



Comparison of 2 Automated Systems for Urine Chemistry and Urine Sediment Analysis

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ABSTRACT

We compared 2 automated systems currently used for analysis of urine chemistries and sediment. We analyzed 500 consecutive urine samples by the IRIS 900UDx urine pathology system (including a Super UA urine chemistry analyzer) and the Sysmex UF-100 urine cell analyzer (coupled with a Bayer Atlas urine chemistry system). Our study evaluated these 2 semiautomated urinalysis systems by (1) comparing results between the systems, (2) using manual microscopic review of sediment to resolve discrepancies, (3) screening chemical urinalysis results to minimize need for sediment analysis, and (4) determining the convenience of use in the laboratory. The chemical urinalysis systems showed excellent agreement, with almost no real discrepancies. As expected, there were more discrepancies between sediment counts, with 8 for red blood cells, 15 for white blood cells, 9 for epithelial cells, and 9 for casts. The large number of discrepancies for bacteria (n = 111) were related to several factors, including the different methods of identification used by the 2 analyzers. Arbitration of these discrepancies with manual microscopy favored each instrument nearly equally. Therefore, we conclude that the 900UDx and the UF-100 agree substantially and would be equally reliable in clinical use. *Lab Hematol.* 1999;5:123-129.

KEY WORDS: Urinalysis · Automation

Imaging Systems [IRIS], Chatsworth, CA) was developed several years ago [1]. This instrument automatically scans flowing urine for formed elements (eg, cells, casts) and displays pictures of these items on a video screen. Visual review by a skilled technologist to confirm, delete, or reclassify the objects in each field is required before the analyzer reports the result.

More recently, another automated urinalysis analyzer (UF-100, Sysmex Corporation of America, Long Grove, IL) has been introduced; it uses laser flow cytometry to differentiate and determine the concentrations of stained formed elements by simultaneous measurement of their scatter, fluorescence, and impedance [2]. Quantitative results are reported directly for red blood cells, white blood cells, bacteria, squamous epithelial cells, and total casts. The instrument flags for suspected presence of yeast and pathologic (nonhyaline) casts, which are confirmed microscopically. In some cases, the UF-100 flags results on samples that have high particle counts, abnormal conductivity, or unusual patterns of scatter versus fluorescence for rerun or dilution. This system has been reported to give results comparable to manual microscopy of centrifuged urine [2].

We analyzed 500 consecutive urine samples by both the current IRIS 900UDx (with a Chemstrip Super UA urine chemistry analyzer [Roche Diagnostics, Indianapolis]) and the Sysmex UF-100 (coupled with a Clinitek Atlas urine chemistry system [Bayer Corporation, Tarrytown, NY]). Our study intended to evaluate these 2 semiautomated urinalysis systems by (1) comparing results between the systems, (2) using selected manual microscopic review of sediment to resolve discrepancies, (3) determining the efficiency of

TABLE 1. Comparisons of Super UA and Atlas Glucose Results

		Super UA (mg/dL)					
		0	50	100	250	500	≥1000
Atlas (mg/dL)	≥1000						17
	500				1		5
	250			5	3		
	100		2	7			
	Negative	458	2				

technologist, who may delete or reclassify individual analytes before the analyzer counts and reports the results. The 900UDx also automatically determines urine specific gravity, color, and clarity. The urine sediment results from the 900Dx were set to report in counts per field (low-power field [lpf] or high-power field [hpf]).

Sysmex UF-100 urine cell analyzer. The UF-100 incorporates flow cytometry and impedance to identify and count formed elements in urine sediment. Stained urine is scanned at a high flow rate by an argon laser beam, with light scatter, fluorescence, and impedance measured simultaneously. Signal ratios are then processed by mathematical cluster analysis to identify and quantify formed sediment elements. For this study, the UF-100 was set to report sediment analyte counts per μL , with instrument reference ranges programmed to match the corresponding 900UDx per-field limits. Theoretical volume equivalency factors used were $\text{objects/hpf} \times 5.5 = \text{objects}/\mu\text{L}$ and $\text{objects/lpf} \times 0.39 = \text{objects}/\mu\text{L}$. Five parameters (red blood cells, white blood cells, epithelial cells, casts, and bacteria) are reported quantitatively, and 5 others (pathologic casts, crystals, small round cells, yeast-like cells, and sperm) are flagged at thresholds defined by the user. The appearance of any REVIEW flag due to suspected sediment abnormalities or system- or sample-related errors often requires manual sediment review.

Clinitek Atlas automated urine chemistry analyzer. The Clinitek Atlas is an automated urine test strip analyzer that performs 9 chemistry tests on each sample (leukocytes, ketones, protein, nitrite, blood, glucose, urobilinogen, pH, and bilirubin) plus specific gravity, color, and clarity.

Program and flag settings for all analyzers were according to manufacturer's recommendations.

