

Technical method

Dipstick analysis for screening of paediatric urine

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The examination of urine specimens constitutes a major portion of the work of a clinical microbiology laboratory. Although the prevalence of urinary tract infection varies for different patient populations, most urine specimens are culture negative. In this laboratory only 12% of paediatric urines show evidence of urinary tract infection.

The availability of a rapid reliable screening test for the presence of bacteriuria would have many advantages. Among these would be the more timely provision of information to the clinician and a more efficient cost effective method of processing urine specimens in the laboratory.

Several studies have been made on the use of reagent strips as a rapid method to indicate the presence of urinary tract infection and renal disease.¹⁻¹⁴ Most of these methods, however, have used the detection of leucocyte esterase, or nitrite, or a combination of both, and have been performed on unselected patient populations. To date no studies have been carried out specifically on paediatric patients.

We report a rapid strip test screening method using the detection of nitrite, blood, and protein as indicators of bacteriuria in paediatric patients.

Material and methods

COLLECTION OF SPECIMENS

A total of 700 urine specimens submitted to the laboratory from hospital paediatric inpatient and outpatient sources were included in the study. The age range of the patients was from newborn to 14 years. All urines were sent to the laboratory in sterile bottles containing 1.8% boric acid (Medical Wire and Equipment Co, Corsham, England).

REAGENT STRIPS

N-Labstix strips (Ames Division, Miles Laboratories, Stoke Poges, England) contain reagent tests for the determination of pH, protein, glucose, ketones, blood

and nitrite. N-Multistix SG strips (Ames) are similar but also include tests for bilirubin, urobilinogen, and specific gravity. For each of 536 samples an N-Labstix reagent strip was dipped into a well mixed urine, and all the tests were read according to the manufacturer's instructions. For positive reactions, the reagent strip tests are designed to react progressively to produce colour changes after specified time intervals. The results were determined by careful visual comparison of the reacted test strip with a colour chart provided on the bottle label.

A total of 164 samples were tested using the N-Multistix SG strips, which were read photometrically by the Clinitek 200 reflectance photometer (Ames). Test results were automatically recorded on a built-in thermal printer.

For the purpose of this study, the strip results from both systems were regarded as negative if all three tests for nitrite, blood, and protein were negative, and positive when one or more tests were positive.

CULTURE

The routine laboratory culture method used in the study was the simple and inexpensive blotting paper strip technique of Leigh and Williams,¹⁵ using both blood agar and MacConkey agar.

All of the cultures were interpreted using the criteria of Kass.¹⁶ For the purpose of this study "contaminated" cultures were considered to be negative. Negative culture was one that had no growth, or no significant growth ($< 10^5$ organisms/ml). Positive culture was one that had $\geq 10^5$ organisms/ml (significant bacteriuria) in either pure culture, or mixed culture of not more than two different species.

Significant bacteriuria was taken as an objective laboratory criterion of urinary tract infection, although the method of obtaining the urine samples was not standardised.

STATISTICAL TERMS

The sensitivity, specificity, and predictive values for positive and negative strip tests were calculated separately for both the N-Labstix and N-Multistix strips according to the methods of Galen and Gambino.¹⁷

Sensitivity (%) =

$$\frac{\text{true positives}}{\text{true positives} + \text{false negatives}} \times 100$$

Specificity (%) =

$$\frac{\text{true negatives}}{\text{true negatives} + \text{false positives}} \times 100$$

Predictive value for positive result (%) =

$$\frac{\text{true positives}}{\text{true positives} + \text{false positives}} \times 100$$

$$\text{Predictive value for negative result (\%)} = \frac{\text{true negatives}}{\text{true negatives} + \text{false negatives}} \times 100$$

Results

The number and percentage of urines that produced negative strip tests was 344 (64.2%) when read visually and 112 (68.3%) when read photometrically (table 1)—that is, the nitrite, blood, and protein tests were all negative in these specimens. The false negativity rate for the two systems was 2.4% and 0.6%, respectively.

Table 2 shows the numbers and types of bacterial

Table 1 *Distribution of reagent strip results*

	Visual No (%)	Photometric No (%)
Total No of tests	536	164
Total No of positive cultures	67 (12.5)	15 (9.1)
No of negative strip tests	344 (64.2)	112 (68.3)
No of positive strip tests*	192 (35.8)	52 (31.7)
Negative tests with positive culture	13 (2.4)	1 (0.6)

*One or more positive strip test.

