COLLEGE of AMERICAN PATHOLOGISTS

Surveys and Anatomic Pathology Education Programs

Comprehensive Hematology with Automated Differential
FH9-B 2020

Participant Summary

1.0 Credit of Continuing Education Available

This document is available online in e-LAB Solutions Suite.

© 2020 College of American Pathologists. The CAP does not permit reproduction of any substantial portion of the material in this Report without its written authorization. The CAP hereby authorizes participants in the program to use the material in this Report solely for educational purposes within their own institutions. The CAP prohibits use of the material in the Report — and any unauthorized use of the CAP's name or logo — in connection with promotional efforts by marketers of laboratory equipment, reagents, materials, or services. Data from this program do not necessarily indicate the superiority or inferiority of instruments, reagents, or other materials used by participating laboratories. Use of these data to suggest such superiority or inferiority may be deceptive and misleading. The CAP will take all steps open to it under the law to prevent unauthorized reproduction of substantial portions of the material in this Report, deceptive use of any such material, and any unauthorized use of the CAP's name or logo in connection with promotional efforts by marketers of laboratory equipment, reagents, materials, or services.

TABLE OF CONTENTS

HEMATOLOGY AND CLINICAL MICROSCOPY COMMITTEE

Eric D. Hsi, MD, FCAP, Chair
Natasha M. Savage, MD, FCAP, Vice Chair

Archana M. Agarwal, MD, FCAP
Catalina Amador, MD, FCAP
Kyle T. Bradley, MD, MS, FCAP
Yuri D. Fedoriw, MD, FCAP
Alexandra E. Kovach, MD, FCAP
Rebecca L. Kunak, DO, Junior Member
Michael R. Lewis, MD, FCAP
Etienne R. Mahe, MD, MSc, FCAP
Megan O. Nakashima, MD, FCAP
Horatiu Olteanu, MD, PhD, FCAP
Sherrie L. Perkins, MD, PhD, FCAP, Advisor
Olga Pozdnyakova, MD, PhD, FCAP
Philipp Raess, MD, FCAP
Timothy P. Skelton, MD, PhD, FCAP
Lauren B. Smith, MD, FCAP
Lawrence Tsao, MD, FCAP
Maria (Ria) Vergara-Lluri, MD, FCAP
Roberta L. Zimmerman, MD, FCAP
Amrom Obstfeld, MD, PhD, ICSH, Liaison

© 2020 College of American Pathologists

INSTRUMENT SURVEY PLACEMENT

Being in the correct Survey will provide better statistics when determining instrument performance. Please use the chart below as well as the Surveys catalog page to ensure your instrument is in the correct Survey. Contact the CAP customer service department to make a change in Survey prior to the next mailing.

Instrument	Appropriate FH Survey
Abbott Cell Dyn Emerald	FH1
Abbott Cell Dyn Sapphire	FH3
Coulter AcT, MD2-16	FH2
Coulter AcT Diff (AL, CP, OV)	FH10
Coulter LH 500	FH6
Coulter LH 780, 785	FH13
Coulter STKS	FH6
Coulter Unicell DxH 800	FH13
Horiba ABX Micros	FH2
Horiba ABX Pentra 60/80	FH10
Medonic M-Series	FH2
Mindray BC-3000/3200 Series	FH2
Siemens Advia 120/2120	FH4
Sysmex KX-21/KX-21N	FH1
Sysmex pocH 100i	FH1
Sysmex XE-2100 D/L (Blood center)	FH9
Sysmex XE 2100/2100 D/L	FH9
Sysmex XN Series	FH9
Sysmex XN L-Series	FH9
Sysmex XP-Series	FH1
Sysmex XS 1000i	FH9
Sysmex XT 1800i/2100i	FH9

© 2020 College of American Pathologists

2020 FH9-B
PARTICIPANT SUMMARY

Program Update

Don't Miss Out on this Educational Opportunity!
With your participation in CAP's Surveys programs, *every member of your team* can take part in education activities: earn Continuing Education (CE) credits or receive Self-Reported Training* at no additional charge.

This Survey mailing includes an online education activity to earn **1.0** CE credit. To access the activity, see page 33.

**CAP Self-Reported Training activities do not offer CE credit but can be used towards fulfilling requirements for maintenance of certification (MOC) by agencies such as the American Society of Clinical Pathology (ASCP). Please verify with your certifying agency to determine your education requirements.*

Evaluation Criteria

The CAP is required to submit PT results to the Centers for Medicare and Medicaid Services (CMS) for all labs that have provided a CLIA identification number. If you do not notify the CAP that your lab has discontinued testing of a regulated analyte, **a score of zero will be given**. Your reporting preferences are outlined on the CMS Analyte Reporting Selections document. If new products are ordered and/or canceled, this may affect your reporting selections, so it is recommended that you periodically check this report on e-*LAB* Solutions Suite, which will always reflect the most up-to-date information. This information can also be obtained by calling the Customer Contact Center at 800-323-4040, Option 1 (domestic) or 001-847-832-7000, Option 1 (international).

As published in the January 24, 2003 Federal Register, (42 CFR Part 493, Medicare, Medicaid, and CLIA Programs; Laboratory Requirements Relating to Quality Systems and Certain Personnel Qualifications; Final Rule) effective April 24, 2003, proficiency-testing (PT) providers are required to grade all analytes regulated for PT at 80% participant or referee consensus. For information on criteria for grading analytes not regulated for PT, please review your Participant Summary.

The quantitative data tables provided in this Participant Summary include multiple statistical values which may include the median, low, and high values reported for each peer group. The low and high values are not the limits of acceptability. The acceptable limits are located on your participant evaluation report.

To provide a timely evaluation of your results, statistics presented in this Participant Summary reflect participant data received by the due date.

In the event a result is not graded, a numeric code will appear next to your result. A definition of the code will appear on the first page of your evaluation. Please see "Actions Laboratories Should Take when a PT Result is Not Graded" on page 31.

Additional data is displayed for groups of 3-9 laboratories. This information is provided solely for internal use and may be used to perform a self-assessment.

© 2020 College of American Pathologists

Evaluation Criteria, cont'd.

Analytes regulated for proficiency testing appear in **bold** type.

Quantitative

Analyte	Target Value	Evaluation Criteria
Basophils*	Peer Group	± 3 SD or ±1.0 (whichever is greater)
Eosinophils*	Peer Group	± 3 SD or ±1.0 (whichever is greater)
Hematocrit	Peer Group	± 6%
Microhematocrit (waived)	Peer Group	± 6% or 2 SD (whichever is greater)
Hemoglobin	Peer Group	± 7%
IG	Not Graded	Educational
Immature Platelet Fraction	Not Graded	Educational
Lymphocytes*	Peer Group	± 3 SD or ±1.0 (whichever is greater)
MCV	Peer Group	± 3 SD
MCH	Peer Group	± 3 SD
MCHC	Peer Group	± 3 SD
Monocytes*	Peer Group	± 3 SD or ±1.0 (whichever is greater)
MPV	Peer Group	± 3 SD
Neutrophils/Granulocytes*	Peer Group	± 3 SD or ±1.0 (whichever is greater)
nRBC	Not Graded	Educational
Platelet Count	Peer Group	± 25%
RDW	Peer Group	± 3 SD
Red Blood Cell Count	Peer Group	± 6%
White Blood Cell Count	Peer Group	± 15%

Results for IG, Immature Platelet Fraction, and nRBC are **not** formally evaluated; however, statistics appear in the Participant Summary for your information.

