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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Screening of urinary tract infections in children using fluorescent flow cytometry – a single-center study

Darija Knežević[1], Duška Jović[1], Maja Travar[1,2], Snežana Petrović-Tepić[1,2]

[1]University of Banja Luka, Faculty of Medicine, Banja Luka, Republic of Srpska, Bosnia and Herzegovina;
[2]University Clinical Centre of the Republic of Srpska, Banja Luka, Republic of Srpska, Bosnia and Herzegovina

SUMMARY

Introduction/Objective Urinary tract infections (UTIs) in children represent a significant public health problem due to their high prevalence and the need for timely diagnosis and adequate treatment. Automated methods using fluorescent flow cytometry are increasingly being used in laboratories for the screening of UTIs. The aim of this study was to determine the cutoff values for leukocyturia and bacteriuria using fluorescent flow cytometry for the screening of urinary tract infections in the pediatric population.

Methods A total of 821 urine samples were cultured, of which 366 samples met the criteria for fluorescent flow cytometry on the automated Sysmex UF- 4000 analyzer. The counts of leukocytes and bacteria were compared with the culture results.

Results Of the total urine cultures tested, 209 (25.5%) were positive, and 599 (73%) were negative. There was a statistically significant difference in the prevalence of uropathogens according to the age of the children ($p < 0.001$). The area under the curve (AUC) for leukocyte count was 0.77 (95% CI: 0.71–0.84), while the AUC for bacterial count was 0.85 (95% CI: 0.81–0.89). A low negative likelihood ratio (0) was observed at the bacterial cutoff of 40.1, and the negative predictive value was high (between 91% and 99%).

Conclusion Determination of leukocyte and bacterial counts in urine in children using fluorescent flow cytometry can serve as an initial test when deciding on urine culture in microbiological laboratories. These results may indicate the necessity of reducing unnecessary urine cultures while providing faster confirmation of negative test results.

Keywords: fluorescent flow cytometry; leukocytes; bacteria; cutoff value; urine culture

INTRODUCTION

Urinary tract infections (UTIs) represent one of the most common bacterial infections in the pediatric population, affecting all age groups of children. They constitute a significant public health problem globally, given their high incidence and the need for timely diagnosis and therapy. Despite the growing problem of antimicrobial resistance, the use of antibiotics remains an indispensable part of the therapeutic approach in the treatment of UTIs in children [1, 2]. The incidence of UTIs in children varies and depends on age, sex, and race. The incidence rate is significantly high in both sexes during the first year of life. Boys have a higher incidence than girls in the first year of life, after which the rate declines. Girls are predominantly affected by UTIs, at a rate of 2–4 times higher than in boys [3, 4]. Functional urination disorders are common in recurrent urinary tract infections. They can cause damage to the upper urinary tract and kidneys, as well as negatively affect the quality of life of children, which is why their early detection and treatment are important [5]. Inadequate selection of antibiotics may lead to therapeutic failure and contribute to the development of antimicrobial resistance. Recurrent UTIs, particularly in children, represent a significant clinical problem due to consequent irreversible damage, including scarring of the renal parenchyma, progressive impairment of renal function, arterial hypertension, and the development of chronic kidney disease. Evidence from research indicates a high prevalence of multidrug resistance among Gram-negative bacteria, which represent the most common etiological agents of UTIs [6, 7]. Microbiological analysis of urine, that is, urine culture, is still considered the most reliable method for the detection and identification of UTI pathogens. The diagnostic process may be complicated by the presence of fecal flora, due to colonization of the perineal region and distal urethra [8, 9]. To minimize sample contamination, suprapubic aspiration and catheterization are considered reference methods for urine collection for culture in young children. Given the invasive nature of certain diagnostic procedures, inflammation in the urinary tract may be indirectly assessed through quantification of white blood cells (WBCs) and bacteria in urine [10, 11].

