Disappointing dipstick screening for urinary tract infection in hospital inpatients

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Abstract

Aim—To compare the performance of leucocyte esterase and nitrite dipstick tests with microscopic examination and culture of first morning urines (n = 420) of hospital inpatients.

Results—The sensitivity, specificity, and negative predictive value of the leucocyte esterase test for the cutoff of > 10 WBC/µl were 57%, 94%, and 68%, respectively. For > 5 WBC per high power field (HPF) these variables were 84%, 90%, and 93%. For > 10³ colony counts/ml, the sensitivity of the nitrite test was 27%, specificity 94%, and negative predictive value 87%. When either leucocyte esterase or nitrite positivity was accepted as a marker of urinary tract infection, the sensitivity was 78%, specificity 75%, and negative predictive value 94%, and there were 22% false negative results. Semiquantitative microscopic estimation of bacteria per HPF yielded 40% false positives.

Conclusions—Leucocyte esterase and nitrite dipstick tests are not suitable for screening for urinary tract infections.

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Keywords: leucocyte esterase; nitrite; dipstick

Screening of urine specimens for urinary tract infection by means of dipstick leucocyte esterase and nitrite test is not an uncommon practice, although the standard method for diagnosis of infected urine remains microscopic examination and quantitative culture of urine. We have evaluated the diagnostic performance of the dipstick test in hospital inpatients in comparison with the microscopic and culture results.

Methods

Over a three week period, 420 first morning urine samples from hospital inpatients on which urine cultures had been requested were randomly selected for additional tests. These tests included (1) test strip screening with multistix 8 SG (Bayer Corporation, New York, USA), (2) direct microscopic counting of the white blood cells (WBC) and bacteria per micro litre of urine using Kova counting chambers (Hycor Biomedical Inc, California, USA), (3) urine sediment microscopy, after centrifugation at 350 g for five minutes, to obtain WBC and bacteria per high power field (HPF). The strips were read by reflectance spectrophotometric method on Clinitek 200+ (Bayer).

Urine cultures were performed by inoculating, from a standard loop, 10 µl of uncentrifuged and well mixed urines on to blood agar and MacConkey plates (Oxoid, Hampshire, UK), and incubating aerobically at 37°C overnight. Growth of ≤ 10⁻⁵ colony forming units (CFU) per ml was considered negative.

The patients consisted of 234 females (mean age 55 years, range 17 days to 97 years) and 186 males (mean age 58 years, range 9 to 94 years) and they belonged to the following general groups: paediatrics (4), oncology (5), obstetrics/gynaecology (39), surgery (51), geriatrics (57), ambulant consultation (68), internal medicine (93) and medical and postoperative intensive care (103).

Results

Using the standard criterion of ≥ 10⁵ CFU/ml for urinary tract infection, 72 patients’ urines (17%) produced positive cultures. Of these 18 (25%) were infected with non-nitrate-reducing organism, these being mainly enterococci and candida. With a less stringent criterion of

Table 1 Performance of urine dipstick tests in comparison with microscopic and culture results

<table>
<thead>
<tr>
<th>Positive screening test</th>
<th>Reference cutoff</th>
<th>n</th>
<th>%FN</th>
<th>%FP</th>
<th>%Sen</th>
<th>%Spec</th>
<th>%PPV</th>
<th>%NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leucocyte esterase (LE)</td>
<td>&gt; 10 WBC/µl</td>
<td>204</td>
<td>43</td>
<td>61</td>
<td>97</td>
<td>94</td>
<td>91</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>&gt;20 WBC/µl</td>
<td>136</td>
<td>23</td>
<td>22</td>
<td>77</td>
<td>91</td>
<td>81</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>&gt; 5 WBC/HPF</td>
<td>126</td>
<td>20</td>
<td>11</td>
<td>84</td>
<td>90</td>
<td>77</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>≥ 5 × 10⁵ CFU/ml</td>
<td>90</td>
<td>31</td>
<td>23</td>
<td>75</td>
<td>77</td>
<td>45</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>≥ 10⁵ CFU/ml</td>
<td>72</td>
<td>26</td>
<td>24</td>
<td>84</td>
<td>76</td>
<td>39</td>
<td>93</td>
</tr>
<tr>
<td>Nitrite</td>
<td>≥ 5 × 10⁵ CFU/ml</td>
<td>90</td>
<td>73</td>
<td>67</td>
<td>22</td>
<td>77</td>
<td>93</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>≥ 10⁵ CFU/ml</td>
<td>72</td>
<td>67</td>
<td>62</td>
<td>22</td>
<td>77</td>
<td>93</td>
<td>52</td>
</tr>
<tr>
<td>Nitrite or LE</td>
<td>≥ 5 × 10⁵ CFU/ml</td>
<td>90</td>
<td>28</td>
<td>25</td>
<td>77</td>
<td>72</td>
<td>46</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>≥ 10⁵ CFU/ml</td>
<td>72</td>
<td>22</td>
<td>26</td>
<td>86</td>
<td>78</td>
<td>75</td>
<td>94</td>
</tr>
<tr>
<td>Nitrite plus LE</td>
<td>≥ 5 × 10⁵ CFU/ml</td>
<td>90</td>
<td>77</td>
<td>69</td>
<td>20</td>
<td>72</td>
<td>94</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>≥ 10⁵ CFU/ml</td>
<td>72</td>
<td>71</td>
<td>51</td>
<td>20</td>
<td>72</td>
<td>94</td>
<td>51</td>
</tr>
<tr>
<td>Signif bacteria/HPF</td>
<td>≥ 5 × 10⁵ CFU/ml</td>
<td>90</td>
<td>17</td>
<td>15</td>
<td>101</td>
<td>83</td>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>≥ 10⁵ CFU/ml</td>
<td>72</td>
<td>8</td>
<td>8</td>
<td>140</td>
<td>92</td>
<td>60</td>
<td>32</td>
</tr>
</tbody>
</table>

CFU, colony forming units; FN, false negative; FP, false positive; HPF, high power field; NPV, negative predictive value; PPV, positive predictive value; Sen, sensitivity; Spec, specificity.