Qualitative

Analyte	Evaluation Criteria
Blood Cell Identification*	80% referee or participant consensus

*Blood Cell Identification results are included in the CMS performance summary. In the event that Blood Cell Identification is not performed, results from the flow through differential will be reported.

© 2020 College of American Pathologists

Performing a Self-Evaluation When PT is Not Graded

Graded proficiency testing (PT) provides an external check on a laboratory's quality management program. The CAP strives to grade as many PT results as possible, but occasionally a laboratory's PT results are not graded. This most commonly occurs because there are an insufficient number of results to form a peer group for grading (Code 20) but may also arise from lack of consensus (Code 27), or for other reasons.

Good laboratory practices, the CAP Laboratory Accreditation Program, and other regulatory entities require that laboratories perform a self-assessment when a PT result is not graded. The self-evaluation must be documented.

There are different methods for performing a PT self-evaluation. The laboratory director is responsible for choosing a self-evaluation method appropriate for the laboratory's individual circumstances.

Any PT results falling outside the laboratory's established criteria for acceptable performance should be investigated and corrective action should be taken, as would be done for graded PT results.

Quantitative Results. If a specimen has fewer than 10 participants reporting PT results for a method/instrument, those results are not graded and are assigned "Code 20" by the CAP. The laboratory may then perform a self-evaluation using a target value from a similar method, all methods combined, or using the data provided in the Data Tables for Groups of 3-9 Laboratories. All this information can be found in the Participant Summary.

For example, your laboratory's ungraded PT result is 13.8 g/dL and a similar method has group mean of 13.77 g/dL. Your laboratory director can decide to use 13.77 g/dL as a target value and self-evaluate using the same range of acceptability that was used for graded results (± 7% in this example):

> Your Result: 13.8 g/dL (Not graded by CAP due to peer group size <10 laboratories)
> Target Value for a Similar Method: 13.77 g/dL (Found in the Participant Summary)
> Range of Acceptability: 12.8-14.8 g/dL (Target Value for Similar Method ± 7%)
> Self-Evaluation: Acceptable (Your result falls within range for acceptability)

© 2020 College of American Pathologists

White Blood Cell Count x 10E9/L or x 10E3/µL	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	2.82	0.10	3.6	46	2.83	0.09	3.1	44	16.95	0.28	1.7	46	6.47	0.25	3.8	46	2.87	0.08	2.7
Sysmex XE-2100 D/L (Bld Ctr)	61	2.86	0.07	2.4	62	2.85	0.09	3.2	62	16.99	0.49	2.9	62	6.45	0.23	3.6	62	2.88	0.12	4.1
Sysmex XE-5000	128	2.84	0.08	3.0	128	2.81	0.09	3.2	128	16.95	0.40	2.3	127	6.38	0.19	3.0	128	2.86	0.10	3.5
Sysmex XN-L Series	392	3.03	0.09	2.8	389	2.71	0.08	3.1	388	17.12	0.30	1.8	389	6.37	0.16	2.5	392	3.05	0.08	2.8
Sysmex XN-Series	2531	2.94	0.07	2.5	2539	2.68	0.07	2.8	2530	16.61	0.25	1.5	2533	6.16	0.13	2.0	2529	2.96	0.08	2.5
Sysmex XN-Series (RL App)	81	2.92	0.08	2.8	80	2.66	0.07	2.6	81	16.45	0.27	1.6	81	6.12	0.12	2.0	81	2.93	0.08	2.6
Sysmex XS (Except RL App)	499	3.13	0.09	3.0	497	2.81	0.09	3.1	497	17.51	0.33	1.9	493	6.53	0.15	2.3	498	3.15	0.09	2.9
Sysmex XS-1000iC (RL App)	65	3.11	0.09	3.0	65	2.84	0.09	3.0	65	17.58	0.38	2.2	65	6.55	0.18	2.7	65	3.16	0.10	3.3
Sysmex XT-1800i/2000i	96	2.82	0.11	3.8	97	2.82	0.09	3.2	97	16.93	0.50	3.0	97	6.62	0.20	3.0	96	2.84	0.10	3.4
Sysmex XT-4000i	78	2.83	0.10	3.6	80	2.82	0.10	3.6	78	16.95	0.52	3.0	78	6.62	0.21	3.1	79	2.83	0.10	3.6
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	2.8	2.7	2.9	8	2.7	2.7	2.9	8	16.8	16.3	17.2	8	6.4	6.2	6.6	8	2.8	2.7	2.9

Red Blood Cell Count 10E12/L or x 10E6/µL	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	48	6.256	0.087	1.4	48	2.320	0.032	1.4	48	5.231	0.061	1.2	48	4.353	0.049	1.1	47	5.253	0.060	1.1
Sysmex XE-2100 D/L (Bld Ctr)	64	6.256	0.071	1.1	64	2.317	0.028	1.2	64	5.225	0.065	1.2	64	4.353	0.039	0.9	64	5.240	0.068	1.3
Sysmex XE-5000	125	6.246	0.076	1.2	128	2.318	0.029	1.3	127	5.213	0.068	1.3	126	4.350	0.050	1.1	128	5.241	0.066	1.3
Sysmex XN-L Series	389	6.407	0.065	1.0	389	2.217	0.024	1.1	390	5.296	0.055	1.0	389	4.298	0.042	1.0	389	5.299	0.053	1.0
Sysmex XN-Series	2516	6.368	0.061	1.0	2533	2.224	0.028	1.2	2528	5.263	0.050	1.0	2526	4.288	0.040	0.9	2522	5.269	0.050	0.9
Sysmex XN-Series (RL App)	81	6.363	0.084	1.3	81	2.228	0.033	1.5	80	5.258	0.061	1.2	80	4.281	0.048	1.1	80	5.269	0.062	1.2
Sysmex XS (Except RL App)	495	6.354	0.057	0.9	497	2.257	0.025	1.1	493	5.279	0.048	0.9	494	4.312	0.040	0.9	493	5.279	0.045	0.9
Sysmex XS-1000iC (RL App)	61	6.307	0.061	1.0	62	2.304	0.041	1.8	60	5.270	0.034	0.6	62	4.337	0.041	0.9	62	5.284	0.048	0.9
Sysmex XT-1800i/2000i	97	6.337	0.087	1.4	97	2.322	0.034	1.5	98	5.240	0.074	1.4	96	4.364	0.058	1.3	98	5.253	0.072	1.4
Sysmex XT-4000i	80	6.363	0.079	1.2	80	2.333	0.027	1.2	80	5.262	0.065	1.2	80	4.382	0.048	1.1	80	5.263	0.059	1.1
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	6.19	6.13	6.34	8	2.30	2.26	2.34	8	5.16	5.06	5.24	8	4.28	4.25	4.34	8	5.17	5.09	5.29