Modern fully automated urine analysis systems, including combined chemical and sediment analyzers, as well as devices based on digital microscopy and flow cytometry, have become an integral part of routine laboratory practice. These technologies enable standardized, efficient, and reproducible sample processing, thereby supporting clinicians in the early identification and management of

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Correspondence to:
Darija KNEŽEVIĆ
University of Banja Luka
Faculty of Medicine
Save Mrkalja 14
78000 Banja Luka
Republic of Srpska
Bosnia and Herzegovina
darija.a.knezevic@med.unibl.org

suspected UTI samples [12, 13]. Fluorescent flow cytometry allows rapid and reliable analysis of urine samples, enabling UTI screening in less than one minute. An additional advantage of this technology is its ability to differentiate between Gram-positive and Gram-negative bacteria [14, 15, 16].

The aim of this study was to examine the most common causative agents of UTIs in children and the role of fluorescent flow cytometry as an auxiliary diagnostic method during microbiological urine analysis.

METHODS

From January to July 2025, we analyzed urine samples from the Clinic of Pediatric Diseases, University Clinical Center of the Republic of Srpska (UCC RS), which were routinely submitted to the microbiology laboratory for culture. The study was conducted over this six-month period to ensure consistent laboratory procedures, stable analytical conditions, and an adequate sample size across all age groups, while minimizing variability related to procedural or organizational changes over longer study periods. Participants were stratified into the following age groups to reflect distinct developmental and physiological stages: 0–6 months, seven months to four years, 5–9 years, 10–14 years, and 15–18 years.

Urine cultures were performed exclusively in hospitalized pediatric patients admitted to the pediatric ward. Both urinalysis and urine culture were requested only when clear clinical indications were present, based on the treating physician's assessment (e.g., signs or symptoms suggestive of urinary tract infection). Exclusion criteria included: urine samples obtained as part of routine screening examinations; outpatient urine samples; samples with incomplete clinical or laboratory data; contaminated urine samples; and repeated urine samples from the same patient, with only the first eligible sample included in the analysis. A total of 906 urine samples obtained through voiding and urinary catheterization were analyzed, of which 821 samples were included in our study. Of these, 366 urine specimens met the criteria, that is, a minimum of 2 mL of urine for fluorescent flow cytometry using the automated analyzer Sysmex UF-4000 (Siemens Corporation).

Fluorescent flow cytometry is an analytical method that enables rapid measurement of light scatter and fluorescence emission produced by adequately illuminated cells or particles. During analysis, cells or particles are suspended in a liquid medium and generate optical signals as they individually pass through a laser light beam. Because measurements are performed separately for each particle or cell, the results represent cumulative individual cytometric characteristics. Urine particle analysis is based on sheath flow principles, whereby each particle within the sample stream is individually illuminated by laser light, generating forward-scattered light, side-scattered light, side fluorescence, and depolarized side-scattered light, which are subsequently converted into electrical signals. In this study, urine samples were analyzed using an automated urine flow cytometer (Sysmex UF-4000, Sysmex Corporation, Kobe, Japan). The system utilizes a blue laser to enhance bacterial detection and depolarized side-scattered light to improve differentiation between erythrocytes and crystals. Fluorescent staining is performed using proprietary reagents with radio-frequency identification (RFID) technology to ensure accurate measurement and differentiation of bacteria. The analyzer enables differentiation of epithelial cells and urinary casts and allows rapid exclusion of negative urinary tract infection samples. The UF-4000 provides quantitative analysis of 17 diagnostic parameters in urine mode and nine diagnostic parameters in body fluid mode, with results reported as particles per microliter using manufacturer-provided algorithms. The method allows for the analysis of physiological and cellular properties of urine and other body fluids, such as cerebrospinal fluid, pleural fluid, synovial fluid, and others. The analytical parameters that the Sysmex UF-4000 can detect and quantify include: erythrocytes, non-lysed erythrocytes, white blood cells (WBCs), WBC clusters, epithelial cells (squamous, non-squamous, transitional, and renal epithelial cells), casts (hyaline and pathological casts), bacteria, fungi, crystals, spermatozoa, and mucus. The detection range for WBCs on the Sysmex UF-4000 is 1–10,000/μL, and for bacteria 5–10,000/μL.

