Evaluation of the IDEXX SediVue Dx™ Urine Sediment Analyzer

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Background

Urine sediment microscopy has traditionally been a manual process that requires skilled technicians to prepare the sample and analyze the sample microscopically. Furthermore, urine samples should be analyzed within 60 minutes of collection to minimize sample degradation,[1] making submission to a reference laboratory suboptimal.

The IDEXX SediVue Dx™ Urine Sediment Analyzer has recently been introduced to the veterinary market to bring automation, consistency, efficiency, and accuracy to urine sediment microscopy. It is the only in-clinic automated microscopy analyzer designed for veterinary medicine and is intended for use with canine and feline urine samples.

The user dispenses 165 µL of fresh, unconcentrated urine into a consumable (the SediVue V70i™ Cartridge) before initiating the analysis. An onboard centrifuge accelerates settling of the formed elements onto the floor of the consumable before imaging. Seventy digital microscopic images, representing approximately 45 high-power (40X objective) fields of view are captured and analyzed with a convolutional neural network (CNN) to classify the formed elements. Semiquantitative results and digital images are provided to the user after approximately 3 minutes.

Similar technology is widely used in human reference laboratories for routine urinalysis,[2] however, the CNN was not "trained" for veterinary samples.[3] During the development of the SediVue Dx analyzer, IDEXX analyzed over 50,000 veterinary samples.

Materials and methods

To evaluate the performance of the CNN, a total of 631 urine samples were analyzed, using a combination of 15 SediVue Dx analyzers installed in general practices (12) and IDEXX Laboratories (3). To facilitate a thorough evaluation of analyzer performance, the sample set was deliberately biased toward samples with formed elements. The prevalence of formed elements in this sample set will not reflect typical veterinary practice.

The SediVue Dx images were manually analyzed by licensed technicians and by the SediVue CNN (algorithm version 1.0.0). The technicians were blinded to the reported results from the CNN.

Each sample was then determined to be positive or negative, using the average of the manual results with respect to each formed element. The clinically relevant thresholds used are provided in table 1. Any result greater than the threshold value was classified as positive.

The manual and automated results were compared and reported for red blood cells (RBCs), white blood cells (WBCs), squamous epithelial cells, nonsquamous epithelial cells (includes transitional and renal tubular), hyaline casts, nonhyaline casts (e.g., granular casts), struvite crystals, calcium oxalate dihydrate crystals, unclassified crystals (all crystals except struvite and calcium oxalate dihydrate), bacteria rods, and bacteria cocci.

Formed element	Threshold	Unit
RBC	5	HPF
WBC	5	HPF
Squamous epithelial cell	1	HPF
Nonsquamous epithelial cell	1	HPF
Hyaline cast	1	LPF
Nonhyaline cast	1	LPF
Struvite crystal	1	HPF
Calcium oxalate dihydrate crystal	1	HPF
Unclassified crystal	1	HPF
Bacteria: rods	Present	per sample
Bacteria: cocci	Suspect presence	per sample

LPF = low-power field (10X objective)
HPF = high-power field (40X objective)

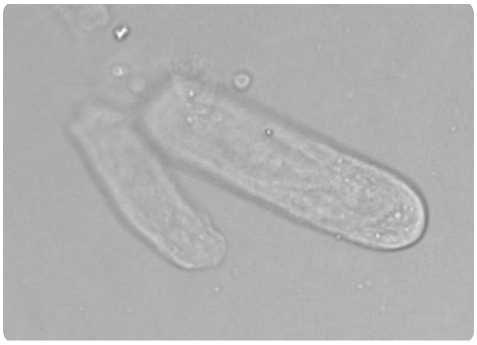
Table 1. Clinically relevant thresholds used to determine if a sample was positive or negative for each formed element.