Hemoglobin - g/dL	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	45	18.27	0.23	1.3	46	6.11	0.09	1.5	46	16.63	0.20	1.2	45	12.48	0.10	0.8	46	16.17	0.18	1.1
Sysmex XE-2100 D/L (Bld Ctr)	73	18.20	0.24	1.3	72	6.06	0.08	1.3	73	16.56	0.22	1.3	73	12.44	0.12	1.0	73	16.13	0.18	1.1
Sysmex XE-5000	125	18.24	0.24	1.3	127	6.09	0.08	1.3	127	16.60	0.21	1.3	126	12.43	0.15	1.2	126	16.14	0.19	1.2
Sysmex XN-L Series	389	18.11	0.13	0.7	389	5.97	0.06	1.1	391	16.55	0.12	0.7	388	12.39	0.09	0.8	391	16.10	0.13	0.8
Sysmex XN-Series	2537	18.06	0.15	0.8	2545	5.94	0.07	1.2	2536	16.49	0.13	0.8	2526	12.34	0.10	0.8	2536	16.02	0.13	0.8
Sysmex XN-Series (RL App)	80	18.14	0.19	1.0	81	5.94	0.08	1.4	81	16.54	0.17	1.0	81	12.36	0.11	0.9	81	16.06	0.17	1.0
Sysmex XS (Except RL App)	497	18.23	0.17	0.9	499	5.91	0.07	1.3	497	16.68	0.16	0.9	496	12.40	0.12	1.0	498	16.19	0.15	0.9
Sysmex XS-1000iC (RL App)	61	18.27	0.16	0.9	61	5.90	0.08	1.3	60	16.71	0.15	0.9	60	12.43	0.11	0.9	60	16.23	0.13	0.8
Sysmex XT-1800i/2000i	97	17.95	0.26	1.4	97	5.97	0.08	1.3	97	16.39	0.21	1.3	96	12.37	0.14	1.1	96	15.94	0.20	1.2
Sysmex XT-4000i	80	17.93	0.19	1.1	79	5.97	0.07	1.2	79	16.36	0.15	0.9	80	12.42	0.12	1.0	79	15.94	0.16	1.0
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	18.4	17.9	18.6	8	6.1	6.0	6.3	8	16.7	16.4	16.8	8	12.5	11.9	12.7	8	16.2	15.9	16.5

© 2020 College of American Pathologists

Hemoglobin - g/L	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	45	182.73	2.30	1.3	46	61.11	0.92	1.5	46	166.26	2.00	1.2	45	124.82	0.98	0.8	46	161.70	1.82	1.1
Sysmex XE-2100 D/L (Bld Ctr)	73	181.96	2.38	1.3	72	60.64	0.79	1.3	73	165.63	2.16	1.3	73	124.40	1.21	1.0	73	161.27	1.78	1.1
Sysmex XE-5000	125	182.42	2.39	1.3	127	60.90	0.81	1.3	127	166.04	2.12	1.3	126	124.34	1.46	1.2	126	161.40	1.89	1.2
Sysmex XN-L Series	389	181.09	1.34	0.7	389	59.66	0.64	1.1	391	165.52	1.20	0.7	388	123.89	0.95	0.8	391	160.98	1.29	0.8
Sysmex XN-Series	2537	180.59	1.50	0.8	2545	59.44	0.74	1.2	2536	164.92	1.34	0.8	2526	123.37	1.05	0.8	2536	160.22	1.31	0.8
Sysmex XN-Series (RL App)	80	181.41	1.89	1.0	81	59.44	0.82	1.4	81	165.36	1.66	1.0	81	123.59	1.14	0.9	81	160.60	1.66	1.0
Sysmex XS (Except RL App)	497	182.29	1.66	0.9	499	59.13	0.75	1.3	497	166.85	1.58	0.9	496	124.04	1.21	1.0	498	161.85	1.47	0.9
Sysmex XS-1000iC (RL App)	61	182.74	1.60	0.9	61	59.02	0.79	1.3	60	167.13	1.46	0.9	60	124.27	1.07	0.9	60	162.33	1.32	0.8
Sysmex XT-1800i/2000i	97	179.53	2.55	1.4	97	59.66	0.79	1.3	97	163.91	2.11	1.3	96	123.70	1.37	1.1	96	159.40	1.96	1.2
Sysmex XT-4000i	80	179.29	1.92	1.1	79	59.66	0.71	1.2	79	163.58	1.55	0.9	80	124.15	1.19	1.0	79	159.42	1.64	1.0
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	183.5	179.0	186.0	8	60.5	60.0	63.0	8	166.5	164.0	168.0	8	124.5	119.0	127.0	8	161.5	159.0	165.0

Hematocrit -%	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	51.935	0.904	1.7	46	18.348	0.482	2.6	45	47.111	0.804	1.7	46	36.391	0.537	1.5	45	46.178	0.576	1.2
Sysmex XE-2100 D/L (Bld Ctr)	77	51.987	0.896	1.7	77	18.325	0.498	2.7	77	47.182	0.899	1.9	76	36.408	0.636	1.7	76	46.197	0.864	1.9
Sysmex XE-5000	128	52.008	0.799	1.5	128	18.336	0.474	2.6	128	46.953	0.782	1.7	127	36.331	0.578	1.6	128	46.102	0.662	1.4
Sysmex XN-L Series	387	52.540	0.852	1.6	392	17.495	0.511	2.9	389	47.136	0.725	1.5	389	35.617	0.596	1.7	389	46.069	0.731	1.6
Sysmex XN-Series	2514	52.534	0.746	1.4	2545	17.443	0.498	2.9	2543	46.883	0.709	1.5	2541	35.552	0.565	1.6	2543	45.926	0.688	1.5
Sysmex XN-Series (RL App)	81	50.444	0.880	1.7	81	17.062	0.289	1.7	81	45.519	0.615	1.4	81	34.519	0.594	1.7	81	44.420	0.739	1.7
Sysmex XS (Except RL App)	500	52.822	0.839	1.6	499	18.048	0.279	1.5	499	48.082	0.799	1.7	497	36.278	0.585	1.6	500	46.964	0.710	1.5
Sysmex XS-1000iC (RL App)	61	52.984	0.846	1.6	60	18.350	0.481	2.6	61	48.852	0.813	1.7	60	36.883	0.585	1.6	61	47.590	0.692	1.5
Sysmex XT-1800i/2000i	96	52.604	0.923	1.8	96	18.365	0.505	2.8	96	47.750	0.821	1.7	95	36.305	0.670	1.8	96	46.802	0.720	1.5
Sysmex XT-4000i	80	52.825	0.839	1.6	80	18.525	0.503	2.7	80	47.963	0.683	1.4	80	36.438	0.570	1.6	80	46.888	0.729	1.6
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	49.0	48.0	50.0	8	18.0	17.0	18.0	8	45.0	44.0	46.0	8	35.0	34.0	35.0	8	44.0	43.0	45.0