Urine cultures were performed using a 1-μL loop on chromogenic agar plates (BioMérieux, Marcy-l'Étoile, France) to enable identification and quantification of microorganisms, incubated at 37°C for 18–24 hours. After the incubation period, only those samples with significant growth (cutoff ≥ 10^5 CFU/mL) of a single uropathogen were considered to confirm UTIs. For colony counts between 10^4 and 10^5 CFU/mL, results were evaluated in accordance with the sampling method and the child's clinical presentation. Negative samples were sterile or mixed/contaminated with insignificant growth (cutoff ≤ 10^3 CFU/mL) and were not further tested. Mixed cultures, defined as those containing two or more types of uropathogens, required repeat urine sampling.

Identification of microorganisms was performed according to the manufacturer's recommendations for chromogenic agar plates. For cultures where the microorganism could not be reliably determined, identification was carried out using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS, Zhuhai DL Biotech CO) and an automated identification and antibiotic susceptibility testing system, Vitek 2 (BioMérieux, Marcy-l'Étoile, France).

Statistical analysis

For statistical data processing, IBM SPSS Statistics Version 23 (IBM Corp., Armonk, NY, USA) and Microsoft Excel Office 2019 were used. Descriptive statistics (frequencies and percentages) were applied for the distribution of categorical data, and the chi-square (χ^2) test was used to test associations. Receiver operating characteristic (ROC) curve analysis was applied to compare the performance of different parameters, while the values of the area under the curve (AUC) were used to assess diagnostic accuracy in

Table 1. Distribution of patient characteristics with urine culture test by age and sex

Variables	Total	Urine culture test results, N (%)			p
	N = 821	Positive N = 209 (25.5)	Negative N = 599 (73)	Contamination N = 13 (1.5)	
Age					
0–6 months	294	95 (45.5)	197 (32.9)	2 (15.4)	< 0.001*
7 months – 4 years	256	76 (36.4)	174 (29)	6 (46.2)	
5–9 years	100	15 (7.2)	83 (13.9)	2 (15.4)	
10–14 years	74	7 (3.3)	65 (10.9)	2 (15.4)	
15–18 years	97	16 (7.7)	80 (13.4)	1 (7.7)	
Sex					
Male	389	92 (44)	291 (48.6)	6 (46.2)	0.522
Female	432	117 (56)	308 (51.4)	7 (53.8)	

*$\chi^2 = 32.487$, df = 8;
$\chi^2 = 1.301$, df = 2

detecting urinary tract infections (UTIs). A p-value < 0.05 was considered significant.

Ethics: Approval for conducting the study was obtained from the Ethics Committee of UCC RS (01-19-162-2/25) in order to protect the rights of participants in accordance with the current Declaration of Helsinki.

RESULTS

The results showed that out of the total urine cultures tested, 209 (25.5%) were positive, 599 (73%) were negative, and contamination with normal physiological flora was identified in 13 (1.5%) samples. A statistically significant difference was observed in urine culture results in relation to the age of children (p < 0.001). The highest percentage of positive results was recorded in the youngest children (0–6 months) at 45.5%, and the percentage of positive results decreased with age. Although the prevalence of urinary tract infections was higher in girls (56%), the difference compared to boys was not statistically significant (p = 0.522) (Table 1).

There was a statistically significant difference in the distribution of uropathogens in relation to the age of children (p < 0.001). *Escherichia coli* (46.6%) was most frequently isolated in the age group of seven months to four years, with its frequency decreasing with increasing age. *Klebsiella spp*. (68.9%), Enterococcus faecalis (55.6%), and *Acinetobacter spp*. (80%) were significantly represented in urine cultures of the youngest age group of children (0–6 months). The lowest frequencies of urinary tract infection causative agents were observed in children aged 10–14 years, namely *E. coli* (5.2%) and *Klebsiella spp*. (2.2%). Based on the analysis of urinary tract infection causative agents in relation to sex, different patterns of their distribution were observed. E. coli was more frequently isolated in girls (56%), as was E. faecalis (66.7%), while in boys *Klebsiella spp*. (53.3%) and *Proteus mirabilis* (70%) were more frequently isolated. However, the observed statistical value (p > 0.05) indicated that there was no statistically significant difference in the frequency of isolated microorganisms from urine between boys and girls (Table 2).