Urine Specimens

We used random urine samples with sufficient volume ($>10\text{ mL}$)

TABLE 2. Comparisons of Super UA and Atlas Ketone Results

		Super UA (mg/dL)				
		0	5	15	50	≥150
Atlas (mg/dL)	>80			1		3
	40				1	1
	15			6	1	
	Trace	6	6			
	Negative	470	5			

The 4 technologists who participated in this study were validated by each performing manual microscopy on 11 urine samples preserved in Mucollex. The results of this evaluation showed that, even among experienced technologists, 5% to 10% of results disagreed in being called positive or negative.

Evaluation of Agreement Between Methods

We grouped quantitative results by each method into ranges that were believed to be analytically significant and were based on those used in an earlier report [2]. The numbers of samples in each result range are displayed in figures as grids representing each result range.

RESULTS

Comparison of Urine Chemistry Results (900UDx versus Atlas)

Glucose. Of the 500 samples studied, 42 had at least 1 positive result for glucose, and 458 were negative by both analyzers. Agreement was excellent, with all results within 1 quantitative result rank, as shown in Table 1.

Ketones. In 30 samples, at least 1 result indicated either a trace or a positive amount of ketone (Table 2). Only 14 samples were not in exact agreement by the instruments, and only 1 sample differed by 2 result ranks. The 2 instruments also had nearly equal numbers of samples positive for ketones. The only sample that differed by 2 result ranks would be considered positive for ketones by either instrument.

pH. A comparison of pH differences in the 2 instruments showed that the Atlas had slightly higher pH results, with 205 results higher than the Super UA, whereas the Super UA had 59 pH results higher than the Atlas. Of the 499 results, however, 497 were within 1.0 pH unit. The 2 that differed by 1.5 pH units had higher results by the Super UA: 6.5/5.0 and 7.0/5.5. Considering the clinical requirements for urine pH, it is unlikely that either of these differ-

TABLE 3. Comparisons of Super UA and Atlas Blood Results*

		Super UA (RBC/ μ L)					
		0	10	25	50	150	250
Atlas (RBC/ μ L)	Large						22
	Mod				4	13	4
	Small			8	21	2	
	Trace	8	19				
	Negative	347	46	6			

*RBC indicates red blood cells.

because trace hematuria could require further clinical investigation such as urethroscopy, and a false-negative result might delay diagnosis and treatment of bladder or kidney trauma, inflammation, or tumor. Of these 6 samples that differed by 2 result ranges, with results of 25 by Super UA and negative by Atlas, sediment analysis by both the UF-100 and 900UDx indicated that 1 sample had red blood cells present, 2 had trace amounts, 2 had none, and 1 had positive results by the 900UDx and negative results by the UF-100. Therefore, this analysis does not clearly favor either the Super UA or the Atlas for these 6 samples.

The Atlas uses 5 graded results for blood in urine (negative, trace, small, moderate, or large), whereas the Super UA uses 6 numbers: 0, 10, 25, 50, 150, and 250 (cells/ μ L). Therefore, a possible result of 10 on the Super UA could be reported as either negative or a trace by the Atlas, and a negative/25 pair might be an expected result of using these ranges.

Protein. All samples gave results for protein that were within 1 result rank by each analyzer (Table 4). The Super UA may be somewhat more sensitive at low levels, with 30 samples giving results of 15 mg/dL on the Super UA and negative results on the Atlas and only 4 samples giving opposite results (0 on the Super UA and trace amounts on the Atlas). At higher protein levels, however, the Atlas may be more sensitive, with 27 results \geq 100 mg/dL compared to the Super UA's 17 results \geq 100 mg/dL.

Bilirubin. The results of the 22 samples indicated that some bilirubin was present. All were within 1 reporting unit, with 8 samples having positive results on the Super UA and negative results on the Atlas, and 4 samples showing 0 mg/dL on the Super UA and small amounts on the Atlas.

Urobilinogen. There were 494 samples with both urobilinogen results \leq 1 mg/dL, 6 samples with either result $>$ 1 mg/dL, and only 2 samples with both results over 1 mg/dL. No further evaluation of

TABLE 4. Comparisons of Super UA and Atlas Protein Results

		Super UA (mg/dL)				
		0	15	30	100	500
Atlas (mg/dL)	300				4	3
	100			10	10	
	30		17	23		
	Trace	4	29	1		
	Negative	369	30			

Super UA had a result category of 15 cells/ μ L, for example, many of the Atlas trace results may have been 15 cells/ μ L by the Super UA.

To determine which of the 8 samples called "small" for leukocyte esterase by the Atlas and "0 cells/ μ L" by the Super UA were more likely to be correct, we looked at the corresponding white blood cell counts by the urine sediment analyzers and by the manual counts when available. This analysis slightly favored the Atlas, with 4 samples having white blood cells, 2 samples consistent with a negative result, and 2 samples with the additional information inconclusive.