Hematocrit - L/L	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	.519	0.009	1.7	46	0.183	0.005	2.6	45	0.471	0.008	1.7	46	0.364	0.005	1.5	45	0.462	0.006	1.2
Sysmex XE-2100 D/L (Bld Ctr)	77	.520	0.009	1.7	77	0.183	0.005	2.7	77	0.472	0.009	1.9	76	0.364	0.006	1.7	76	0.462	0.009	1.9
Sysmex XE-5000	128	.520	0.008	1.5	128	0.183	0.005	2.6	128	0.470	0.008	1.7	127	0.363	0.006	1.6	128	0.461	0.007	1.4
Sysmex XN-L Series	387	.525	0.009	1.6	392	0.175	0.005	2.9	389	0.471	0.007	1.5	389	0.356	0.006	1.7	389	0.461	0.007	1.6
Sysmex XN-Series	2514	.525	0.007	1.4	2545	0.174	0.005	2.9	2543	0.469	0.007	1.5	2541	0.356	0.006	1.6	2543	0.459	0.007	1.5
Sysmex XN-Series (RL App)	81	.504	0.009	1.7	81	0.171	0.003	1.7	81	0.455	0.006	1.4	81	0.345	0.006	1.7	81	0.444	0.007	1.7
Sysmex XS (Except RL App)	500	.528	0.008	1.6	499	0.180	0.003	1.5	499	0.481	0.008	1.7	497	0.363	0.006	1.6	500	0.470	0.007	1.5
Sysmex XS-1000iC (RL App)	61	.530	0.008	1.6	60	0.184	0.005	2.6	61	0.489	0.008	1.7	60	0.369	0.006	1.6	61	0.476	0.007	1.5
Sysmex XT-1800i/2000i	96	.526	0.009	1.8	96	0.184	0.005	2.8	96	0.478	0.008	1.7	95	0.363	0.007	1.8	96	0.468	0.007	1.5
Sysmex XT-4000i	80	.528	0.008	1.6	80	0.185	0.005	2.7	80	0.480	0.007	1.4	80	0.364	0.006	1.6	80	0.469	0.007	1.6
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	0.5	0.5	0.5	8	0.2	0.2	0.2	8	0.5	0.4	0.5	8	0.4	0.3	0.4	8	0.4	0.4	0.5

© 2020 College of American Pathologists

MCV - Femtoliters (fL)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	82.97	0.97	1.2	46	78.84	0.96	1.2	46	89.97	0.94	1.0	46	83.38	0.84	1.0	46	87.84	0.96	1.1
Sysmex XE-2100 D/L (Bld Ctr)	43	83.20	0.89	1.1	43	78.96	0.83	1.1	43	90.13	0.82	0.9	43	83.50	0.81	1.0	43	88.05	0.84	1.0
Sysmex XE-5000	128	83.06	1.00	1.2	128	78.88	0.97	1.2	128	89.94	1.06	1.2	128	83.43	1.06	1.3	128	87.85	1.05	1.2
Sysmex XN-L Series	392	81.89	0.97	1.2	391	78.68	0.91	1.2	391	88.91	0.97	1.1	390	82.74	0.94	1.1	391	86.85	0.99	1.1
Sysmex XN-Series	2534	82.40	0.86	1.0	2532	78.32	0.84	1.1	2531	88.99	0.88	1.0	2528	82.77	0.82	1.0	2531	87.06	0.88	1.0
Sysmex XN-Series (RL App)	79	79.26	0.74	0.9	80	76.67	0.75	1.0	79	86.48	0.85	1.0	80	80.71	0.79	1.0	79	84.22	0.75	0.9
Sysmex XS (Except RL App)	492	83.08	0.83	1.0	495	80.16	0.77	1.0	493	91.04	0.87	1.0	496	84.05	0.80	1.0	494	88.92	0.85	1.0
Sysmex XS-1000iC (RL App)	59	84.03	0.96	1.1	61	79.58	1.15	1.4	59	92.50	1.15	1.2	59	84.87	0.91	1.1	60	89.76	1.08	1.2
Sysmex XT-1800i/2000i	94	83.14	0.79	0.9	94	79.29	0.69	0.9	93	91.21	0.81	0.9	95	83.31	0.82	1.0	93	89.11	0.82	0.9
Sysmex XT-4000i	80	83.03	0.82	1.0	80	79.18	0.80	1.0	78	91.09	0.79	0.9	80	83.13	0.78	0.9	80	88.98	0.94	1.1

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	79.4	78.2	80.1	8	76.5	75.3	77.8	8	87.4	86.0	88.6	8	81.0	80.0	82.0	8	85.0	83.9	85.6

MCH - Picograms (pg)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	29.27	0.34	1.2	46	26.29	0.38	1.4	45	31.82	0.29	0.9	46	28.68	0.37	1.3	44	30.83	0.24	0.8
Sysmex XE-2100 D/L (Bld Ctr)	38	29.12	0.39	1.3	38	26.26	0.41	1.6	38	31.74	0.51	1.6	38	28.54	0.37	1.3	37	30.79	0.35	1.1
Sysmex XE-5000	127	29.19	0.33	1.1	127	26.27	0.34	1.3	127	31.84	0.37	1.2	125	28.58	0.31	1.1	125	30.82	0.30	1.0
Sysmex XN-L Series	386	28.26	0.30	1.1	385	26.91	0.34	1.3	387	31.25	0.34	1.1	388	28.84	0.31	1.1	386	30.38	0.32	1.1
Sysmex XN-Series	2510	28.36	0.31	1.1	2515	26.72	0.36	1.4	2510	31.34	0.35	1.1	2510	28.77	0.33	1.1	2506	30.41	0.33	1.1
Sysmex XN-Series (RL App)	82	28.49	0.38	1.3	81	26.69	0.41	1.5	80	31.50	0.45	1.4	81	28.88	0.37	1.3	79	30.51	0.36	1.2
Sysmex XS (Except RL App)	479	28.69	0.27	0.9	478	26.20	0.35	1.3	479	31.61	0.34	1.1	480	28.77	0.31	1.1	477	30.67	0.30	1.0
Sysmex XS-1000iC (RL App)	60	29.00	0.36	1.2	60	25.59	0.55	2.1	60	31.70	0.33	1.0	59	28.66	0.31	1.1	60	30.72	0.36	1.2
Sysmex XT-1800i/2000i	93	28.29	0.39	1.4	96	25.71	0.51	2.0	95	31.26	0.48	1.5	94	28.37	0.45	1.6	95	30.34	0.45	1.5
Sysmex XT-4000i	75	28.19	0.30	1.1	78	25.60	0.47	1.8	78	31.10	0.40	1.3	78	28.32	0.40	1.4	78	30.31	0.39	1.3

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	29.6	29.0	29.9	8	26.4	25.8	27.6	8	32.2	31.6	32.8	8	29.3	27.8	29.4	8	31.3	30.6	31.5

MCHC - g/dL	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	35.28	0.56	1.6	45	33.36	0.69	2.1	45	35.34	0.48	1.4	45	34.36	0.45	1.3	45	35.06	0.41	1.2
Sysmex XE-2100 D/L (Bld Ctr)	38	35.03	0.63	1.8	38	33.27	0.68	2.0	38	35.24	0.69	1.9	38	34.24	0.59	1.7	38	35.04	0.69	2.0
Sysmex XE-5000	126	35.16	0.54	1.5	126	33.31	0.57	1.7	126	35.41	0.53	1.5	125	34.26	0.52	1.5	126	35.06	0.54	1.6
Sysmex XN-L Series	390	34.53	0.51	1.5	388	34.21	0.59	1.7	388	35.16	0.52	1.5	388	34.86	0.51	1.5	387	34.99	0.52	1.5
Sysmex XN-Series	2522	34.42	0.49	1.4	2525	34.12	0.58	1.7	2524	35.22	0.50	1.4	2523	34.76	0.50	1.4	2523	34.93	0.49	1.4
Sysmex XN-Series (RL App)	81	35.95	0.52	1.5	82	34.81	0.56	1.6	81	36.39	0.52	1.4	81	35.81	0.53	1.5	80	36.24	0.47	1.3
Sysmex XS (Except RL App)	488	34.57	0.46	1.3	484	32.69	0.49	1.5	484	34.73	0.45	1.3	489	34.23	0.47	1.4	487	34.47	0.44	1.3
Sysmex XS-1000iC (RL App)	60	34.51	0.55	1.6	59	32.19	0.58	1.8	60	34.26	0.58	1.7	60	33.75	0.57	1.7	60	34.20	0.58	1.7
Sysmex XT-1800i/2000i	94	34.10	0.60	1.8	95	32.44	0.71	2.2	94	34.31	0.61	1.8	94	34.09	0.59	1.7	94	34.09	0.58	1.7
Sysmex XT-4000i	76	33.95	0.48	1.4	78	32.33	0.67	2.1	77	34.16	0.51	1.5	78	34.08	0.63	1.8	77	34.05	0.54	1.6

