Use of a LaserCyte® for the complete blood count in dogs with oncohematological disorders

A. Gavazza*, G. Lubas, D. Maccari, M. Bizzeti, B. Gugliucci and M. Giorgi

Department of Veterinary Clinic, University of Pisa, Italy
*Correspondence: Via Livornese, lato monte, 56122 San Piero a Grado, Pisa, Italy, E-mail: agavazza@vet.unipi.it

(Received July 17, 2012; Accepted January 20, 2013)

Abstract

The reliability of complete blood counts (CBC) obtained by LaserCyte® were evaluated in 41 dogs affected by malignant lymphoma (29 cases), leukemia (8 cases) and miscellaneous blood disorders (4 cases). A total of 89 CBCs were performed. Different degrees of anemia, leukocytosis, leucopenia and thrombocytopenia or thrombocytosis were detected. Results provided from LaserCyte® were compared with those from HeCo VET C® impedance cell counter, manual leukocyte differential counts and reticulocyte counts by the regression coefficient (r). The LaserCyte® cell counter provides reliable results for diagnosing and monitoring onco-hematological disorders, in part due to the provision of alarm codes that indicate when a review of the stained blood smear is necessary. The only unreliable CBC parameter was eosinophil count.

Keywords: CBC; LaserCyte®; Dogs; Oncohematological disorders; Blood cell count.
Available online at http://www.vetmedmosul.org/ijvs

إستخدام ليزرسايت لعد مكونات الدم في الكلاب ذوات اضطرابات دموية مسرطنة

أي كفازا، جي لوباس، دي مكاري، إم بيزتي، بي كوليوجي و إم جيورجي

قسم العلوم السريرية البيطرية، جامعة بيزا، ايطاليا

الخلاصة

جرى تقييم عد مكونات الدم الكامل بجهاز ليزرسايت ®LaserCyte في ٤١ كلباً تعاني من تأثر الغدد الليمفاوية الخبيثة (٢٩ حالة)، وسرطان الدم (٨ حالات) واضطرابات الدم المتنوعة (٤ حالات). تم تنفيذ ما مجموعه ٨٩ فحصاً، وتم الكشف عن درجات مختلفة من فقر الدم، وزيادة عدد الكريات البيض ونقصها فضلاً عن نقص الصفيحات الدموية أو كثرتها. وتمت مقارنة النتائج مع تلك الناتجة من فحص هيكو ®VETC والعد اليدوي بمعامل الانحدار. ولوحظ بأن الليزرسايت يقدم نتائج موثوقة لتشخيص ورصد اضطرابات الكلاب الدموية المسرطنة، ويرجع ذلك جزئيا إلى توفير رموز التنبيه التي تشار عند فحص المسحات الدموية. وكان الفحص الوحيد الذي لايمكن الاعتماد علية هو عد الكريات الحمضة.

Introduction

In veterinary clinical practice it is important to have a cell counter that provides convenient, rapid and reliable complete blood counts (CBC), even during severe hematolological derangements (1). In several oncohematological diseases, as lymphomas and leukemia, drastic alteration of the CBC are observed (anemia, leukocytosis, leucopenia, thrombocytopenia and thrombocytosis). The increasing availability of more sophisticated instruments means that they should be accessible, even to a practitioner working in small to medium size facilities (2). LaserCyte® is a laser cell counter that measures 24 hematological parameters including reticulocytes, important markers of degree of regeneration in cases of anemia, and the complete differential leukocyte count (1-3).

The goal of this study was to evaluate reliability of the hematological results supplied by LaserCyte® for dogs with previously diagnosed oncohematological disorders (4,5). These findings were compared with results obtained from an impedance cell counter (HeCo VET C®), and from manual counts of both the leukocyte partition and reticulocytes.

Materials and methods

Patient selection

Forty-one dogs of various breed, gender, and age were included in the described study (Tables 1, 2). These dogs had been diagnosed with several different hematological disorders, including malignant lymphoma (ML) (n= 29), leukemia (LEUK) (n= 8) and other miscellaneous blood disorders (MBD) (n= 4). Most of these patients were repeatedly tested over the time period resulting in 89 CBCs in total. Full information on signalment and diagnosis is reported in Table 2.