Results derived from automated flow cytometry

Table 3 presents the mean values and medians with interquartile ranges for the number of WBC and bacteria in two groups of urine samples (negative and positive). In negative samples, the mean WBC count was significantly lower (88.5), while in positive samples it was significantly increased (1,166.9). The WBC median count also showed a large difference: 7.7/μL (IQR 2.7–34.05) in negative samples and 125.6/μL (IQR 19.1–751.6) in positive samples. The mean number of bacteria in negative samples was 781.94, whereas in positive samples it was markedly increased to 12,453.19 (Table 3).

Table 3. Medians and ranges of white blood cell counts and bacterial numbers by the UF-4000 device

UF-4.000	Negative	Positive
WBC ($\bar{x}$)	88.5	1166.9
Median/μL [IQR]	7.7 (2.7–34.05)	125.6 (19.1–751.6)
Bacteria ($\bar{x}$)	781.94	12,453.19
Median/μL [IQR]	32 (11.4–114.6)	689.3 (150.75–7659.95)

WBC – white blood cells

ROC curves for WBC count and bacterial count in urine are presented in Figure 1. The area under the curve (AUC) for WBC count was 0.77 (95% CI: 0.71–0.84), while the AUC for bacterial count was 0.85 (95% CI: 0.81–0.89).

Table 2. Distribution of types of pathogens causing urinary tract infections in children by age and sex

Variables	*Escherichia coli*	*Klebsiella spp.*	*Enterococcus faecalis*	*Proteus mirabilis*	*Acinetobacter spp.*	*Other*	*p*
Age							
0–6 months	41 (35.3)	31 (68.9)	15 (55.6)	1 (10)	4 (80)	3 (50)	0.001*
7 months – 4 years	54 (46.6)	7 (15.6)	8 (29.6)	6 (60)	0 (0)	1(16.7)	
5–9 years	8 (6.9)	1 (2.2)	3 (11.1)	3 (30)	0 (0)	0 (0)	
10–14 years	6 (5.2)	1 (2.2)	0 (0)	0 (0)	0 (0)	0 (0)	
15–18 years	7 (6)	5 (11.1)	1 (3.7)	0 (0)	1 (20)	2 (33.3)	
Sex							
Male	51 (44)	24 (53.3)	9 (33.3)	7 (70)	2 (40)	2 (40)	0.372
Female	65 (56)	21 (46.7)	18 (66.7)	3 (30)	3 (60)	3 (46.7)	

Other – *Pseudomonas aeruginosa*, *Enterococcus faecium*, *Serratia marcescens*, *Candida spp.;*
*$\chi^2 = 47.447$, df = 20;
$\chi^2 = 5.372a$, df = 5;

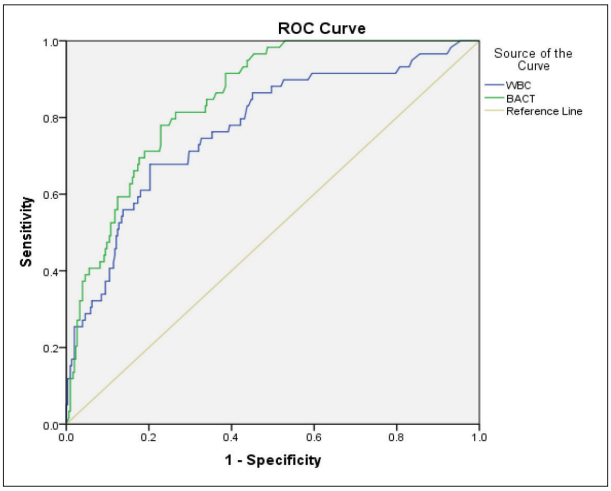

Figure 1. The receiver operating characteristic (ROC) curves for urinalysis test in children;
WBC – white blood cells; BACT – bacterial

