# The Validity of the Rapidly Diagnostic Tests for Early Detection of Urinary Tract Infection

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**SUMMARY**

Urinary tract infectious (UTI) is the most common of all bacterial infections; the purpose of the present study was to determine the validity of rapidly diagnostic tests for the early detection of UTIs in patients. 128 patients who had UTIs and control group consisted of 128 subjects who had not UTIs were included to the study. Urine specimens obtained from the patients were evaluated for possible UTI by Gram staining, microscopic pyuria, dipstick (nitrite and leukocyte esterase), and quantitative urine culture. Using the quantitative urine culture as the gold standard (reference test), the sensitivity, specificity, and positive (PPV) and negative predictive values (NPV) of all the screening tests were determined and compared. The sensitivity, specificity, PPV, and NPV for the four screening methods were calculated against the urine culture (reference method) for the diagnosis of UTI. In conclusion, validity of Gram stain was found higher compared to other rapid diagnostic tests.

**Key words:** Urinary tract infection, Gram stain, screening tests

# Üriner Sistem Enfeksiyonlarının Erken Saptanmasında Hızlı Tanı Testlerinin Değeri

**ÖZET**

Üriner sistem enfeksiyonları (ÜSİ) tüm bakteriyel enfeksiyonların en sık nedenidir; sunulan bu çalışmanın amacı üriner sistem enfeksiyonlarının erken saptanmasında hızlı tanı testlerinin değerinin belirlenmesidir. ÜSİ olan 128 hasta ve kontrol grubu olarak 128 sağlıklı kişi çalışmaya dahil edildi. Hastalardan elde edilen idrar örnekleri Gram boyama, mikroskopik piyüri, dipstik (nitrit ve lökosit esteraz) ve kantitatif idrar kültürü ile olası ÜSİ yönünden değerlendirildi. Tüm tarama testlerinin duyarlılığı, özgüllüğü, pozitif (PPV) ve negatif kestirim değerleri (NPV) altın standart olarak idrar kültürleri kullanılarak belirlendi ve karşılaştırmalar yapıldı. Bu dört tarama metodu için duyarlılık, özgüllük, PPV ve NPV değerleri idrar kültür sonuçlarına (referans yöntem) göre hesaplandı. Sonuç olarak, Gram boyama diğer hızlı tanı yöntemleri ile karşılaştırıldığında daha değerli bulundu.

**Anahtar kelimeler:** Üriner system enfeksiyonu, Gram boyama, tarama testleri

## INTRODUCTION

Urinary tract infectious (UTI) is defined by the presence of organisms in the urinary tract, which is usually sterile. However, since asymptomatic colonization of the urinary tract can occur, other features such as the presence of inflammatory markers or follow-up cultures may be needed to definitively diagnose a UTI. Clinically important infections usually occur due to bacteria, although viruses, fungi, and parasites can also cause infection (1).

The gold standard for diagnosis of UTI is growth of pathogenic bacteria in a urine culture. However, diagnosis is complicated by contamination from fecal bacteria that colonize the perineal area and distal urethra. In the 1950s, Kass studied adult women and established a threshold of 100,000 CFU per ml in a voided specimen as the standard to define a positive urine culture (2). Although urine culture is the gold standard for diagnosis of UTI, results are not available for 24 to 48 h. Rapid techniques to predict UTI include urine dipstick tests for leukocyte esterase and nitrites and various forms of urinalysis, including Standard microscopy on a centrifuged specimen, high-powered microscopy with a hemacytometer, and Gram stain of unspun urine for organisms (1).

The purpose of the present study was to determine the validity of rapidly diagnostic tests for the early detection of UTIs in patients.

## MATERIALS AND METHODS

This was a cross-sectional study conducted prospectively in Duzce Medical Faculty Hospital and its clinical laboratories. One hundred and twenty eight patients who had UTIs and control group consisted of 128 subjects who had not UTIs were included to the study. The urine specimens were sent to the hospital laboratories in sterile containers, and trained laboratory technologists performed the tests using standard laboratory procedures. Urine for culture was refrigerated if not plated within 10 minutes of receipt. The urine dipstick, urine white blood cell count/$mm^3$ and Gram stain tests were performed immediately on fresh urine. Extra urine was saved by each laboratory and stored at 2°C to 6°C, and the two nonstandard tests (cell count and Gram stain) were performed daily.

Results of the dipstick test (Multistix 10SG 228, Bayer Diagnostics, Elkhart, IN) were interpreted visually according to standard color charts. The leukocyte esterase measurement was read after 2 minutes and recorded as negative, trace, small (+1), moderate (+2), or large (+3). The nitrite measurement was read at 60 seconds and recorded as negative or positive.

For the WBC count, uncentrifuged urine was drawn into a Neubauer (Reichert, Buffalo, NY) hemocytometer by capillary action. Leukocytes were counted on one side of the chamber and multiplied by 1.1 to obtain a total cell count per cubic millimeter.

Quantitative urine cultures and Gram stain were performed in the hospital microbiology laboratory. Urine received in sterile containers was inoculated onto blood and MacConkey agar plates with a 0.01 mL calibrated loop, incubated at 35°C, and examined daily for growth for 2 days. Smears were prepared using 2 drops of uncentrifuged urine on a slide within the standardized marked area (1.5 cm in diameter), air-dried, fixed, and Gram-stained. The average number of bacteria per 10 oil immersion fields, morphology, and Gram stain were recorded. A positive urine culture was defined as growth of a urinary tract pathogen at $\geq 10^4$ colony-forming units per milliliter (CFU/mL) (3).