Results

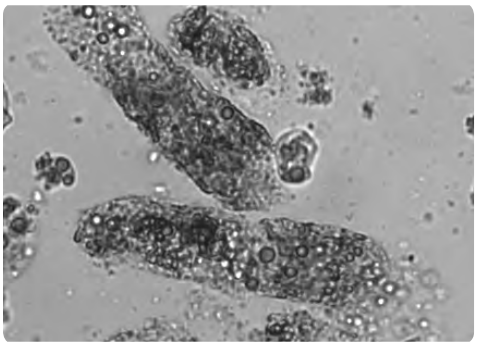
The results are summarized in tables 2 and 3.

Formed element	Positive sample count	Negative sample count
RBC	182	449
WBC	147	484
Squamous epithelial cell	48	583
Nonsquamous epithelial cell	217	414
Hyaline cast	51	580
Nonhyaline cast	86	545
Bacteria: rods	81	550
Bacteria: cocci	77	554
Struvite crystal	74	557
Calcium oxalate dihydrate crystal	37	594
Unclassified crystal	16	615

Table 2. Manual classification of the 631 urine samples according to the thresholds defined in table 1.



Hyaline casts



Non-hyaline casts

Figure 1. Example images from urine sediments obtained with the IDEXX SediVue Dx™ Urine Sediment Analyzer.

Blood cells

	Red	White
None to rare	95.1% (n = 434)	93.5% (n = 492)
>5/HPF	81.7% (n = 197)	82.7% (n = 139)

Epithelial cells

	Squamous	Nonsquamous
None to rare	98.0% (n = 588)	86.7% (n = 437)
>1/HPF	83.7% (n = 43)	82.0% (n = 194)

Casts

	Hyaline	Nonhyaline
None to rare	97.3% (n = 552)	95.0% (n = 501)
>1/LPF	95.5% (n = 22)	68.5% (n = 54)
Suspect presence*	(n = 57)	(n = 76)

*Confirm with review of SediVue Dx images.

Bacteria

	Rods	Cocci
None to rare	95.2% (n = 523)	92.3% (n = 534)
Present	72.4% (n = 58)	Not applicable
Suspect presence*	(n = 50)	(n = 97)

*Confirm with an air-dried, stained cytological preparation and/or urine culture and sensitivity.

Crystals

	Struvite	Calcium Oxalate dihydrate	Unclassified
None to rare	97.0% (n = 559)	98.3% (n = 601)	99.6% (n = 488)
>1/HPF	79.2% (n = 72)	90.0% (n = 30)	9.8% (n = 143)

Table 3. The SediVue Dx CNN performance for the 631 samples showing percentage agreement with the manual review of SediVue Dx images.

Discussion

These findings document that the SediVue Dx™ Urine Sediment Analyzer provides high clinical utility. This analyzer enables general practitioners to perform urine microscopy with standardization, efficiency, and accuracy.

The images were consistently of excellent quality and available for user review, consultation, and sharing with the pet owner. A selection of the images were then stored in the permanent patient record (figures 1 and 2).

As with conventional microscopy by an experienced technician, noncast structures resembling genuine casts can be problematic for the CNN. Examples include mucus threads, amorphous debris or crystalline material, clumps of epithelial cells or WBCs, and others. The user is encouraged to review images for immediate verification of positives and "suspect presence" results. This replicates what takes place at most academic and commercial reference laboratories: experienced technicians consult with other colleagues to assure accurate reporting.

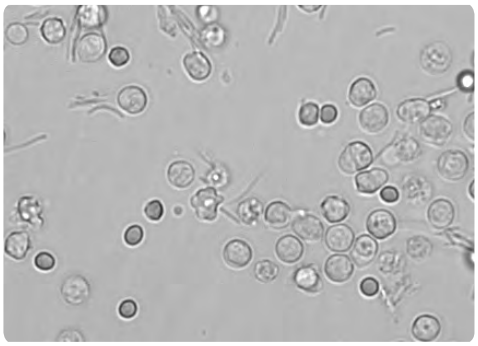
Identification of coccal bacteria is also a well-documented challenge with manual microscopy.[4] To avoid over- and underinterpreting cocci presence, the SediVue Dx results report uses "suspect presence" and recommends follow-up testing, including manual microscopy with an air dried, stained cytological preparation and/or urine culture and sensitivity. This approach is similar to the recommendations for manual microscopy by well-trained technicians to improve both the sensitivity and specificity for bacterial identification.[4]

The "crystals unclassified" parameter is intended to alert the user to possible crystalline material other than struvite or calcium oxalate dihydrate. Crystals currently include ammonium biurate, cystine, amorphous crystalline material, and others. In addition, fragments and portions of struvite crystals, as well as small calcium oxalate dihydrate crystals, may also be incorporated into this category. Therefore, manual review of the images provided with the SediVue Dx results report is recommended.