Table 4. Diagnostic accuracy performance of UF-4000 with different cut-off for WBC/μL and bacteria/μL

Variables*	Cut-off WBC count/μL				Cut-off BACT count/μL			
	13.4	25.8	39.8	59.4	40.1	54.4	61.9	95
TP (n)	46	38	40	36	57	54	51	48
FP (n)	97	83	70	23	2	5	8	11
TN (n)	202	216	229	244	215	190	198	231
FN (n)	13	21	19	23	84	109	101	86
SE (%)	78	64.4	67.8	61	96.6	91.5	86.4	81.4
SP (%)	67.6	72.2	76.6	81.6	71.9	63.5	66.6	72.9
LR+	2.4	2.3	2.9	3.3	3.4	2.5	2.6	3
LR-	0.3	0.5	0.4	0.5	0	0.1	0.2	0.3
PPV (%)	32.2	31.4	36.4	39.6	40.4	33.1	33.8	35.8
NPV (%)	94	91.1	92.3	91.4	99.1	97.4	96.1	95.5

WBC – white blood cells; BACT – bacterial; TP – true positives; FP – false positives; TN – true negatives; FN – false negatives; SE – sensitivity; SP – specificity; LR(-) – negative likelihood ratio; LR(+) – positive likelihood ratio; PPV – positive predictive value; NPV – negative predictive value

The diagnostic efficiency of bacterial count in urine was significantly higher compared to WBC count ($p < 0.001$) (Figure 1).

In Table 4, three different cutoff values for WBC and bacterial counts were evaluated to assess the performance of urine flow cytometry in predicting urinary tract infection. These cutoff values were selected based on a combination of previously published literature in pediatric populations and our preliminary ROC curve analysis. Lower cutoffs were included to maximize sensitivity and reduce false-negative results, while higher cutoffs were chosen to increase specificity and reduce false-positive results. This approach allows comparison of test performance across a range of clinically relevant thresholds, highlighting the trade-off between sensitivity and specificity for different clinical decision-making scenarios. Sensitivity decreased with increasing cutoff values: WBC count/μL (from 78% at 13.4 to 61% at 59.4). Sensitivity was also considerably higher for bacterial cutoff values, particularly at lower thresholds (96.6% at 40.1 vs. 81.4% at 95). Specificity increased with higher cutoff values and was higher for WBC than for bacteria at the observed thresholds (67.6–81.6% *vs.* 63.5–72.9%). The low negative likelihood ratio value (0) for a bacterial cutoff of 40.1 indicated that it was nearly perfect for ruling out disease. The positive predictive value (PPV) was low (between 31% and 40%) due to a higher number of false-positive test results. The negative predictive value (NPV) was high (between 91% and 99%), indicating that the test was very effective in ruling out disease when negative (Table 4).

DISCUSSION

Our study showed that 25.5% of urine cultures were positive, while 73% were negative. Negative urine cultures represent a significant portion of the overall clinical and microbiological load. The use of highly sensitive diagnostic tests to rule out UTIs in pediatric patients could contribute to reducing the number of unnecessary urine cultures, as well as the inappropriate use of antibiotics in suspected cases of infection [17].