Comparison of Urine Sediment Analysis (900UDx versus UF-100)

Red blood cells. For red blood cell data, 84.2% of samples were in the same rank and 98.2% agreed within 1 rank (Figure 1); leaving only 7 samples with substantial disagreement. Review of the available manual counts on these samples showed that the 900UDx was probably correct on 3 samples, the UF-100 was correct on 2, and no manual urinalysis data were available on the other 2.

White blood cells. For white blood cell data, 81.4% of results were in the same rank by both methods (Figure 2), and 97.0% of results were within 1 rank, leaving 15 samples with results differing by 2 or more ranks. Manual urinalysis of these samples revealed that 4 results favored the UF-100 and 3 favored the 900UDx. One sample with results of 30/hpf by UF-100, 2/hpf by 900UDx, and manual readings of 3, 3, and 12/hpf, was judged to be inconclusive. Seven of the discrepant result pairs had no manual white blood cell counts available.

Epithelial cells (squamous, renal, transitional). For epithelial cell data, 97.8% of results were within the same rank, and 99.6% were within 2 ranks (Figure 3). Of the 9 samples that differed by

TABLE 5. Comparison of Super UA and Atlas Protein Results

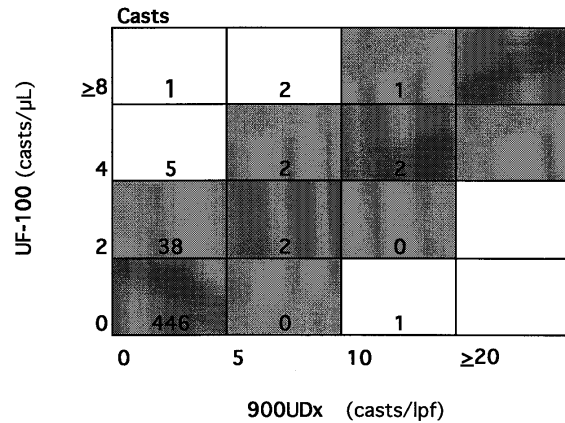


FIGURE 4. Comparisons of casts counted by each analyzer. Numbers in grid boxes represent the number of samples in corresponding result ranges. The result range for each grid includes the numbers shown on the axes, which go up to the number shown for the next result range.

either negative or rare by the 900UDx. A possible explanation for these results is that the 900UDx uses both a nonspecific stain and images of small particles, which are interpreted as bacteria by the technologist. The UF-100 uses 2 fluorescent stains, a phenanthridine dye for DNA and nucleic acid and a carbocyanine dye for negatively charged cell membranes, including nuclear and mitochondrial membranes. Both types of dyes have to be detected for the UF-100 to give a positive result for bacteria.

The resolution of these differences between instruments might be difficult because microbiologic culture detects only live bacteria, whereas neither system under evaluation differentiates live from dead bacteria or pathogenic from nonpathogenic bacteria. In addition, manual counting of bacteria in urinalysis is a very crude and variable technique and is inadequate as a reference method.

Samples Requiring Further Microscopic Review

For the 900UDx, 11 of 500 urine samples (2.2%) had flow errors indicating possible inaccurate counts due to flow disruption. These were not rerun and were not used in the data set for either instrument. For the UF-100, 15 of the 500 samples (3.0%) yielded either a high total count or high conductivity that would have been diluted and rerun. An additional 16 (3.2%) samples indicated that manual sediment review was necessary owing to “voteout,” which means that the UF-100 detected information that could not be interpreted by its algorithms.

In routine operation, both the flow error samples on 900UDx and the total count/conductivity error urines on UF-100 would typically be diluted and rerun, although neither instrument provides the option of built-in dilution factor compensation.

Effectiveness of Atlas and Super UA Systems in Screening for Positive/Negative Sediment

Chemical urinalysis to eliminate the need for sediment analysis could save considerable time, although at the expense of some missed sediment findings [3]. Using this process, samples with negative or trace results for blood, leukocyte esterase (trace or <25 cells/ μ L), protein (30 mg/dL), or nitrite would not have sediment analysis performed by either manual microscopy or a sediment analyzer such as the 900UDx or the UF-100. Table 6 summarizes the relative effectiveness of the Atlas and the Super UA in