Figures in brackets represent numbers of cases.
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nostic sensitivity improved at the cost of 
esterase positive result was used for the 
assessed at di 
tests for leucocyte esterase and nitrite was 
forsignificantbacteria(>50bacteria/HPF)by 
considered positive for urinary tract infection.

> 5 × 10^4 CFU/ml, 90 patients (21%) could be 
considered positive for urinary tract infection. 
Two hundred and six specimens were positive 
for significant bacteria (> 50 bacteria/HPF) by 
microscopic examination of the sediment.

The diagnostic performance of the Multistix 
tests for leucocyte esterase and nitrite was 
assessed at different cutoff levels of WBC and 
CFU per ml of urine, respectively. The results 
are shown in table 1.

Discussion

Multistix test for WBC measures leucocyte 
esterase of neutrophil granules and has analyti- 
cal sensitivity of 10–25 WBC/µl or 5–15 WBC/ 
HPF (manufacturer’s data sheet). The nitrite 
test is an indirect measure of nitrate reducing 
bacteria (which include all enterobacteria, and 
most non-fermenters and Gram negative cocci) 
provided urine contains sufficient dietary nitrate and has been retained in the bladder for longer than four hours. This test is sen-
titive to > 13 µmol/l nitrate.

Of 420 specimens, 204 contained > 10 
WBC/µl and 126 had > 5 WBC/HPF. The 
diagnostic sensitivity, specificity, and positive 
predictive value of the leucocyte esterase test were 
57%, 94%, and 91%, respectively, for 
> 10 WBC/µl, and 84%, 90%, and 77% for > 5 
WBC/HPF (our reference intervals being < 10 
WBC/µl and/or < 5 WBC/HPF). False negative 
leucocyte esterase results at these cutoff levels 
of WBC were respectively 43% and 16%. Raising 
the diagnostic cutoff for WBC/µl to > 20 
WBC/µl improves the sensitivity (77%) and 
negative predictive value (88%), but the false 
negative results still remained high at 23%. 
This makes the leucocyte esterase test unsuitable 
as a surrogate of microscopic examination for 
WBC.

The reference intervals for urinary WBC of 
< 10 WBC/µl and < 5 WBC/HPF imply that 
these limits are equivalent. This assumption 
was not substantiated by our results. Whereas 
204 urines had > 10 WBC/µl, only 126 samples 
were found to contain > 5 WBC/HPF. On the 
other hand the results for cutoff values of > 20 
WBC/µl and > 5 WBC/HPF were similar. This 
clearly showed—albeit indirectly—that the 
common reference intervals of < 10 WBC/µl 
and < 5 WBC/HPF are not equivalent. There 
is no ready method for interconverting results 
per HPF and results per µl. Nevertheless it can 
be stated that > 5 WBC/HPF is probably more 
neatly equivalent to > 20 WBC/µl than to > 10 
WBC/µl.

For the detection of bacteria, the diagnostic 
sensitivity of the nitrite test was 27% for > 5 × 
10^4 CFU/ml and 33% for > 10^5 CFU/ml. 
When either a nitrite positive or a leucocyte 
esterase positive result was used for the 
diagnosis of urinary tract infection, the diagno-
sis sensitivity improved at the cost of 

specificity, while the opposite was true when 
both nitrite and leucocyte esterase were 
required to be positive for the detection of 
infected urine. Although the negative predict-
ive value for the nitrite/leucocyte esterase 
positive combination was more than 90%, the 
false negative rate of > 20% is unacceptably 
high for hospital inpatients (see table 1). This 
is also borne out by the fact that even when urine 
contained > 10^5 nitrite producing bacteria/ml, 
only 43% samples yielded positive results with 
the nitrite test. When we further subdivided the 
patients with > 10^5 nitrite producing bacteria/ml (n = 72) into those from whom 
urine was collected from an indwelling catheter 
(n = 23) and those who voided unaided (n = 49) we found that 19 patients (83%) with in-
dwelling catheters and 29 (59%) of the self 
voiding patients had negative nitrite test 
results. The poor concordance between the 
culture and the nitrite test results in these 
inpatients may have been the result of short 
contact time, reduced nitrate excretion, or 
dilution of urine by large volumes of 
intravenous infusions.

Microscopic estimates of significant bacteria 
(> 50 bacteria/HPF) in the urine sediments 
gave 40% false positive results. Although nega-
tive predictive values would indicate (see table 
1) that the microscopic estimation of bacteria 
in the sediments is a good screening method, 
this needs to be weighed against false negative 

erates of 17% and 8% for the urines of hospital 
inpatients containing > 5 × 10^4 CFU/ml and 
> 10^5 CFU/ml, respectively.

From this study we conclude that because of 
their high false negative rates the leucocyte 
esterase and nitrite dipstick tests are not 
suitable for screening of hospital inpatients 
for urinary tract infections. This conclusion is 
supported in different settings by other pub-
lished reports with respect to leucocyte 
esterase, nitrate, and leucocyte esterase and 
nitrite tests. Two groups, however, have 
reported that dipstick tests are a good screen-

ing method for urinary tract infections in new 
paediatric patients. With a false positive 
result rate of 40%, semiquantitative micro-
scopic estimation of bacteria (per HPF or per 
µl) is also an unreliable marker of infected 
urine.

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