The diagnosis was formulated based on complete physical examination and the interpretation of several laboratory investigations including CBC, serum biochemical profile, urinalysis, serum protein electrophoresis, *Leishmania infantum* and *Ehrlichia canis* serology, lymph-node and bone marrow cytopathological evaluation, immunophenotyping on cell retrieved from lymph node, bone marrow or peripheral blood, and diagnostic imaging (abdominal ultrasound and/or thoracic and/or abdominal radiology) (6-8). The blood collected from the jugular vein or, alternatively, from the cephalic vein was split in two tubes with K3EDTA as anticoagulant. One tube was analyzed by HeCoVet C® cell counter, and the other by Lasercyte®. All the blood samples were analyzed within one hour of the collection.

Table 1: List of malignant lymphoma cases in dogs.

Case number (breed, gender, year)	Cytological diagnosis	Immuno-phenotype	Clinical diagnosis	CBCs (n)
1-8 (Mixed, f 9y; Bullmastiff, m 5y; Labrador, f 5y; Argentine Dogo, f 6y; Shitzu, m 9y; Labrador, m 5y; Mixed, m 8y; German shepherd, m 9y)	Centroblastic polymorphic	B-cell	Multicentric lymphoma, stage III	15
9 (German shepherd, f 9y)	Small cell	T-cell		7
10 (Boxer, m 9y)	Lymphoplasmocitic			2
11-15 (Mixed, m 5y; Rottweiler, f 9y; German shepherd, m 7y; Corso, f 8y; Mixed, m 6y)	Centroblastic polymorphic	B-cell	Multicentric lymphoma, stage IV	13
16-17 (Dobermann, m 5y; German shepherd, m 5y)	Immunoblastic			10
18 (Dobermann, f 10y)	Lymphoblastic	nd		3
19-22 (Collie, m 11y; Bulldog, m 6y; Mixed, f 5y; German shepherd, m 13y)	Centroblastic polymorphic	B-cell	Multicentric lymphoma, stage Va	4
23 (Boxer, f 10y)	Mixed Pleomorphic	T-cell		1
24 (Mixed, f 8y)		nd	Intestinal lymphoma, stage IV	1
25 (Boxer, m 7y)	Mixed Pleomorphic		Mediastinal lymphoma	1
26 (Mixed, m 9y)	Lymphocitic	T-cell		1
27 (Golden Retriever, m 8y)	Lymphoblastic			5
28 (Dobermann, m 10y)	Macronucleated medium size cell	nd	Multicentric lymphoma, stage Vb	1
29 (Golden Retriever, f 4y)	Immunoblastic	T-cell		1

Legend: f, female; m, male; nd, not determined; n, number; y, year; romanic numbers represent clinical stage of lymphoma.

LaserCyte® cell-counter

LaserCyte® Hematology Analyzer (IDEXX, Laboratories Inc., Westbrook, ME, USA) is a laser cell counter that measures 24 hematological parameters: total erythrocyte count (RBC), hematocrit (HCT), hemoglobin (HGB), mean corpuscular volume (MCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell dimension width (RDW), reticulocytes (RETIC both percentage [%] and absolute value [av]), total leukocyte count (WBC), neutrophils count (NEU, both % and av), lymphocytes (LYM, both % and av), monocytes

(MONO, eosinophils (EOS, both % and av), basophils (BAS, both % and av), platelet (PLT), mean platelet volume (MPV), plateletcrit (PCT) and platelet dimension width (PDW). Both parameters are reported as absolute or percentage values within about ten minutes of the analysis commencing (using the 1.84 version software) (1,2,9).

LaserCyte® requires 95 µl of anticoagulated blood collected in the VetCollect™ lavender top tube. This is mixed with a special solution containing new Methylene blue dye, a reagent that cause the erythrocytes to became spherical, and qualiBeads®, this mixture is provided in a tube, CBC5R. The LaserCyte® has 33 different 'alarm codes' that appear on the result data sheet if there has been a problem during sample analysis. These codes query the validity of one or more of the values obtained. Moreover, they instruct the operator to carry out trouble shooting investigations (2,9).

Table 2: Cases of leukemia and miscellaneous blood disorders.