Table 2 *Sensitivity of strip tests in detecting potential pathogens isolated from significant bacteriuria*

Organism	No isolated (%)		Sensitivity of test (%)	
	Visual	Photometric	Visual	Photometric
"Coliforms"	48 (71.6)	11 (73.3)	85.4	90.9
Enterococci	7 (10.4)	0	71.4	
<i>Proteus</i> spp	4 (6.0)	3 (20.0)	75.0	100
Staphylococci	4 (6.0)	1 (6.7)	50.0	100
Streptococci (group B)	1 (1.5)	0	100	
Mixed culture*	3 (4.5)	0	66.7	

*Culture of not more than two different bacterial species.

Table 3 *Comparison of urine culture with visually read reagent strip tests (nitrite, blood, and protein) individually and in combination*

Comparison	Sensitivity (%)	Specificity (%)	Predictive value for positive result (%)	Predictive value for negative result (%)
Culture/nitrite	55.2	97.9	78.7	93.8
Culture/blood	25.4	88.9	24.6	89.3
Culture/protein	40.3	76.8	19.9	90.0
Culture/nitrite, blood + protein	80.6	71.2	28.6	96.3

Table 4 *Comparison of urine culture with photometrically read reagent strip tests (nitrite, blood, and protein) individually and in combination*

Comparison	Sensitivity (%)	Specificity (%)	Predictive value for positive result (%)	Predictive value for negative result (%)
Culture/nitrite	53.3	98.6	80.0	94.8
Culture/blood	53.3	84.6	25.8	94.7
Culture/protein	53.3	83.9	25.0	94.7
Culture/nitrite, blood + protein	93.3	75.2	27.5	99.1

species isolated and the sensitivity of the three strip tests in detecting particular species. As expected "coliforms" were the predominant clinical isolates followed by enterococci and *Proteus* spp. The sensitivity of both systems in detecting individual species ranged from 50% to 100%.

Tables 3 and 4 compare the relation between the presence of significant bacterial growth ($\geq 10^5$ organisms/ml) on blood agar or MacConkey agar, or both, and the visually and photometrically read strip results for nitrite, blood, and protein, singly or in combination.

For both systems, the nitrite test showed very high specificity with good predictive values for positive and negative results. The predictive value for a negative strip result, however, was greatest with the three tests combined and was higher by photometric measurement (99.1%) than by visual comparison (96.3%).

Discussion

Direct comparison of the results of this study with previous work carried out on reagent strip tests for screening urines is difficult for two reasons. First, only

one other study¹⁸ has used the same criteria of nitrite, blood, and protein. Secondly, no work of this type, specifically on urine specimens from paediatric patients, has been conducted.

The nitrite test exhibited a very high specificity when read both visually (97.9%) and photometrically (98.6%), which did compare favourably with the results of Lowe.¹⁸ Conversely, lower figures for the positive predictive values (78.7% and 80.0%) were obtained, which may be due to the fact that urines tested in this study were randomly collected. First morning urine, or urine that has remained in the bladder for several hours, is more likely to yield a positive nitrite test result in the presence of significant bacteriuria than a random urine sample that may have been in the bladder only a short time.

To constitute an effective screening test for the elimination of negative (abacteriuric) urines the system must have a high predictive value for a negative result—that is, a high rate of negative accuracy. Although the nitrite test has a high negative predictive value using both methods (93.8%) and (94.8%), the combination of nitrite, blood, and protein increased the values to 96.3% and 99.1%, respectively.

In combination, the three reagent strip tests reliably predicted negative results. This is obviously a most useful diagnostic tool in a hospital laboratory where almost 90% of the paediatric urines cultured are negative. The results of this study show that two thirds of all paediatric urines submitted to the laboratory could be discarded immediately after testing with N-Labstix or N-Multistix reagent strips when the tests for nitrite, blood, and protein are all negative.

Only 164 urines were exclusively read photometrically using the Clinitek, and for this reason an accurate comparison between these results and those obtained by visual reading cannot be made. The higher predictive negative value (99.1%) obtained by the Clinitek, however, its high throughput speed of 360 urines/hour, and its purely objective reading of the strips indicate that the use of this instrument would increase the accuracy and efficiency of this screening method.

We are convinced that it is well worth using the Ames reagent strip tests for nitrite, blood, and protein in combination to screen out "negative" paediatric urines and to predict indirectly bacteriuria. When all three tests are negative it is unnecessary to examine urine specimens further. When one or more of the three tests are positive, culture and microscopy should be performed. This will in no way prevent the clinician from requesting culture and microscopy on specimens from specific problematic patients.

It may also be worth considering the use of the reagent strips as a "self-monitoring" test for patients

who suffer from periodic urinary tract infections.

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