Using the quantitative urine culture as the gold standard (reference test), the sensitivity, specificity, and positive and negative predictive values of all the screening tests were determined and compared. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for the four screening methods were calculated against the urine culture (reference method) for the diagnosis of UTI.

## RESULTS

Gram staining, microscopic pyuria, nitrite, and leukocyte esterase test and culture methods were evaluated for the diagnosis of the UTI and shown in Table 1. Comparison of Sensitivity, Specificity, PPV, and NPV values are shown in Table 2.

## DISCUSSION

Several rapid screening tests are used commonly to make a presumptive diagnosis of UTI, including dipstick biochemical analysis of urine for nitrites or leukocyte esterase, as well as microscopic examination of urine for formed elements including white blood cells or bacteria. Numerous studies have been published concerning the usefulness of these tests in diagnosing UTI (4-6).

The urine Gram stain, has been proposed both as a more sensitive and specific method for identifying patients with UTI and as a means of screening for when to have a urine culture performed (7, 8). A study by Lockhart and colleagues (9) of 207 patients with fever found the Gram stain to have a sensitivity of 94% and specificity of 92%. Hoberman et al. (8) found 96% sensitivity for the enhanced urinalysis (urine white blood cell count/mm3 plus Gram stain) in a similar sample of 4253 children < 24 months of age, with a positive urine culture defined as ≥ 50 000 CFU/mL. According to the present study, for predicting a positive urine culture, the presence of any bacteria on a Gram-stained urine specimen offers the better combination of sensitivity and specificity than other tests evaluated. However, the dipstick test performs nearly as well, with a slightly lower sensitivity for the presence of any nitrite or LE (Table 2).

Many bacteria (mainly gram negative) that cause UTI can metabolize dietary nitrate in the urine to nitrite. Detection of nitrite in urine is therefore a valuable indicator of bacterial invasion of the bladder (10). In a

**Table1.** Comparison of urine culture (reference test) and screening tests for diagnosis of UTI (*n* =128)

| Urine Culture | Gram staining | | Micros. pyuria | | Nitrite | | Leukocyte esterase | |
|---|---|---|---|---|---|---|---|---|
| | Pos | Neg | Pos | Neg | Pos | Neg | Pos | Neg |
| Pos (n=128) | 111 (86.7%) | 17 (13.3%) | 41 (32%) | 87 (68%) | 79 (61.7%) | 49 (38.3) | 61 (47.7%) | 67 (52.3) |
| Neg (n=128) | 0 (0.0%) | 128 (100%) | 8 (6.2%) | 120 (93.8%) | 4 (3.1%) | 124 (96.9%) | 6 (4.7%) | 122 (95.3%) |

meta-analyse (11), overall, the sensitivity of the urine dipstick test for nitrites was low (45-60% in most situations) with higher levels of specificity (85-98%). The typically low pre-test probabilities resulted in high predictie values of negative test resuts. The test for nitrites had its highest accuracy in specific populations such as pregnant women, urology patients and elderly people. Only in the elderly did the test for nitrites reach a high sensitivity, while in pregnant women sensitivity was the lowest. Although statistically not significant, the test for nitrites might perform better in asymptomatic patients and in patients who are not on antibiotics. In this study, the urine dipstick test for nitrites had 61.7% sensitivity, 96.9% specificity, 95.2 PPV and 71.7% NPV. Results of the present study were similar to other studies.

**Table2.**Comparison the sensitivity, specificity, PPV, and NPV to Gram staining, microscopic pyuria, nitrite, and leukocyte esterase in the early diagnosis of UTI.

| Test | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|---|---|---|---|---|
| Gram staining | 86.7 | 100 | 100 | 88.3 |
| Microscopic pyuria | 32.0 | 93.7 | 83.7 | 58.0 |
| Nitrite | 61.7 | 96.9 | 95.2 | 71.7 |
| Leuk. esterase | 47.7 | 95.3 | 91.0 | 64.5 |

White cells are normally found in urine, but an increase (pyuria) is an indication of inflammatory change. Leukocyte esterase measurement has been shown to give an accurate estimate of the number of leucocytes present (10). Sensitivity of the urine dipstick test for leukocyte-esterase was, in general, slightly higher than for the dipstick test for nitrites (48-86%), while the specificity was slightly lower (17-93%). Generally, this resulted in a lower accuracy, compared to the test for nitrites, lower predictive values of positive test results and similar predictive values of negative test results (11). In present study, the urine dipstick test for leukocyte esterase had 47.7% sensitivity, 95.3% specificity, 91.0 PPV and 64.5% NPV. These results were similar to literature.

Because Gram staining's cost and difficulty of performance are much greater than the for the dipstick test, it is not as attractive as the dipstick test in clinical practice. In combination with the cell count, it comprises the enhanced urinalysis. The cell count alone shows no advantage over dipstick tests or Gram stain because it had comparable sensitivity and is less specific. As a less expensive screen for when to send a urine culture and perform a Gram stain (12). The urine dipstick test for leukocyte esterase and nitrite continues to be a low-cost excellent screening test for UTI (13). Of all the tests studied, it is the only one not requiring Clinical Laboratory Improvement Amendments certification and can be performed by the bedside nurse or physician. The strategy of urine dipstick and culture tests for patients for whom a UTI is considered is less costly, identifies patients with UTI, and allows one to screen which patients should begin presumptive treatment.

In conclusion, according to the present study, of the four screening tests, Gram staining had the highest sensitivity, specificity, PPV and NPV. Accordingly, Gram stain seems to be useful according to dipstick tests. Gram stain can be recommended highly as a rapid tool to rule out the diagnosis of UTI in both the clinical and the laboratory setting.

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