UTIs occur more often in girls than in boys and are among the most commonly observed bacterial infections in the pediatric population [11]. Similar to other literature reports, the results of our study also showed that UTIs were more frequent in girls (56%) compared to boys (44%) [18, 19]. These infections were more frequently recorded in infants and young children than in school-aged children. This is consistent with the literature noting that the peak of UTIs occurs during the first year of life and then between two and four years of age, which corresponds to the period of toilet training [20, 21]. Similar to other studies on the causative agents of UTIs in the pediatric population, in our study *E. coli* was the most frequently isolated bacterium from urine [22, 23, 24]. *Klebsiella* spp., *E. faecalis*, and *Acinetobacter* spp. were the most common isolates from infants' urine, which may imply hospital-acquired infections. In the study by Moghnia et al. [25], of a total of 3996 urine samples processed, 282 showed significant bacteriuria, mostly in boys (185). The most common isolates also produced Extended-spectrum beta-lactamases, particularly *K. pneumoniae* (56%) and *E. coli* (38.3%) [25].

UTIs are among the most common and most serious bacterial infections encountered by pediatricians and general practitioners. Although the diagnosis and treatment of these infections may seem uncomplicated, they still represent some of the most controversial issues in pediatrics. A partial source of controversy regarding UTIs arises from nonspecific clinical presentation, suboptimal methods of urine sample collection, revised guidelines for radiological evaluation of the urinary tract, as well as heterogeneity in therapeutic and preventive approaches [26].

Urine culture is the gold standard in the diagnosis of UTIs in children and is one of the most common laboratory tests. Obtaining a quality urine specimen in children is quite difficult by voiding, especially in newborns, infants, and children who are not toilet trained. In the era of laboratory automation, in order to facilitate the work of laboratory staff and obtain results more quickly, alternative

methods are being sought to accelerate the process of obtaining urine culture results. In patients with negative results on urine dipstick, microscopic, or automated urinalysis, urine culture is not necessary if other causes of fever are present [2].

In our study, we assessed the optimal counts of WBC and bacteria in urine in children using the Sysmex UF-4000 automated analyzer immediately before urine culture. The results showed that WBC values were significantly higher in positive samples [125.6 (19.1–751.6)] compared to negative samples [7.7 (2.7–34.05)]. The median number of bacteria per μL of urine in negative samples was 32 (11.4–114.6), and in positive samples it was 689.3 (150.75–7659.95). Similar results were obtained by Savitri et al. [27], who evaluated the number of WBCs in infants' urine; the values in positive samples for WBC and bacteria were 88.5 (27.9–182.5); 400.4 (39.5–44,914.4), and those in negative samples were 19.7 (0.5–181.8); 51.2 (0–6,283.7). Increased WBCs in urine in children, diagnosed by a leukocyte esterase test or microscopic analysis, indicate inflammation, most often UTI. However, certain noninfectious and systemic conditions can lead to false-positive WBC findings in urine, including infections caused by **g**roup A *Streptococcus*, Kawasaki disease, and physiological changes induced by intensive physical activity [9].

In this study, we evaluated different thresholds of WBC and bacteria in urine associated with positive urine culture results in the pediatric population using sensitivity, specificity, PPV, NPV, and positive and negative LR values. ROC curve analysis assessed the diagnostic value of WBC and bacteria counts in distinguishing participants with positive from those with negative urine culture findings. The obtained area under the curve (WBC AUC = 0.77; bacterial count AUC = 0.85) indicates satisfactory discriminative ability, suggesting that WBC and bacteria counts can, to some extent, differentiate negative from positive urine culture results. These results are consistent with other studies that evaluated the significance and role of automated WBC and bacterial counts using flow cytometry as a screening test for UTIs in children [27, 28].

The optimal cutoff value for leukocyturia and bacteriuria was 40 cells/μL, with sensitivity of 67% and 96.6%, specificity of 76.6% and 71.6%, PPV of 36.4% and 40.4%, and NPV of 92.3% and 99.1%, respectively. The high NPV of leukocyturia and bacteriuria demonstrated the ability of these two parameters to accurately predict negative urine culture results in order to rule out urinary tract infections in children. Liu et al. [29] identified a similar optimal cutoff value of 40.8 WBC/μL, which showed the largest area under the ROC curve and the highest Youden index. The following diagnostic characteristics were achieved: sensitivity 80.7% (95% CI: 0.770–0.840), specificity 77.8% (95% CI: 0.761–0.792), PPV 96.5% and NPV 35.2%. Determining the number of WBCs in urine by flow cytometry provides optimal performance as an initial diagnostic test for urinary infections in febrile children. A study conducted in Belgium showed that if a cutoff value of > 35 WBC/μL of urine was used, which also provided high sensitivity (99.5% [95% CI, 99 to 100%]) and acceptable specificity (80.6% [95% CI, 78 to 83%]), the number of urine samples sent to the laboratory for culture would be reduced by 67% [17].