Case number (breed, gender, year)	Clinical and cytological diagnosis	CBCs (n)
Leukemia		
30-31(Golden Retriever, f 4y; Mixed, f 9y)	Acute lymphoblastic leukemia	2
32-34 (Mixed, m 5y; German shepherd, f 6y; English Setter, m 9y)	Acute myeloid leukemia	3
35 (Mixed, f 3y)	Acute myelomonocitic leukemia	1
36 (Pomeranian, m 11y)	Chronic lymphatic leukemia	1
37 (Mixed, f 12y)	Essential thrombocytemia	6
Miscellaneous blood disorders		
38 (Labrador, m 12y)	Multiple myeloma	3
39 (Rottweiler, f 9y)	Paraneoplastic syndrome from an oral carcinoma	2
40 (Weimarainer, m 12y)	Paraneoplastic syndrome of unknown origin	4
41 (Mixed, m 10y)	Leukemoid reaction from gastrointestinal neoplasia	1

Legend: f, female; m, male; n, number; y, year.

Comparative instrumentation or procedure

For comparative purposes an electric impedance cell-counter HeCo VET C® (SEAC, Calenzano, Firenze, Italy) was used. This device does not measure leukocyte differential or reticulocyte count however, these were obtained through manual methods. The HeCo VET C® measures RBCs, WBCs, PLTs, MCV, and MPV directly by means of impedance principle. Subsequent calculations provide MCH, MCHC, RDW and PDW. HGB is measured directly by means of photometric method, using a solid sensor with a 546 nm filter (10,11).

The manual leukocyte differential count was performed on a thin peripheral blood smear, prepared within one hour of blood collection and stained with Diff-Quik® (Medion Diagnostics GmbH, Dudingen, Switzerland). Using a light microscope, at least 100 WBCs were subdivided into five populations (NEU, LYM, MONO, and EOS) by two different experienced operators. The BASO count was not performed as the stain technique used does not adequately identify dog basophils. Reticulocyte count was performed using the new methylene blue technique and by counting at least 1,000 RBCs. Only samples with a HCT of less than 30% were evaluated by this method, there were 28 samples fitting this criteria. The entire procedure for comparison is similar to that reported in previous papers (3,12-19).

Statistical analyses

In order to compare results obtained from LaserCyte® and the adopted comparative methods, a linear regression study was performed (Excel®, Microsoft). The regression line, its equation, the resulting regression coefficient (*r*) values and the calculated P value were considered (20,21-25).

The (*r*) value estimates the concordance between two methods, it is considered optimal within the range 1-0.9, fair between 0.89-0.75, acceptable between 0.74-0.5 and inadequate when < 0.5 (10,16,17,19).

Both the full (with and without considering the alarm) results and results without considering the alarm were compared with the results obtained using HeCo VET C®.

Results

The (*r*) values for all the samples obtained both before and after considering the alarm codes flagged by LaserCyte® are reported in Table 3.

It is noteworthy that 57 out of 89 CBCs showed several degrees of anemia and 34 out of 89 and 25 out of 89 showed leukocytosis and leucopenia, respectively.

Table 3: Regression coefficient (*r*) measured for all the CBCs.

Parameter	Results irrespective of alarm codes			Results considering alarm codes		
	CBCs (n)	(*r*)	evaluation	CBCs (n)	(*r*)	evaluation
RBC	89	0.95 **	Optimal	88	0.95 **	Optimal
HCT	89	0.94 **	Optimal	88	0.94 **	Optimal
HGB	88	0.97 **	Optimal	72	0.97 **	Optimal
MCV	89	0.77 **	Fair	88	0.77 **	Fair
MCH	89	0.37 *	Inadequate	88	0.37 *	Inadequate
MCHC	64	0.14 ns	Inadequate	64	0.14 ns	Inadequate
RDW	89	0.85 **	Fair	88	0.83 **	Fair
% RETIC	28	0.81 **	Fair	28	0.81 **	Fair
RETIC	28	0.74 **	Acceptable	28	0.74 **	Acceptable
WBC	88	0.98 **	Optimal	71	0.97 **	Optimal
NEU	88	0.32 *	Inadequate	59	0.97 **	Optimal
LYM	88	0.67 **	Acceptable	58	0.90 **	Optimal
MONO	88	0.24 *	Acceptable	51	0.81 **	Fair
EOS	88	0.03 ns	Inadequate	66	0.19 ns	Inadequate
PLT	89	0.97 **	Optimal	82	0.92 **	Optimal
MPV	87	0.55 **	Acceptable	80	0.58 **	Acceptable

Legend: **, P< 0.01; * P< 0.05; ns, not significant.