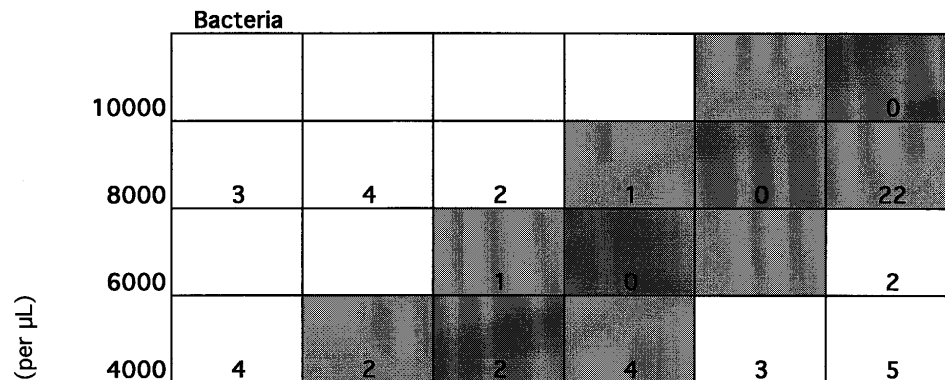


TABLE 6. Sediment Analysis of Samples Positive or Negative by Chemical Urinalysis

		Atlas POS	Atlas NEG	SupUA POS	SupUA NEG
	Total	154	341	154	341
POS by both UF and UDx	150	99	51	99	51
NEG by both UF and UDx	253	24	229	26	227

Criteria for positive result by each instrument were as follows:

RBC, >5/hpf (UDx) and ≥ 28 (UF); WBC, ≥ 5 /hpf (UDx) and ≥ 28 (UF); bacteria, \geq few (UDx) and ≥ 4000 (UF); yeast: "any" (UDx) and ≥ 35 , nonreportable, or flag (UF); total casts, >1/lpf (UDx) and ≥ 2 (UF); path casts, "any" (UDx) and ≥ 0.55 , nonreportable, or flag (UF).

screening for negative-sediment samples on which manual microscopy would not be performed. The criteria for positive sediment are listed in Table 6.

Because we did not have manual counts on most samples, we considered 150 samples that were positive for sediment by both the 900UDx and the UF-100 to be true positives and 253 samples that were negative by both analyzers to be true negatives. Both the Atlas and the Super UA test strip analyzers had 341 samples negative by our criteria. Of these, 51 samples (15%) were apparently true positives and would have been missed by this screening method. Therefore, of the 495 samples in this comparison, screening for negative sediment samples by chemical urinalysis would have missed 51 samples that were sediment positives (about 10% of all samples). Of the 154 samples positive by chemical urinalysis, 55 (11% of all samples) would have had apparently unnecessary manual microscopy performed.

DISCUSSION

Our study was intended to evaluate 2 partly automated urinalysis systems for comparability of results with discrepancies resolved by selected manual microscopic review of sediment; efficacy of chemical urinalysis to minimize the need for sediment analysis; and relative ease and convenience of operability.

The comparability of chemical urinalysis results was excellent between the Atlas and the Super UA, with only 17 of 4500 total results from the 500 samples differing by 2 or more result ranks: 1 for ketone, 2 for pH, 6 for blood, and 8 for leukocyte esterase. The combination of our result range cutoffs allowed nearly all the discrepancies between the 2 analyzers to be eliminated. For example, combining the current results of 10 and 25 cells/ μ L for blood by the Super UA into a single result range of 1-25 cells/ μ L would eliminate the 6 discrepancies noted for blood. Similarly, combining

UF-100. These results agree with a recent report recommending that casts and yeast cells reported by the UF-100 should be confirmed by microscopic review, because false-positives occurred [4].

Bacterial counts represent special consideration. There were 111 discrepancies for bacteria, resulting from (1) the difficulty of accurately identifying and counting the many different types of bacteria, both live and dead, and (2) the different methods used by each analyzer to identify bacteria, as discussed previously in Results. Furthermore, because culturing detects live bacteria, it would not resolve these discrepancies, and the clinical value of any sediment bacteria count is questionable.

The percentages of samples that could not be measured by each instrument were relatively low: 2.2% (attributable to flow errors) for the 900UDx and 6.2% (system and sample errors) for the UF-100. In addition, urine samples in which nonhyaline casts were suspected (6.6%) in UF-100 would routinely be followed up by sediment examinations. Because the 900UDx relies on a skilled operator to identify and reject images, this analyzer rejects virtually no images. The UF-100 uses light scatter, fluorescence, and impedance measurements to directly quantitate the formed elements and more frequently relies on manual identification and counting when the data available cannot clearly identify a formed element.

Concerning screening by chemical urinalysis test strip to minimize sediment analysis, of the 341 samples negative for blood, protein, leukocyte esterase, and nitrite, 85% would be correctly identified as negative and 15% would have undetected abnormalities. Our study appears to be consistent with an earlier study that reported that 13% of samples negative by chemical urinalysis would be positive by manual microscopy [3]. That study also concluded that most of these undetected samples represent conditions that are clinically inconsequential. Whether this percentage of missed positives is generally acceptable remains to be answered in each institution.

the Sysmex UF-100. Our study also supports the conclusion that the urinalysis systems would be equally reliable in clinical practice.

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