ORIGINAL ARTICLE

Urinary Cytology: The DxU-850 Iris automaton versus Microscopic Examination

Cytologie urinaire: L'automate Iris DxU-850 versus examen microscopique

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Abstract

Introduction: The use of urine cytobacteriological examination is a common and essential practice in medicine which helps guide therapeutic management in case of urinary tract infection. The cytological examination of urine samples can be done using the manual (microscopic) or automated technique. The automated approach, which involves the use of artificial intelligence, is faster, more reliable, and more efficient for laboratories.
Aim: This work aims to evaluate the performance of the DxU-850 Iris automate by comparing it to the microscopic method.
Methods: Using a four-month prospective study from May to August 2023, we analyzed urine samples received during this period by the Microbiology laboratory of Mohammed VI University Hospital in Oujda. Strict quality standards were respected when obtaining the results. Several elements were analyzed, and various parameters calculated to evaluate the performance of this automaton.
Results: The present study investigated 1000 CBEU samples, mainly from outpatient clinics (46.34%) and emergency departments (21.72%). Most patients were males (50.58%) and asymptomatic (72.9%). The samples' culture showed varied results: concordance between the results of automaton and microscopic count was satisfactory except for crystals and yeasts in turbid samples.
Conclusion: Automation has advantages like speed, traceability, error reduction, and time optimization. The results reveal a satisfactory concordance between the two methods despite discordances occurring mainly with crystals and yeasts, especially in turbid urine samples. The DxU-850 Iris automaton is an effective way to screen for urinary tract infections. We recommend that automated and manual techniques be considered complementary.

Key words: automation; DxU 850 Iris; microscopic examination; urinary cytology.

Résumé

Introduction: Le recours à l'examen cytobactériologique des urines est une pratique courante et essentielle en médecine qui permet d'orienter la prise en charge thérapeutique en cas d'infection urinaire. Cet examen peut être effectué à l'aide du microscope ou de l'automate. L'approche automatisée est plus rapide, plus fiable et plus efficace.
Objectif: Evaluer les performances de l'automate DxU-850 Iris en le comparant à la méthode microscopique.
Méthodes: A travers une étude prospective de quatre mois, allant du mois Mai jusqu'au mois Aout 2023, nous avons analysé des échantillons d'urine reçus durant cette période. Des normes de qualité strictes ont été respectées lors de l'obtention des résultats. Plusieurs éléments et paramètres ont été analysés pour évaluer les performances de cet automate.
Résultats: L'étude a porté sur 1 000 échantillons d'urine, provenant de consultations externes (46,34 %) et de services d'urgence (21,72 %). La plupart des patients étaient des hommes (50,58 %) et asymptomatiques (72,9 %). L'analyse statistique des résultats de la culture des échantillons a montré des résultats variés : la concordance entre les résultats de l'automate et ceux du microscope était satisfaisante sauf pour les cristaux et les levures dans les échantillons troubles, pour lesquels l'automate avait donné des résultats faussement positifs.
Conclusion: L'automatisation présente des avantages tels que la rapidité, la traçabilité, la réduction des erreurs et l'optimisation du temps. Les résultats révèlent une concordance satisfaisante entre les deux méthodes malgré des discordances survenant principalement avec les cristaux et les levures, notamment dans les échantillons d'urines troubles. L'automate DxU-850 Iris est un moyen efficace de dépister les infections des voies urinaires, nous recommandons que les techniques automatisées et manuelles soient considérées comme complémentaires.

Mots clés: automatisation ; DxU 850 Iris ; examen microscopique ; cytologie urinaire.

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LA TUNISIE MEDICALE-2024; Vol 102 (12): 1009-1012 DOI: 10.62438/tunismed.v102i12.5143

Introduction

Urinary tract infection (UTI) is one of the most common infections in humans [1]. It is characterized by the presence of significant bacteriuria and leukocyturia [1]. The annual incidence of UTIs is estimated at more than 150 million cases worldwide, with high morbidity and significant medical costs [2]. Diagnosis is based on urine cytobacteriological examination , which, due to the high frequency of this infection, is the most common test in a medical microbiology laboratory [3–7]. The cytological component can be evaluated either manually using a microscope or automatically. Despite the affordability of the microscopic approach, it has the disadvantage of being time-consuming and requires an experienced operator [6,8–11].

In this context, the use of artificial intelligence is a breakthrough for laboratories, offering automated solutions that optimize workflow by minimizing the need for manual sample processing. This approach thus contributes significantly to reducing sample processing times and improving the overall efficiency of laboratory operations. Besides, the automated method helps overcome these problems by providing faster results, offering enhanced traceability, reducing the risk of errors, and optimizing the technician's time [5,6,8,10,12].