Determining an appropriate cutoff value within an exclusion strategy represents a significant challenge, since improving the sensitivity of the test often comes at the expense of its specificity, thereby increasing the risk of false-positive results. The presence of WBCs in urine indicates an inflammatory response, which may be caused by various factors, not necessarily infection, thus increasing the risk of false-positive findings. Additionally, sample contamination may result in a clinically significant bacterial count even in the absence of true infection. Since urine culture is the diagnostic gold standard, such discrepancies often cannot be clearly identified without additional analyses [30].

CONCLUSION

The screening method for excluding negative urine cultures in children using fluorescent flow cytometry can assist in clinical decision-making. In children without symptoms and signs of UTIs, WBC and bacterial counts below 40/μL can be used for screening negative cultures. To avoid missing clinically significant cases of UTIs in children, and for a more efficient evaluation of fluorescent flow cytometry as a screening method, further studies in different pediatric populations using complementary diagnostic methods are recommended.

Conflict of interest: None declared.

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Скрининг инфекција уринарног тракта код деце помоћу флуоресцентне проточне цитометрије – студија једног центра

Дарија Кнежевић[1], Душка Јовић[1], Маја Травар[1,2], Снежана Петровић-Тепић[1,2]

[1]Универзитет у Бањој Луци, Медицински факултет, Бања Лука, Република Српска, Босна и Херцеговина;
[2]Универзитетски клинички центар Републике Српске, Бања Лука, Република Српска, Босна и Херцеговина

САЖЕТАК

Увод/Циљ Инфекције уринарног тракта код деце представљају значајан јавноздравствени проблем због високе учесталости и потребе за благовременом дијагностиком и адекватним лечењем. Аутоматизована метода помоћу флуоресцентне проточне цитометрије све више се данас користи у лабораторијама за скрининг уринарних инфекција. Циљ овог истраживања био је одредити граничне вредности леукоцитурије и бактериурије коришћењем методе флуоресцентне проточне цитометрије за скрининг инфекција уринарног тракта у педијатријској популацији.

Методе Укупно је култивисан 821 узорак урина, а критеријум за флуоресцентну проточну цитометрију на аутоматском анализатору *Sysmex UF*-4.000 задовољило је 366 узорака. За препознавање и квантификацију микроорганизама коришћене су хромогене подлоге. Број леукоцита и бактерија поређен је са резултатима култивације.

Резултати Од укупног броја тестираних уринокултура, 209 (25,5%) било је позитивно, а 599 (73%) негативно. Постојала је статистички значајна разлика у заступљености уропатогена у односу на узраст деце ($p < 0,001$). Површина испод *ROC* криве за број леукоцита износила је 0,77 (95% *CI*: 0,71–0,84), а за број бактерија 0,85 (95% *CI*: 0,81–0,89). Ниска вредност негативног односа вероватноће (0,0) забележена је за граничну вредност од 40,1 за бактерије, а негативна предиктивна вредност била је висока (између 91% и 99%).

Закључак Одређивање вредности леукоцита и бактерија у урину код деце помоћу флуоресцентне проточне цитометрије може да буде почетни тест приликом одлучивања за култивацију урина у микробиолошким лабораторијама. Ови резултати би могли указати на неопходност смањења непотребне култивације урина, а истовремено и на брже добијање негативних резултата теста.

Кључне речи: флуоресцентна проточна цитометрија; леукоцити; бактерије; граничне вредности; уринокултура