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	37.1	36.4	37.8	8	34.5	33.5	36.0	8	37.2	35.7	37.7	8	35.9	34.2	36.4	8	36.9	36.2	37.6

© 2020 College of American Pathologists

MCHC - g/L	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	352.83	5.6	1.6	45	333.62	6.92	2.1	45	353.40	4.82	1.4	45	343.64	4.54	1.3	45	350.62	4.06	1.2
Sysmex XE-2100 D/L (Bld Ctr)	38	350.32	6.3	1.8	38	332.66	6.78	2.0	38	352.39	6.87	1.9	38	342.37	5.86	1.7	38	350.39	6.87	2.0
Sysmex XE-5000	126	351.57	5.37	1.5	126	333.1	5.71	1.7	126	354.08	5.33	1.5	125	342.57	5.23	1.5	126	350.63	5.45	1.6
Sysmex XN-L Series	390	345.27	5.09	1.5	388	342.09	5.93	1.7	388	351.65	5.18	1.5	388	348.59	5.12	1.5	387	349.88	5.19	1.5
Sysmex XN-Series	2522	344.23	4.93	1.4	2525	341.25	5.80	1.7	2524	352.18	5.02	1.4	2523	347.58	4.96	1.4	2523	349.29	4.91	1.4
Sysmex XN-Series (RL App)	81	359.51	5.23	1.5	82	348.11	5.65	1.6	81	363.90	5.23	1.4	81	358.09	5.27	1.5	80	362.36	4.73	1.3
Sysmex XS (Except RL App)	488	345.67	4.56	1.3	484	326.89	4.92	1.5	484	347.30	4.47	1.3	489	342.31	4.67	1.4	487	344.71	4.44	1.3
Sysmex XS-1000iC (RL App)	60	345.05	5.46	1.6	59	321.93	5.81	1.8	60	342.63	5.82	1.7	60	337.53	5.70	1.7	60	342.02	5.83	1.7
Sysmex XT-1800i/2000i	94	340.99	5.97	1.8	95	324.4	7.07	2.2	94	343.14	6.07	1.8	94	340.94	5.93	1.7	94	340.88	5.83	1.7
Sysmex XT-4000i	76	339.51	4.75	1.4	78	323.26	6.75	2.1	77	341.57	5.14	1.5	78	340.79	6.26	1.8	77	340.45	5.43	1.6
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	371.0	364.0	378.0	8	344.5	335.0	360.0	8	371.5	357.0	377.0	8	359.0	342.0	364.0	8	368.5	362.0	376.0

Platelet Count x 10E9/L or x 10E3/µL	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	46	127.1	5.4	4.3	46	59.7	2.7	4.6	46	521.1	16.9	3.2	46	233.2	6.0	2.6	46	131.3	7.0	5.3
Sysmex XE-2100 D/L (Bld Ctr)	76	137.1	7.9	5.8	76	61.3	3.0	4.8	76	543.9	20.0	3.7	75	241.4	7.5	3.1	76	137.5	5.3	3.9
Sysmex XE-5000	126	127.1	6.1	4.8	128	59.9	2.9	4.9	127	520.7	15.5	3.0	127	233.8	6.8	2.9	127	130.0	5.9	4.5
Sysmex XN-L Series	388	143.3	7.9	5.5	390	58.7	3.1	5.2	393	553.5	12.4	2.2	390	240.3	6.6	2.7	390	141.7	6.6	4.7
Sysmex XN-Series	2511	140.7	7.1	5.0	2526	55.7	3.0	5.4	2522	540.3	11.9	2.2	2526	233.6	6.7	2.9	2511	138.2	6.2	4.5
Sysmex XN-Series (RL App)	80	148.0	6.3	4.3	81	59.5	3.3	5.6	80	550.1	11.8	2.1	80	238.9	7.6	3.2	81	143.4	6.9	4.8
Sysmex XS (Except RL App)	494	131.0	6.9	5.3	495	59.4	3.2	5.4	494	523.7	12.0	2.3	490	229.9	6.5	2.8	494	131.1	6.2	4.7
Sysmex XS-1000iC (RL App)	61	137.2	8.6	6.2	60	62.3	3.5	5.7	61	540.3	15.1	2.8	61	237.4	7.0	3.0	60	137.2	7.1	5.2
Sysmex XT-1800i/2000i	95	129.4	7.9	6.1	95	60.5	3.1	5.0	96	494.4	18.5	3.7	96	227.3	8.6	3.8	97	128.9	7.0	5.5
Sysmex XT-4000i	77	129.4	7.4	5.7	79	60.8	2.8	4.6	78	493.9	15.1	3.0	80	226.8	7.8	3.4	79	128.3	7.3	5.7
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	126	117	139	8	59	57	62	8	536	506	546	8	234	220	249	8	133	123	134

MPV - Femtoliters (fL)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	39	10.18	0.25	2.4	39	9.75	0.29	3.0	39	9.99	0.18	1.8	39	9.89	0.20	2.0	39	10.22	0.25	2.5
Sysmex XE-2100 D/L (Bld Ctr)	30	9.99	0.24	2.4	29	9.48	0.18	1.9	30	9.99	0.19	1.9	30	9.81	0.20	2.0	30	10.00	0.23	2.3
Sysmex XE-5000	125	10.12	0.28	2.7	124	9.71	0.28	2.9	124	9.97	0.20	2.0	125	9.87	0.23	2.3	124	10.17	0.29	2.8
Sysmex XN-L Series	354	10.01	0.30	3.0	359	10.56	0.34	3.3	358	9.87	0.16	1.6	356	10.10	0.22	2.2	358	10.23	0.30	3.0
Sysmex XN-Series	2410	10.07	0.28	2.8	2401	10.58	0.31	3.0	2413	9.94	0.13	1.3	2412	10.17	0.19	1.9	2412	10.30	0.31	3.0
Sysmex XN-Series (RL App)	74	11.23	0.26	2.3	74	11.73	0.33	2.8	72	11.08	0.12	1.1	74	11.37	0.19	1.7	74	11.44	0.30	2.6
Sysmex XS (Except RL App)	437	10.28	0.28	2.7	434	9.62	0.30	3.1	439	10.12	0.14	1.4	435	9.91	0.18	1.8	437	10.41	0.29	2.7
Sysmex XS-1000iC (RL App)	54	10.69	0.39	3.7	54	9.88	0.30	3.0	54	10.47	0.28	2.7	54	10.26	0.28	2.7	54	10.82	0.40	3.7
Sysmex XT-1800i/2000i	87	10.50	0.27	2.6	85	9.72	0.25	2.6	86	10.36	0.13	1.2	86	10.12	0.18	1.8	85	10.60	0.25	2.3
Sysmex XT-4000i	75	10.54	0.35	3.3	76	9.73	0.24	2.5	74	10.34	0.10	1.0	75	10.12	0.15	1.5	76	10.61	0.28	2.6
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	4	10.2	9.9	10.6	4	9.9	9.8	10.1	4	10.3	10.1	10.5	4	10.0	9.9	10.5	4	10.6	10.2	10.6