In the described study, some parameters (mostly MCHC, occasionally HGB, WBC, NEU, LYM, MONO, EOS, and MPV) were not considered because LaserCyte® software did not provide results when these values were out of acceptable ranges.

CBC results, irrespective of whether or not the alarm was triggered gave optimal (r) values for RBC, HCT, HGB, WBC, and PLT, fair values for MCV, RDW, and % RETIC, acceptable values for RETIC, LYM, MONO and MPV, but inadequate values for MCH, MCHC, NEU, and EOS. Using flagged values or values detected with alarm codes (r) only improved consistency for NEU (from inadequate to optimal), LYM (from acceptable to optimal), and MONO (from acceptable to fair). In contrast, the (r) value did not improve for the other parameters.

65 CBCs from ML patients were examined, however some parameters (mostly MCHC, occasionally HGB, WBC, NEU, LYM, MONO, and EOS) were not measured for the reasons stated above. The (*r*) value was optimal for RBC, HCT, HGB, WBC, and PLT, fair for RDW and NEU, and finally acceptable for MCV, % RETIC, RETIC, MONO, and MPV, it was inadequate for MCH, MCHC, and EOS however.

Thirteen CBCs from LEUK patients were examined. The (*r*) was optimal for RBC, HCT, WBC, NEU, and MPV, fair for HGB, MCV, and LYM, acceptable for MCHC and MONO, RDW and % RETIC, but inadequate for MCH, RETIC, EOS, and PLT. Some parameters could not be evaluated due to the small sample size.

Ten CBCs from MBD patients were examined. The (*r*) was optimal for RBC, HCT, HGB, RDW, % RETIC, RETIC, WBC, NEU, MONO, and PLT, fair for MCV, and MCH, acceptable for LYM and EOS, but inadequate for MCHC and PLT.

The (*r*) obtained considering the alarm codes and subdividing the patients based on their disorder are reported in Table 4.

The significance of alarm codes occurring in this study is reported in Table 5.

The occurrence of alarm codes from the CBCs obtained from LaserCyte® in all patients and in patients subdivided by disorders is reported in Table 6. The most frequently recorded alarms were the HI 1 and RB 9, followed by DB 1/2 and DB 1/3.

Discussion

The LaserCyte® and associated software considerably aid the practitioner in evaluating patient CBCs. Indeed, even if there is severe hematological derangement, the instrument has alarms that guide interpretation of results.

Specifically, there was optimal concordance between the LaserCyte® and HeCo VET C® for RBC, HCT and HGB. Hence, LaserCyte® can correctly identify anemia regardless of severity, as previously documented in other papers (5,17).

The concordance between the two instruments for MCV was always fair except in the lymphoma cases where the (*r*) decreased to 0.71. In contrast, MCH and MCHC produced inadequate values, because these parameters are computed and not measured.

Table 4: Regression coefficient (*r*) measured for the different disorder groups (after considering the alarm codes from LaserCyte®).