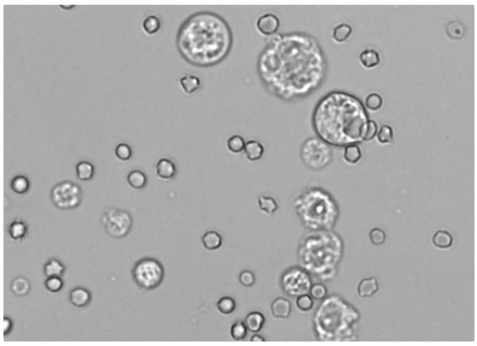
When unclassified crystals are below the threshold, there was strong agreement (99.6%) between the SediVue Dx analyzer and the manual method. However, for samples above the threshold, the lack of agreement (9.8%) was largely driven by the fact the manual review did not include amorphous crystalline material or crystal fragments as "crystals unclassified." Furthermore, the system was designed to provide high sensitivity to assure that unclassified crystals were not missed; this could result in a significant number of false positives. Again, the review of images provides immediate verification.

Future enhancements of the CNN, with the evaluation of additional sample sets, will expand the reported parameters, such as more detailed reporting of crystals or additional formed elements.

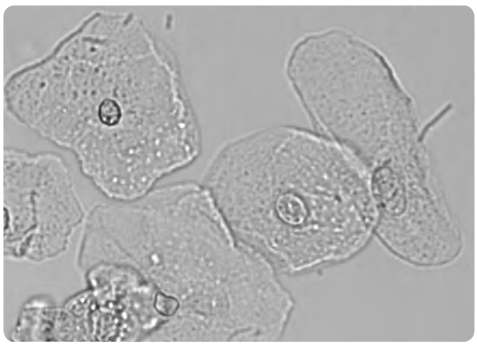
In conclusion, the SediVue Dx™ Urine Sediment Analyzer enables veterinary practices to perform quality urine sediment microscopy in-clinic in a timely fashion.



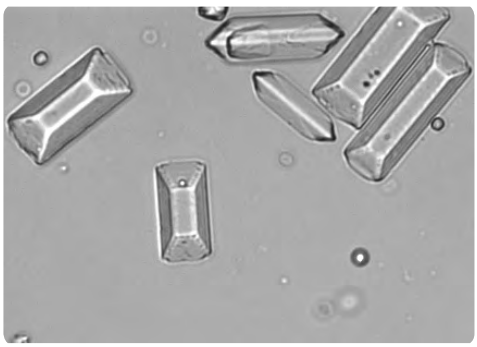
WBCs, RBCs, and bacteria (rods)



Non-squamous epithelial cells, RBCs and WBCs



Squamous epithelial cells and few bacteria (rods)



Struvite crystals

Figure 2. Example images from urine sediments obtained with the IDEXX SediVue Dx™ Urine Sediment Analyzer.

References

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3. Hammond J, Myrick C, McCrann DJ, Scott M, Bilbrough G, DeNicola DB. Application of current automated microscopy technology to qualitative identification of urine formed elements in veterinary medicine [ASVCP abstract]. *Vet Clin Pathol*. 2015;44(4):E1–E18.
4. Swenson CL, Boisvert AM, Gibbons-Burgener SN, Kruger JM. Evaluation of modified Wright-staining of dried urinary sediment as a method for accurate detection of bacteriuria in cats. *Vet Clin Pathol*. 2011;40(2): 256–264.