© 2020 College of American Pathologists

RDW % (RDW-CV)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	33	15.44	0.15	1.0	33	16.44	0.16	0.9	33	13.56	0.11	0.8	33	13.88	0.12	0.9	33	14.01	0.12	0.9
Sysmex XE-5000	102	15.41	0.18	1.2	103	16.41	0.14	0.9	104	13.53	0.12	0.9	103	13.86	0.13	0.9	103	13.98	0.13	0.9
Sysmex XN-L Series	325	17.58	0.44	2.5	311	17.23	0.16	0.9	313	13.98	0.14	1.0	314	14.47	0.14	1.0	314	14.45	0.18	1.3
Sysmex XN-Series	2101	17.61	0.44	2.5	2091	17.25	0.14	0.8	2089	14.18	0.12	0.9	2091	14.60	0.12	0.9	2085	14.64	0.12	0.8
Sysmex XN-Series (RL App)	77	18.66	0.36	1.9	76	17.80	0.13	0.8	77	14.60	0.16	1.1	76	14.85	0.16	1.1	76	14.97	0.20	1.3
Sysmex XS (Except RL App)	408	18.19	0.36	2.0	408	16.59	0.25	1.5	409	14.13	0.19	1.3	410	14.36	0.20	1.4	407	14.50	0.20	1.4
Sysmex XS-1000iC (RL App)	55	20.63	1.42	6.9	55	18.80	1.33	7.1	55	15.86	1.00	6.3	55	15.93	0.94	5.9	55	16.11	0.95	5.9
Sysmex XT-1800i/2000i	77	17.25	0.65	3.7	76	16.62	0.21	1.2	77	13.97	0.17	1.2	77	14.30	0.17	1.2	76	14.38	0.18	1.3
Sysmex XT-4000i	61	16.93	0.52	3.1	61	16.63	0.18	1.1	60	13.94	0.13	0.9	61	14.29	0.13	0.9	60	14.34	0.13	0.9

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	16.0	15.8	16.5	8	17.1	16.9	17.2	8	13.8	13.7	14.3	8	14.1	13.9	14.4	8	14.1	14.0	14.4
Sysmex XE-2100 D/L (Bld Ctr)	3	15.2	15.2	15.7	3	16.3	16.2	16.8	3	13.6	13.4	13.9	3	13.7	13.6	14.1	3	13.9	13.8	14.3

RDW fL (RDW-SD)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	12	45.80	0.53	1.2	12	47.14	0.58	1.2	12	43.73	0.53	1.2	12	41.77	0.58	1.4	12	44.36	0.67	1.5
Sysmex XE-2100 D/L (Bld Ctr)	27	45.96	0.62	1.3	28	47.31	0.61	1.3	27	43.92	0.54	1.2	27	41.85	0.49	1.2	29	44.80	0.90	2.0
Sysmex XE-5000	22	45.69	0.51	1.1	22	46.97	0.48	1.0	22	43.72	0.46	1.0	21	41.66	0.25	0.6	22	44.31	0.66	1.5
Sysmex XN-L Series	57	47.01	0.83	1.8	57	49.10	0.80	1.6	57	45.15	0.58	1.3	56	43.40	0.63	1.5	57	45.70	0.79	1.7
Sysmex XN-Series	401	47.03	0.60	1.3	404	48.11	0.60	1.3	403	45.12	0.58	1.3	404	42.80	0.53	1.2	403	45.35	0.64	1.4
Sysmex XS (Except RL App)	87	47.17	0.90	1.9	85	46.49	0.71	1.5	87	44.25	0.91	2.1	85	41.68	0.64	1.5	87	44.59	0.79	1.8
Sysmex XT-1800i/2000i	20	46.49	0.73	1.6	18	46.43	0.33	0.7	20	43.42	0.82	1.9	20	41.37	0.57	1.4	20	44.12	0.58	1.3
Sysmex XT-4000i	19	46.64	0.51	1.1	19	46.34	0.36	0.8	19	43.61	0.62	1.4	19	41.52	0.52	1.2	19	44.24	0.46	1.0

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XS-1000iC (RL App)	6	49.8	46.3	54.3	6	49.7	44.2	54.8	6	47.3	43.5	51.9	6	43.8	40.5	47.6	6	47.0	44.0	51.0

Neutrophils/Granulocytes - %	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	43	46.36	1.15	2.5	43	46.62	1.28	2.8	42	50.93	0.93	1.8	43	46.72	1.09	2.3	43	46.40	1.32	2.8
Sysmex XE-2100 D/L (Bld Ctr)	19	46.32	1.09	2.4	19	46.64	1.61	3.4	19	51.08	1.05	2.1	19	47.07	1.12	2.4	19	46.95	1.05	2.2
Sysmex XE-5000	124	46.65	1.27	2.7	122	46.61	1.01	2.2	124	50.71	0.96	1.9	124	46.87	1.08	2.3	124	46.71	1.22	2.6
Sysmex XN-L Series	355	41.26	1.08	2.6	353	41.29	1.11	2.7	356	44.37	0.87	2.0	355	41.28	0.94	2.3	352	41.03	1.05	2.6
Sysmex XN-Series	2485	42.39	1.12	2.6	2489	42.79	1.18	2.8	2490	46.07	0.91	2.0	2495	42.47	0.97	2.3	2494	42.39	1.16	2.7
Sysmex XN-Series (RL App)	77	42.38	1.22	2.9	77	43.25	1.29	3.0	78	45.93	1.00	2.2	76	42.54	0.92	2.2	77	42.35	1.39	3.3
Sysmex XS (Except RL App)	464	39.42	1.05	2.7	467	40.15	1.12	2.8	468	42.98	0.90	2.1	467	39.46	0.94	2.4	465	39.36	1.14	2.9
Sysmex XS-1000iC (RL App)	61	39.53	1.17	3.0	61	40.01	1.11	2.8	61	43.10	0.97	2.2	61	39.61	0.97	2.5	61	39.37	0.97	2.5
Sysmex XT-1800i/2000i	95	45.91	1.45	3.2	95	47.27	1.33	2.8	95	50.35	0.82	1.6	94	46.01	1.05	2.3	95	46.23	1.15	2.5
Sysmex XT-4000i	79	46.46	1.35	2.9	79	47.17	1.23	2.6	79	50.29	0.92	1.8	79	46.12	1.08	2.3	79	46.75	1.50	3.2

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	46.5	44.2	48.0	8	46.5	44.5	48.6	8	51.0	48.8	52.0	8	47.4	45.2	49.0	8	48.0	44.0	49.0