Parameter	Lymphoma patients			Leukemia patients			Miscellaneous blood disorder patients		
	n° of CBCs	(*r*)	evaluation	n° of CBCs	(*r*)	evaluation	n° of CBCs	(*r*)	evaluation
RBC	65	0.95 **	Optimal	13	0.96 **	Optimal	10	0.97 **	Optimal
HCT	65	0.92 **	Optimal	13	0.95 **	Optimal	10	0.94 **	Optimal
HGB	53	0.98 **	Optimal	12	0.88 **	Fair	7	0.95 **	Optimal
MCV	65	0.71 **	Acceptable	13	0.79 **	Fair	10	0.81 **	Fair
MCH	65	0.47 **	Inadequate	13	0.07 ns	Inadequate	10	0.77 **	Fair
MCHC	45	0.03 ns	Inadequate	10	0.51 ns	Acceptable	9	0.16 ns	Inadequate
RDW	65	0.80 **	Fair	13	0.67 **	Acceptable	10	0.95 **	Optimal
% RETIC	14	0.63 *	Acceptable	11	0.64 *	Acceptable	3	1.00 **	Optimal
RETIC	14	0.64 **	Acceptable	11	0.24 ns	Inadequate	3	1.00 **	Optimal
WBC	53	0.99 **	Optimal	11	0.96 **	Optimal	7	1.00 **	Optimal
NEU	46	0.81 **	Fair	6	0.99 **	Optimal	7	0.99 **	Optimal
LYM	44	0.91 **	Optimal	7	0.87 ns	Fair	7	0.54 ns	Acceptable
MONO	39	0.62 **	Acceptable	5	0.60 ns	Acceptable	7	1.00 **	Optimal
EOS	51	0.01 ns	Inadequate	8	0.16 ns	Inadequate	7	0.60 ns	Acceptable
PLT	65	0.93 **	Optimal	7	0.23 ns	Inadequate	10	0.97 **	Optimal
MPV	65	0.62 **	Acceptable	5	0.92 *	Optimal	10	0.40 ns	Inadequate

Legend: **, P< 0.01; * P< 0.05; ns, not significant; nd, not determined.

Table 5: Significance of alarm codes of Lasercyte® occurred in this study.

Code	Full text	Flagged Parameters	Type of message[1]	Explanation	Troubleshooting
HI 1	HGB sheath timing	HGB	(a)	Issue reading the HGB reference solution.	Confirm the HGB results
PB 1	PLT out of reportable range	PLT reported as either <1 K/μL or >2500K/μL	(b)	If the PLT value is <1 K/μL, the MPV, PDW and PCT are not reported and PLT is less than 1 K/μL	If the PLT value is >2500 K/μL, Evaluate the patient's condition; if a very high or low PLT value is not expected, rerun sample or evaluate blood film
RB 1	Too many RBC fragments	RBC, HCT, MCH, MCHC, RETIC, %RETIC, PLT, MPV, PDW, PCT	(b)	Fragile RBCs may interfere with the PLT and RBC counts	Confirm the PLT value with a blood film
RB 3	Low PLT statistics. Distribution parameter not reported	MPV, PDW, PCT – no results reported	(b)	The PLT count was less than 25 K/μL	Evaluate the patient's condition; if a very high or low PLT value is not expected, rerun the sample or evaluate the blood film
RB 9	MCHC out of reportable range	MCHC – no results reported. RBC, HCT, PLT, PCT, MCV, MPV	(b)	The MCHC was outside the reportable range (24.0-39.5 g/dL).	Evaluate the patient's condition; if a very high or low PLT value is not expected, rerun the sample
WI 4	Internal QA failure; qualiBeads® not recovered	HGB, WBC, LYM, MONO, NEU, EOS, BASO, %LYM, %MONO, %NEU, %EOS, %BASO – no results reported	(a)	The analyzer did not recover the expected number of qualiBeads® (the internal quality assurance)	Rerun the sample

1 - Type of message: (a) instrument message, (b) sample message.

Table 6: Frequency of occurrence (%) of the alarm codes in the CBCs obtained from Lasercyte® in all patients and in patients subdivided by different blood disorders.

Alarm code	All cases	Lymphoma cases	Leukemia cases	Miscellaneous blood disorders
DB 1/2	16.5	19.1	13.5	0.0
DB 1/3	12.4	15.7	6.4	0.0
DB 1-5	1.0	1.4	0.0	0.0
DB 3/4	0.6	0.0	2.6	0.0
DB 7	3.9	2.9	7.7	0.0
DB 10	2.3	1.9	3.8	0.0
HI 1	20.3	19.5	7.7	83.3
PB 1	4.1	0.0	16.0	0.0
RB 1	5.1	0.0	19.9	0.0
RB 3	1.6	0.0	6.4	0.0
RB 9	29.3	38.1	8.3	16.7
WB 1	1.9	0.0	7.7	0.0
WI 4	1.0	1.4	0.0	0.0

The value of RETIC was acceptable and RETIC % was fair, there was no improvement in these values, even when alarm codes were considered. When patients were analysed according to disorder, the (*r*) was optimal for MBD cases, acceptable for ML cases and acceptable or inadequate (for RETIC and % RETIC, respectively) for LEUK cases. It should be noted that in the LEUK cases, a severe disorder involving RBC was also occurring.

