals of more than 24 h: broth-enrichment and standard procedures

<table>
<thead>
<tr>
<th>Culture</th>
<th>Interval 1 h</th>
<th>Broth</th>
<th>Standard</th>
<th>Interval &gt; 24 h</th>
<th>Broth</th>
<th>Standard</th>
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<td>21</td>
<td>32</td>
<td>32</td>
<td>23</td>
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</tbody>
</table>

Table 4. Number of stable carriers as determined by broth-enrichment and standard procedures

<table>
<thead>
<tr>
<th>Interval of sampling</th>
<th>1 h</th>
<th>&gt; 24 h</th>
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<tbody>
<tr>
<td></td>
<td>Broth</td>
<td>Standard</td>
</tr>
<tr>
<td>Number of carriers</td>
<td>28</td>
<td>24</td>
</tr>
</tbody>
</table>

In conclusion, our work shows that future studies addressing nasal carriage of *S. aureus* and infections in patients on haemodialysis should include broth-enriched cultures. The culture interval is not critical for the establishment of the *S. aureus* carrier state. While screening for MRSA in haemodialysis patients, this rapid screening scheme may be expected to be valuable in infection control.

References


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