© 2020 College of American Pathologists

Neutrophils/Granulocytes x 10E9/L or x 10E3/µl	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	41	1.311	0.055	4.2	40	1.319	0.044	3.4	41	8.631	0.223	2.6	41	3.027	0.119	3.9	41	1.337	0.051	3.9
Sysmex XE-2100 D/L (Bld Ctr)	19	1.329	0.045	3.4	19	1.319	0.069	5.2	19	8.688	0.273	3.1	19	3.055	0.111	3.6	19	1.352	0.060	4.4
Sysmex XE-5000	120	1.323	0.048	3.6	121	1.311	0.052	4.0	122	8.603	0.255	3.0	123	2.994	0.126	4.2	121	1.336	0.052	3.9
Sysmex XN-L Series	362	1.253	0.045	3.6	361	1.119	0.046	4.1	362	7.590	0.197	2.6	361	2.622	0.081	3.1	363	1.258	0.057	4.5
Sysmex XN-Series	2484	1.246	0.045	3.6	2491	1.145	0.044	3.8	2488	7.652	0.189	2.5	2485	2.615	0.080	3.1	2491	1.252	0.046	3.7
Sysmex XN-Series (RL App)	77	1.238	0.059	4.8	77	1.144	0.060	5.2	77	7.561	0.208	2.8	76	2.604	0.072	2.8	77	1.235	0.061	5.0
Sysmex XS (Except RL App)	483	1.236	0.050	4.1	483	1.127	0.044	3.9	483	7.524	0.217	2.9	482	2.576	0.089	3.4	483	1.239	0.051	4.1
Sysmex XS-1000iC (RL App)	60	1.233	0.048	3.9	60	1.135	0.048	4.2	60	7.585	0.259	3.4	60	2.596	0.098	3.8	60	1.246	0.047	3.7
Sysmex XT-1800i/2000i	91	1.296	0.071	5.5	92	1.334	0.056	4.2	91	8.507	0.265	3.1	92	3.048	0.122	4.0	92	1.310	0.055	4.2
Sysmex XT-4000i	76	1.315	0.058	4.4	77	1.328	0.063	4.7	77	8.548	0.327	3.8	76	3.048	0.128	4.2	77	1.325	0.064	4.8

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	1.3	1.2	1.4	8	1.3	1.2	1.4	8	8.5	8.2	8.9	8	3.0	2.9	3.2	8	1.3	1.3	1.4

Lymphocytes - %	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	43	34.90	1.06	3.0	43	32.99	1.41	4.3	42	29.42	1.09	3.7	43	34.31	0.92	2.7	43	34.64	1.48	4.3
Sysmex XE-2100 D/L (Bld Ctr)	18	35.09	1.28	3.6	18	33.43	1.62	4.8	19	29.06	1.47	5.0	18	34.19	0.94	2.7	17	34.01	1.00	3.0
Sysmex XE-5000	124	34.88	1.38	4.0	124	33.51	1.32	3.9	125	29.60	1.03	3.5	125	34.37	1.04	3.0	124	34.65	1.25	3.6
Sysmex XN-L Series	373	32.86	1.07	3.3	369	31.93	1.13	3.5	367	27.87	0.64	2.3	367	32.82	0.85	2.6	370	32.93	1.07	3.3
Sysmex XN-Series	2520	29.83	1.37	4.6	2489	28.06	1.20	4.3	2513	25.25	1.00	3.9	2521	29.97	1.33	4.5	2515	29.70	1.37	4.6
Sysmex XN-Series (RL App)	81	29.99	1.45	4.8	76	27.96	1.22	4.4	81	25.13	1.03	4.1	81	29.84	1.41	4.7	80	29.55	1.24	4.2
Sysmex XS (Except RL App)	465	35.80	1.05	2.9	467	34.15	1.13	3.3	464	30.15	0.50	1.7	464	35.85	0.67	1.9	466	35.74	1.02	2.9
Sysmex XS-1000iC (RL App)	62	35.64	1.01	2.8	62	34.34	1.05	3.1	61	30.10	0.53	1.8	62	35.72	0.70	1.9	62	35.47	0.94	2.7
Sysmex XT-1800i/2000i	94	33.43	1.29	3.9	95	30.91	1.69	5.5	95	27.91	0.64	2.3	94	33.55	1.00	3.0	94	33.24	1.45	4.4
Sysmex XT-4000i	79	33.14	1.39	4.2	79	30.73	1.50	4.9	79	27.87	0.68	2.5	78	33.32	0.81	2.4	79	32.91	1.39	4.2

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	35.0	33.9	37.8	8	33.8	32.9	37.0	8	29.6	29.0	31.0	8	35.0	33.5	37.0	8	34.6	34.0	36.0

Lymphocytes x 10E9/L or x 10E3/µl	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	41	0.985	0.042	4.3	41	0.934	0.048	5.1	40	4.971	0.196	3.9	41	2.225	0.110	4.9	41	0.992	0.053	5.3
Sysmex XE-2100 D/L (Bld Ctr)	17	0.999	0.038	3.8	18	0.949	0.048	5.1	19	4.941	0.277	5.6	19	2.205	0.087	4.0	18	0.987	0.057	5.7
Sysmex XE-5000	121	0.986	0.049	4.9	121	0.942	0.049	5.2	122	5.018	0.183	3.7	121	2.196	0.086	3.9	122	0.989	0.051	5.2
Sysmex XN-L Series	378	0.997	0.038	3.8	379	0.867	0.038	4.3	374	4.773	0.122	2.6	379	2.088	0.067	3.2	379	1.004	0.041	4.1
Sysmex XN-Series	2513	0.877	0.046	5.2	2496	0.751	0.039	5.2	2504	4.193	0.178	4.2	2512	1.846	0.091	4.9	2515	0.878	0.046	5.3
Sysmex XN-Series (RL App)	80	0.878	0.047	5.4	77	0.744	0.035	4.7	80	4.133	0.179	4.3	80	1.828	0.083	4.5	80	0.867	0.042	4.8
Sysmex XS (Except RL App)	480	1.122	0.046	4.1	484	0.959	0.044	4.6	479	5.280	0.129	2.4	479	2.342	0.068	2.9	482	1.124	0.044	3.9
Sysmex XS-1000iC (RL App)	60	1.112	0.050	4.5	60	0.974	0.042	4.4	60	5.303	0.139	2.6	59	2.336	0.064	2.8	59	1.124	0.045	4.0
Sysmex XT-1800i/2000i	91	0.939	0.043	4.5	93	0.870	0.055	6.3	92	4.714	0.166	3.5	91	2.213	0.074	3.4	93	0.937	0.046	4.9
Sysmex XT-4000i	75	0.944	0.058	6.2	74	0.866	0.052	5.9	73	4.723	0.162	3.4	73	2.208	0.076	3.4	75	0.932	0.054	5.8

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	8	1.0	1.0	1.0	8	0.9	0.9	1.0	8	5.0	4.8	5.2	8	2.2	2.2	2.3	8	1.0	0.9	1.0

