Clinica Chimica Acta 485 (2018) 275–281

Contents lists available at ScienceDirect

Clinica Chimica Acta

journal homepage: www.elsevier.com/locate/cca

The development of autoverification rules applied to urinalysis performed on the AutionMAX-SediMAX platform

Rita Palmieri[a], Rosanna Falbo[a,*], Fabrizio Cappellini[a], Cristina Soldi[a], Giuseppe Limonta[a], Paolo Brambilla[a,b]

[a] University Department of Laboratory Medicine, Hospital of Desio, Via Mazzini 1, 20033 Desio, MB, Italy
[b] Department of Experimental Medicine, School of Medicine, University Milano Bicocca, Milano, Italy

ARTICLE INFO

Keywords:
Urine microscopy
Autoverification
Automated urinalysis
Review criteria
SediMAX

ABSTRACT

Background: Fully automated urine analyzers integrated with expert software can help to select samples that need review in routine clinical laboratory. This study aimed to define review rules to be set in the expert software Director for routine urinalysis on the AutionMAX-SediMAX platform.

Methods: A set of 1002 urinalysis data randomly extracted from the daily routine was used. The blind on-screen assessment was used as a reference. The data set was used to optimize the standard rules preset in the software to establish review criteria useful to intercept automated microscopy misidentification and particles suggestive of clinically significant profile. The review rate was calculated. The rules-set was also evaluated for the selection of clinically significant samples.

Results: The review rules established were cross-checked between AutionMAX and SediMAX parameters, element reporting by SediMAX and strip results. For the complete rules-set the review rate was 47.6% and the efficiency for clinically significant sample selection was 58%. Finally, on the basis of the review rules an algorithm for routine practice was created.

Conclusions: Review rules applied to the algorithm for routine practice enhance workflow efficiency and optimize sample screening. Revision is not necessary for samples not flagged by the rules.

1. Introduction

Urinalysis is a very useful tool in screening, diagnosing, and monitoring renal diseases and urinary tract infections. A complete routine urinalysis includes physical, chemical, and microscopic urine sediment examinations [1,2].

The advent of fully automated integrated urine analyzers has greatly changed urinalysis. Automated urinalysis standardizes and allows the examination of a large number of samples. Furthermore, it improves workflow efficiency and analytical quality.

The AutionMAX-SediMAX platform (Menarini Diagnostics, Italy) integrates automated urine physical and chemical testing with cuvette-based automated microscopy urine sediment analysis. Data obtained by each analyzer are integrated by Director (Menarini Diagnostics, Italy), a software which processes standard urine test results and then poses a concluding summary of the significant elements present in the urinary sediment. Moreover, this software consents the review and editing of sediment images before release.

Autoverification rules may be implemented on Director in order to select those samples in need of review and editing. Autoverification is based on algorithms that verify clinical laboratory test results, reducing manual review time and improving the selection of potentially clinically significant samples and test results. Thus, with autoverification every result is subjected to the same review process [3].

This study aims to enhance rules set in the Director software in order to improve the selection of samples that need verification through the development of an algorithm for auto-verification of urinalysis performed on the AutionMAX-SediMAX platform.

2. Materials and methods

2.1. Study samples

This study was performed in the University Department of

Abbreviations: RBC, Red blood Cells; WBC, White Blood Cells; CryOx, calcium-oxalate crystals; URI, uric acid; TRI, triple phosphate crystals; NEC, non-squamous epithelial cells; HPF, High Power Field

* Corresponding author.
E-mail address: rfalbo@asst-monza.it (R. Falbo).

https://doi.org/10.1016/j.cca.2018.07.001
Received 2 May 2018; Received in revised form 30 June 2018; Accepted 2 July 2018
Available online 04 July 2018
0009-8981/

Laboratory Medicine, in Desio Hospital, Desio, Italy. A total of 1002 anonymous fresh urine samples, processed during daily routine testing from December 2013 to February 2014, were randomly extracted and included in the study. According to the internal procedures, all urine samples were stored in a preservative free container at 4 °C until processing and were tested within 2 h of arrival in the laboratory.

All the 1002 urinalysis data were exported, before verification and release, from the software Director to an external hard disk drive. All the chemical, physical, and analytical image parameters, the 15 corresponding digital images of each urinary sediment, and the concluding summary posed by Director for each sample included in the study were collected. All data were entered in a data set.

2.2. AutionMAX-SediMAX platform

Samples were processed using the AutionMax- SediMAX platform.

AutionMAX AX-4030 (ARKRAY Inc. distributed by Menarini Diagnostics, Italy) determines color-tone by reflectance, turbidity by light-scattering, and specific gravity by transmission refractometry. The other parameters such as glucose, albumin, bilirubin, urobilinogen, pH, hemoglobin, ketones, nitrites, leukocyte esterase are evaluated by dual wavelength reflectance which measures the change in color of the test areas on the Uriflet S 9UB strips (ARKRAY Inc.) [4,5].