The objective of this study was to evaluate the performance of the DxU-850 Iris automate (Beckman Coulter, Danaher, USA) by comparing it to the microscopic method (reference method), in accordance with current guidelines and real-world conditions of daily practice at the Microbiology Laboratory of Mohammed VI University Hospital, Oujda.

Methods

This is a four-month prospective study from May to August 2023, focusing on urine samples received in the same period by the Microbiology laboratory of the Mohamed VI University Hospital, Oujda. Samples came from different patients, including pregnant women, children, immunocompromised individuals, patients following antibiotic treatment, patients with urine collection devices, people admitted to the intensive care unit and/or patients who have undergone transplantation.

All analyzes were performed under conditions of ambient temperature and relative humidity in accordance with the manufacturer's recommendations. The study included all urine samples sent to our laboratory for a Urinary Cytobacteriological Examination. All samples were sent to the laboratory within 30 minutes. The standard sample processing protocol in our laboratory is to collect 10 µL of each urine sample, which is then seeded on the Brilliance UTI Agar chromogenic medium (Oxoid Brilliance™, UK) and then incubated from 24 to 48 hours. The germs were identified using the BD Phoenix 100 system (Becton Dickinson, USA). The results are interpreted based on the REMIC criteria (version 7; 2022) [13] , helping in classifying the samples into one of the following three categories: Urinary tract infection (UTI), urinary colonization, and contamination. Immediately after urine seeding, they were examined both by the DxU-850 Iris automaton and under the microscope using the Fast-Read 102® counting cell (Dominique Dutscher SAS, Fr) with a magnification of (40X). The elements studied after analysis with the DxU-850 Iris automaton were the number of white blood cells, the number of red blood cells, the number of epithelial cells, and the presence of yeast, crystals, and casts. In parallel, the microscopic examination helped in counting of the same elements.

To compare the results of the two techniques, we determined positivity thresholds compatible with the clinical-microbiological requirements of the recommendations we follow [13] (Table1).

Table 1. Significant positivity thresholds in our study to assess the degree of concordance between the results of the DxU-850 Iris automaton and manual microscopy.

Parameters	DxU-850 Iris thresholds	Microscopy thresholds
White blood cells	<10000	<10000
	≥ 10000	≥ 10000
Red blood cells	<10000	<10000
	≥ 10000	≥ 10000
Epithelial cells	<10000	Rare
	10000-99999	Average abundance
	≥100 000	High abundance
Casts	<10000	Absence
	≥ 10000	Presence
Crystals	<1000	Absence
	≥ 1000	Presence
Yeasts	<1000	Absence
	≥ 1000	Presence

We calculated various parameters, including the number of true positives, true negatives, false positives, and false negatives. Such calculation allowed us to determine the sensitivity, specificity, positive predictive value, negative predictive value, Youden's index, Yule's Q coefficient, and the Chi2 (χ2) index.

Results

Over the study period, a total of 1,000 urine cultures were analyzed. They came mainly from outpatient clinics (46.34%; n=463), as well as from the emergency department (21.72%; n=217), cardiology (5.6%; n=56), intensive care (4.7%; n=47) and nephrology (4.5% n=45). Of the patients whose urine cultures were analyzed, 509 (50.85%) were male. The average age was 48.72 ±23.17 years. The distribution of patients according to age group is presented in Table 2.

Table 2. Distribution of patients with urine cultures according to age group (n=1000).

Age group	Number of patients (%)
0-15	133 (13,3)
16-30	103 (10,3)
l31-45	140 (14,0)
46-60	228 (22,8)
61-75	315 (31,5)
>75	81 (8,1)

In our series, 72.9% (n=729) were asymptomatic, while 27.1% (n=271) had symptoms of UTI. There were 53 (5.3%) patients with indwelling urinary devices. Requests for urine cultures in our series were motivated by an etiological diagnosis of UTI in 63.2% (n=632) of cases, by a search for urinary colonization in 36.3% (n=363), or by therapeutic monitoring in 0.5% (n=5).

The culture in our series was sterile in 615 (61.5%) cases; it showed contamination in 343 (34.3%) cases, colonization in 21 (2.1%) cases and UTI in 21 (2.1%) cases. We isolated 45 germs in all UTI cases and colonization. Among these germs, Escherichia coli was by far the most isolated (n=28; 62.2%), followed by Candida spp. (N=8; 17.8%).

As for urinary cytology, the results of the correlation between the automated and manual methods are shown in Table 3.

Table 3. Comparison of results of the automated DxU-850 Iris and microscopy (n=1000).