According to previous papers (5,16), the WBC evaluation was optimal. In the differential WBC counts, the value of NEU and LYM was optimal if the alarm codes were considered. The (*r*) for the different disorders was optimal for ML, fair for LEUK cases and acceptable in the MBD cases. It is well established that NEU and LYMP make up a large proportion of the canine WBC population and LaserCyte® is able to characterize them, even in very severe blood disorders.

The concordance for MONO was acceptable if the alarm codes were not considered and fair if they were. Considering both the nature of the disorder and the alarm codes, the (*r*) was acceptable for ML and LEUK patients and optimal for MBD cases. This data reflects the very severe derangements in ML and LEUK patients, this is especially true for the WBC differential counts. In addition, a previous investigation has already reported some difficulties in correctly identifying MONO using LaserCyte® (17).

The EOS value was inadequate in all cases even when the alarm was considered. The lack of concordance for EOS between LaserCyte® and manual differential count has been reported previously (17).

The analysis of PLT produced optimal consistency, except for LEUK patients.

The last parameter to be considered was MPV, concordance was only acceptable when the alarm codes were disregarded. This was likely due to the way in which the impedance instrument measures mean PLT size, it is unable to detect small PLT aggregates.

The frequency of occurrence of the several alarm codes from LaserCyte® was reported and related to the above results for each CBC parameter. The alarm code most represented was RB 9, which is "MCHC out of reportable range", and indeed MCHC concordance was inadequate in all comparisons undertaken. The other, frequently occurring alarm code was related to MCHC, HI 1 "HGB sheath timing". Other two commonly noted alarm codes (DB 1/2 and DB 1/3) indicated that the LaserCyte® was unable to assess WBC morphology correctly because of difficulties in separating LYM from MONO and MONO from NEU respectively. In the LEUK patients, the PB 1 alarm code ("PLT out of reportable range") had a frequency in comparison to the other two disorders, probably because the LEUK patients included a case of essential thrombocytemia.

In conclusion, LaserCyte® appears to be a cell counter able to produce reliable results even during severe oncohematological disorders. If LaserCyte® is displaying alarm codes, these should always be taken into consideration as should the offered explanation and troubleshooting advice. Most of these recommendations include evaluation of the patient's condition and examination of a stained blood smear. Of course this reiterates that blood disorders require careful investigation that usually involves examination of the blood smear. The only parameters that was unreliable, even following consideration of the alarm codes, is the EOS count, this finding has already reported in previous papers.

Conflict of interest statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

Acknowledgement

This work was supported by athenaeum funds (ex 60% University of Pisa). The preparation of manuscript was not supported by any external funding. Authors acknowledged to Dr E. Owen (University of Queensland, Australia) the English editing of the manuscript.