SediMAX (77 Elektronika, distributed by Menarini Diagnostics, Italy) uses cuvette-based automated microscopy. The sediment is analyzed by a bright field microscope at 400× enlargement. A built-in camera takes 15 digital images of the sediment, each one equivalent to one high power field. The images are evaluated by a processing software which bases urine particle recognition on size, shape, and texture features [6,7]. The particles are identified and classified as: red blood cells (RBC); white blood cells (WBC); squamous epithelial cells (EPI); non-squamous epithelial cells (NEC); hyaline casts (HYA), pathological casts (PAT); crystals (CRY) — calcium-oxalate monohydrate (CaOxm), calcium oxalate di-hydrate (CaOxd), triple phosphate (TRI), uric acid (URI); bacteria (BAC); yeast (YEA); sperm (SPRM), and mucus (MUC). The results obtained are semi-quantitatively expressed in p/HPF (number of particles/High Power Field) or p/μl (number of particles/μl) [6,8]. All digital images can be reviewed on-screen and edited by the operator before release, avoiding release of any misidentification of the image recognition software [6].

2.3. Software director and standard rules

Director (Menarini Diagnostics, Italy) is a middleware designed for urine physical-chemical and sediment data integration.The integrated results are then communicated to the host computer. The on-screen report form of Director not only contains sediment images, but all pertinent urinalysis results including a concluding summary of the significant elements present in the sediment [4,9].

Director is also an expert system able to flag the samples to be reviewed using standard autoverification rules preset in the software. Preset standard rules are a cross-check between physical-chemical results and analytical image parameters. The results of the unflagged specimens do not require verification and may be automatically validated and released [9]. The software version applied in this study was 2.1.

2.4. On-screen image review

All 15 digital images of each of the 1002 samples included in the study were examined on-screen by an experienced operator in blind mode. No sample required revision by manual microscopy. Each urinary element identified was semiquantitatively expressed as average per HPF (High Power Field) of the 15 microscopic fields. The results for RBCs and WBCs were expressed in elements per HPF as follows: 1–4/HPF, 5-10/HPF, 11-25/HPF, 26-50/HPF, 51-100/HPF, > 100/HPF. The results for casts were: rare, 1-2/HPF, 3-5/HPF, 5-10/HPF. The count for non-squamous epithelial cells, crystals (calcium-oxalate, triple phosphate, uric acid, amorphous phosphate, amorphous urates), and bacteria, were expressed on a scale of 1+, 2+, 3+. Yeast and mucus were simply considered qualitatively as present or absent. Finally, each urine sediment was classified in a urinary profile by the experienced operator, integrating the chemical results with the on-screen image evaluation. The criteria for classification are described in literature [10,11]. No microbiology laboratory test or culture were performed.

On-screen assessment was then used as a reference for the comparison of automated microscopy results provided by Director software for each of the 1002 samples. For each type of formed element on-screen image review defined the correct identification and the positive finding: if an element was identified by automated microscopy and the on-screen image review was positive, the sample was graded as a “true positive”; if an element was identified by automated microscopy and the on-screen image review was negative, the sample was graded as a “false positive”; if the automated microscopy did not find any element and the on-screen image review was negative, the sample was graded as a “true negative”; if an element was not found by automated microscopy and the on-screen image review contained a positive finding, the sample was graded as a “false negative”.

2.5. Study design

A set of review rules to be set in the Director software were developed from the data set of 1002 urinalysis. The purpose of each rule is to intercept SediMAX misclassifications or instrumental chemical inconsistencies and flag them for manual on-screen review [6]. The on-screen image review evaluation was used as a reference in order to determine the diagnostic performance of automated microscopy and the causes of misclassifications [12–14]. Thus, a set of rules was defined in order to reduce the workload of on-screen review to the greatest possible extent and to improve the selection of samples that needed verification without endangering the patient by reporting false or misleading results [12,13]. Each review rule was derived from the optimization of the standard rules with regard to the urinary element involved. On-screen review analysis and urinalysis guidelines were used [2,15–18]. The rules were tested on the same 1002 data set and the review rate was calculated [19,20]. Finally, an algorithm for screening urine samples was proposed and tested on the data set [21]. Also, the entire rules-set was evaluated for the selection of pathological samples. If a rule was triggered and the urinary sediment corresponded to the rule that was triggered the sample was classified as a “true positive” (TP). If a rule was triggered, but the urinary sediment did not correspond to the rule it was defined as “false-positive” (FP). If a rule was not triggered and the corresponding urinary sediment was not clinically significant it was classified as “true negative” (TN). If a rule was not triggered but the urinary sediment had particles for which the rule should have been triggered the sample was classified as “false negative” (FN) [1].

2.6. Statistical analysis

Data management and statistical analysis were performed on data file Microsoft Excel 2010 using the applications of SAS (Statistical Analysis Software institute Inc., Cary, NC, USA) version 10.1. These softwares were also used to test the review rules on the data set. On-screen image review was used as the reference in all calculations. The diagnostic performance of automated microscopy was calculated. The review rate was calculated as the percentage of samples flagged by one or more rules as follows:

Review rate = (number of samples flagged/total number of samples) × 100% [13–15].

Efficiency was calculated as follows: Efficiency = (true-positives + true-negatives) / total number of samples [19].