Parameters	White blood cells	Red blood cells	Yeasts	Crystals	Casts
True positives	386	404	3	34	25
True negatives	513	484	973	913	970
False positives	96	107	6	6	1
False negatives	5	5	18	47	4
Concordance	89,9%	88,8%	98,79%	95,89%	99,69%
Sensitivity	98,7%	98,8%	14,3%	42,0%	86,2%
Specificity	84,2%	81,9%	99,4%	99,3%	99,9%
Positive predictive value	80,1%	79,1%	33,3%	85,0%	96,2%
Negative predictive value	99,0%	99,0%	98,2%	95,1%	99,6%
Youden's Index ***(Index close to 1 = effective test)***	0,83	0,81	0,14	0,41	0,86
Yule's Coefficient Q (Intensity of the relationship between the two variables: null if Q = 0; very strong if Q = (0.70 - 1)).	1	0,99	0,93	0,98	1
Chi-squared (χ^2)	656,3	629,5	43,1	331,0	824,4

Discussion

A Urinary Cytobacteriological Examination must necessarily examine urinary cytology and count urinary germs [6,9]. Urinary cytology can be evaluated manually or automatically. The manual method uses microscopic counting in a counting chamber. It is time-consuming, but its affordability makes it the most utilized in laboratories [8–11]. Automation allows for rapid results (higher throughput), better traceability (connection to the laboratory's computer system), reduced risk of error (manual transcription errors) and optimized technician time (reduction of repetitive tasks) [5,6,8,10,12].

The DxU-850 Iris automated urinalysis system is a fully automated urinalysis solution based on the innovative Digital Flow Morphology technology with the automated particle recognition software (APR) [14]. This automatic classification is first checked, then validated and saved by the operator. If any abnormal particles are detected, the user can modify this classification by conducting a more detailed analysis of the images before validating them. This ensures that the automaton (machine learning) accurately memorizes the updated information. This technology allows laboratories to provide standardized results using Artificial Intelligence. It allows for the isolation, identification, and characterization of digital images of particles on the screen, thus considerably reducing the need for manual microscopy, all with an impressive throughput of 101 samples per hour. It automatically identifies and processes samples in 10-position holders, presenting a sample sandwiched between enveloping layers of a membrane to a microscope coupled to a charged coupling device (CCD) video camera. Individual particle images are isolated in each image. The automated particle recognition software (APR), a highly trained neural network, uses size, shape, contrast, and texture features to classify each image into one of the following 12 categories: red blood cells, white blood cells, white blood cell clusters, hyaline casts, unclassified casts, squamous epithelial cells, non-squamous epithelial cells, bacteria, yeasts, crystals, mucus, and spermatozoa. The particle concentration is calculated using the number of particle images and the analyzed volume. User-defined release criteria are checked, and the results are sent to an operator review screen [14].

In our study, the concordance rates of results, whether true positives or true negatives, between DxU-850 Iris and the microscope, are very satisfactory for red blood cells, white blood cells, and casts. The discordances in our series are slightly more frequent for false negatives for red blood cells and largely dominated by false negatives for yeasts and crystals. We observed the high false negative rate for yeasts and crystals mainly in turbid urine samples. Sensitivity and specificity remain satisfactory. However, it is important to note that sensitivity is lower for yeasts and crystals compared to other parameters.

Several studies, in the literature, have reported the results of comparing the manual method with automated methods, including those using the flow cytometry technique (such as the Sysmex UF-1000i automated system). They noted discordances slightly dominated by false negatives for white blood cells and red blood cells, and largely dominated by false positives for yeasts and crystals [15]. Sensitivity ranged between 70.9% and 98.8%, and specificity between 73.3% and 90.85% for white blood cells[5,7,16,17]. As for other automated systems using the same technology as DxU-850 Iris (such as the iQ1200 ELITE automated system), one study showed a sensitivity ranging between 91.57% and 100%, and a high specificity ranging from 87.33% to 93.33% for white blood cells and casts, respectively. However, specificity for red blood cells was lower [18].

As for epithelial cells, their interpretation remains a crucial element in the bacteriological examination of urine samples. The presence of Group 4 microorganisms, defined by their role in the etiology of urinary tract infections and considered contaminants from the urethral or genital flora, combined with the presence of urinary epithelial cells in the microscopic examination of urine, almost certainly indicates contamination during

the collection process [13,15]. In our study, concordance between the results of DxU-850 Iris automated system and manual microscopy for epithelial cells was perfect. Youden's indices, Yule's Q coefficient and Chi2 ($\chi 2$) test for white blood cells, red blood cells and casts indicate that DxU-850 Iris is effective, that its results are strongly correlated with those of the microscope, and that this concordance is statistically significant.

Conclusion

Our study has found that DxU-850 Iris automated urinalysis system provides results in satisfactory concordance with those obtained by manual microscopy. Having shown the predominance of discordance for crystals and yeasts, mainly in turbid urine samples, we recommend that the automated and manual techniques be considered as complementary.

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