References

1. Wenger-Riggenbach B, Hassig M, Hofmann-Lehmann R, Lutz H. Evaluation of the Lasercyte: an in-house hematology analyzer for dogs and cats. Comp Clin Pathol. 2006;15:117-129.
2. DeNicola D. IDEXX LaserCyte® hematology analyzer. Case study book and technical guide. Idexx Laboratories s.r.l. Italia, 2008;1-48.
3. Welles EG, Hall AS, Carpenter DM. Canine complete blood counts: a comparison of four in-office instruments with the ADVIA 120 and manual differential counts. Vet Clin Pathol. 2008;38:20-29.
4. Fernandes PJ, Modiano JF, Wojcieszyn J, Thomas JS, Benson PA, Smit R, Avery AC, Burnett RC, Boone LI, Johnson MC, Pierce KR. Use of the Cell-Dyn 3500 to predict leukemic cell lineage in peripheral blood of dogs and cats. Vet Clin Pathol. 2002;31:167-182.
5. Lara A, O'Keef AC,Corn S, Iazbik MC, Russell J, Couto CG. Evaluation of a Point-of-Care hematology analyzer in dogs and cats receiving anticancer chemotherapy. Veterinary Cancer Society Conference Huntington Beach, California. 2005;27-30.
6. Gavazza A, Lubas G, Valori E, Gugliucci B. Retrospective survey of malignant lymphoma cases in the dog clinical, therapeutical and prognostic features. Vet Res Commun. 2008;32:291-293.
7. Gavazza A, Sacchini F, Lubas G, Gugliucci B, Valori E. Clinical, laboratory, diagnostic and prognostic aspects of canine lymphoma: a retrospective study. Comp Clin Pathol. 2009;18:291-299.
8. Gavazza A, Lubas G, Gugliucci B, Maccari D, Rispoli D. Evaluation of a in-house laser cell counter in dogs affected by oncohematological disorders. Proc. LXIII SISVet, Udine 2009;262-264.
9. IDEXX Laboratories, Inc. LaserCyte® Guida dell'operatore (Operator manual) (2002-2004) IDEXX Laboratories Italia Srl. 8-59.
10. Pasquini A, Gavazza A, Lubas G, Gugliucci B. A guide to choose a cell-counter for veterinary hematology: proposal for a quality control protocol and a validation plan. Veterinaria. 1998;1:21-27.
11. SEAC. Manuale d'uso: contaglobuli HeCo VET C (User manual: cell counter Heco VET C). SEAC S.r.l, Firenze. 2006;3-96.
12. Davies DT, Fisher GV. The validation and application of the Technicon H 1 for the complete automated evaluation of laboratory animal hematology. Comp Hematol Int. 1991;1:91-105.
13. Koepke JA, Bentley SA, Pierre RV, Richardson-Jones MD, Ross DV, Saunders AM, Simson E, van Assendelft OW, Wilding P. Reference Leukocyte Count (Proportional) and Evaluation of Instrumental Methods. National Committee for Clinical Laboratory Standards (NCCLS) Document H20-A. 1992;12:1-55.
14. Tvedten H, Haines C. Canine automated differential leukocyte count: study using a hematology analyzer system. Vet Clin Pathol. 1994;23:90-96.
15. Tvedten H, Korcal, D. Automated differential leukocyte count in horses, cattle and cats using the Tecnnicon H-1 E hematology system. Vet Clin Pathol. 1996;25:14-22.
16. Dewhurst EC, Crawford E, Cue S, Dodkin S, German AJ, Papasouliotis K. Analysis of canine and feline haemograms using the VetScan HMT analyser. J Small Anim Pract. 2003;44:443-448.
17. Papasouliotis K, Cue S, Crawford E, Pinches M, Dumont M, Burley, K. Comparison of white blood cell differential percentages determinated by in-house LaserCyte hematology analyzer and a manual method. Vet Clin Pathol. 2006;35:295-302.
18. DeNicola DB, Matthews JA, Fernandes PJ, Frye MB. Comparison of reticulocyte counts to mean corpuscular volume and mean corpuscolar hemoglobin concentration in anemic dogs. Proc. 12th Cong Intl Soc Anim Clin Biochem. Istanbul, TU. 2006;22-26.
19. Roleff S, Arndt B, Bottema B, Junker L, Grabner A and Kohn B. Clinical evaluation of the CA530-VET hematology analyzer for use in veterinary practice. Vet Clin Pathol. 2007;36:155-166.
20. Passing H, Bablok W. A new biometrical procedure for testing the equality of measurements from two different analytical methods. Application of linear regression procedures for method comparison studies in clinical chemistry, Part I. J Clin Chem Clin Biochem. 1983;21:709-720.
21. Passing H, Bablok W. Comparison of several regression procedures for method comparison studies and determination of sample sizes. Application of linear regression procedures for method comparison studies in Clinical Chemistry, Part II. J Clin Chem Clin Biochem. 1984;22:431-445.
22. Bland JM, Altman, DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307-310.
23. Bablok W, Passing H, Bender R, Schneider B. A general regression procedure for method transformation. Application of linear regression procedures for method comparison studies in clinical chemistry, Part III. J Clin Chem Clin Biochem. 1988;26:783-790.
24. Gray TE, Pratt MC, Cusick PK. Determination of agreement between laboratory instruments. Contemp Top Lab Anim Sci. 1999;38:56-59.
25. Twoney PJ, Kroll MH. How to use linear regression and correlation in quantitative method comparison studies. Int J Clin Pract. 2008;62:529-538.