© 2020 College of American Pathologists

Monocytes - %	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	42	8.72	0.81	9.3	41	10.11	1.04	10.3	42	9.05	0.88	9.7	42	8.92	0.68	7.6	42	8.89	0.75	8.4
Sysmex XE-2100 D/L (Bld Ctr)	17	8.38	0.85	10.1	17	10.02	0.92	9.2	17	9.28	0.94	10.1	17	8.99	0.60	6.6	17	8.85	0.81	9.2
Sysmex XE-5000	124	8.51	0.91	10.7	124	9.88	0.99	10.0	124	8.92	0.89	9.9	123	8.84	0.71	8.1	122	8.83	0.79	9.0
Sysmex XN-L Series	370	10.21	0.80	7.8	369	10.99	0.91	8.3	365	10.82	0.49	4.6	367	10.27	0.59	5.7	369	10.30	0.71	6.9
Sysmex XN-Series	2490	12.89	1.20	9.3	2473	14.13	1.07	7.6	2496	12.98	0.96	7.4	2511	12.59	1.29	10.2	2495	13.04	1.21	9.3
Sysmex XN-Series (RL App)	79	12.87	1.23	9.5	77	14.10	1.06	7.5	81	12.98	1.07	8.3	81	12.53	1.27	10.2	79	13.31	1.21	9.1
Sysmex XS (Except RL App)	461	8.93	0.65	7.3	465	10.14	0.80	7.9	463	9.79	0.41	4.2	466	9.16	0.50	5.4	462	9.15	0.72	7.9
Sysmex XS-1000iC (RL App)	61	9.08	0.71	7.8	61	10.10	0.80	7.9	61	9.86	0.35	3.5	61	9.13	0.48	5.2	61	9.27	0.61	6.6
Sysmex XT-1800i/2000i	95	10.73	0.99	9.3	94	12.06	1.11	9.2	95	11.34	0.60	5.3	95	10.53	0.83	7.9	95	10.84	1.16	10.7
Sysmex XT-4000i	79	10.64	1.02	9.6	77	12.28	1.12	9.2	79	11.37	0.67	5.9	77	10.76	0.73	6.8	79	10.70	0.99	9.3
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	8.2	7.0	10.1	8	9.9	8.0	11.0	8	9.0	8.0	9.8	8	8.4	8.0	9.7	8	8.2	7.0	10.0

Monocytes x 10E9/L or x 10E3/µl	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	41	0.244	0.025	10.1	40	0.283	0.028	10.0	41	1.522	0.153	10.1	40	0.572	0.041	7.2	41	0.253	0.020	8.1
Sysmex XE-2100 D/L (Bld Ctr)	17	0.242	0.028	11.5	17	0.284	0.027	9.5	17	1.575	0.157	10.0	17	0.582	0.039	6.6	17	0.254	0.023	9.2
Sysmex XE-5000	122	0.243	0.030	12.2	123	0.279	0.029	10.5	122	1.515	0.160	10.6	121	0.564	0.050	8.9	122	0.252	0.028	11.2
Sysmex XN-L Series	369	0.310	0.024	7.9	371	0.297	0.026	8.6	370	1.852	0.089	4.8	373	0.654	0.041	6.3	370	0.314	0.024	7.6
Sysmex XN-Series	2495	0.378	0.039	10.2	2477	0.377	0.032	8.4	2481	2.155	0.165	7.6	2499	0.774	0.082	10.6	2494	0.385	0.038	9.9
Sysmex XN-Series (RL App)	79	0.375	0.040	10.7	80	0.370	0.043	11.7	80	2.144	0.179	8.4	80	0.766	0.082	10.8	79	0.389	0.039	10.0
Sysmex XS (Except RL App)	475	0.281	0.022	8.0	483	0.285	0.026	9.0	476	1.714	0.082	4.8	480	0.598	0.035	5.9	476	0.288	0.024	8.3
Sysmex XS-1000iC (RL App)	60	0.284	0.026	9.0	60	0.286	0.023	8.0	60	1.729	0.078	4.5	60	0.597	0.035	5.9	60	0.295	0.022	7.3
Sysmex XT-1800i/2000i	93	0.305	0.029	9.4	93	0.336	0.038	11.2	92	1.924	0.115	6.0	92	0.696	0.061	8.8	93	0.307	0.034	11.2
Sysmex XT-4000i	75	0.302	0.034	11.2	75	0.341	0.038	11.1	75	1.936	0.148	7.6	72	0.711	0.057	8.1	74	0.301	0.027	9.1
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	0.2	0.2	0.3	8	0.3	0.2	0.3	8	1.5	1.2	1.7	8	0.5	0.5	0.6	8	0.2	0.2	0.3

Eosinophils - %	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	42	10.02	0.70	6.9	42	10.19	0.81	8.0	42	10.60	0.86	8.1	42	10.04	0.86	8.6	42	10.03	0.92	9.2
Sysmex XE-2100 D/L (Bld Ctr)	18	10.14	0.91	9.0	18	9.77	0.68	7.0	18	10.42	0.92	8.8	18	9.85	0.76	7.7	18	10.13	0.68	6.7
Sysmex XE-5000	124	9.95	0.89	8.9	124	10.01	0.78	7.8	125	10.78	0.77	7.2	125	9.95	0.80	8.0	124	9.84	0.84	8.5
Sysmex XN-L Series	358	9.96	0.84	8.4	355	10.01	0.80	8.0	359	10.92	0.85	7.8	357	9.97	0.79	7.9	354	10.06	0.80	8.0
Sysmex XN-Series	2490	10.09	0.80	7.9	2498	10.23	0.81	7.9	2493	10.87	0.84	7.7	2499	10.14	0.77	7.6	2495	10.07	0.80	8.0
Sysmex XN-Series (RL App)	80	10.02	0.90	9.0	79	10.05	0.78	7.7	80	11.03	0.83	7.5	79	10.07	0.76	7.5	79	10.02	0.79	7.8
Sysmex XS (Except RL App)	466	9.60	0.74	7.8	468	9.59	0.77	8.0	468	10.43	0.77	7.3	468	9.60	0.74	7.7	466	9.56	0.74	7.8
Sysmex XS-1000iC (RL App)	61	9.53	0.77	8.1	61	9.52	0.73	7.7	61	10.31	0.79	7.6	61	9.62	0.72	7.5	60	9.64	0.71	7.3
Sysmex XT-1800i/2000i	95	9.95	0.71	7.1	95	9.81	0.78	8.0	95	10.38	0.73	7.0	95	9.96	0.74	7.5	94	9.68	0.82	8.4
Sysmex XT-4000i	79	9.76	0.75	7.7	79	9.93	0.77	7.7	79	10.46	0.80	7.7	79	9.85	0.73	7.4	79	9.63	0.68	7.1
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	10.0	9.4	11.0	8	9.9	9.0	11.0	8	10.7	9.5	11.9	8	9.6	9.0	10.9	8	10.0	8.9	11.0

© 2020 College of American Pathologists

Eosinophils x 10E9/L or x 10E3/µl	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	42	.282	0.022	7.8	42	0.286	0.025	8.9	42	1.804	0.159	8.8	42	0.644	0.064	10.0	42	0.287	0.029	9.9
Sysmex XE-2100 D/L (Bld Ctr)	18	.291	0.028	9.6	18	0.275	0.019	6.7	18	1.770	0.169	9.6	18	0.638	0.051	8.1	18	0.291	0.019	6.4
Sysmex XE-5000	123	.283	0.026	9.1	123	0.283	0.024	8.7	125	1.829	0.142	7.7	125	0.635	0.053	8.4	123	0.281	0.025	8.9
Sysmex XN-L Series	360	.303	0.027	8.8	357	0.272	0.023	8.6	359	1.864	0.145	7.8	359	0.634	0.052	8.3	353	0.306	0.026	8.5
Sysmex XN-Series	2471	.297	0.024	8.2	2480	0.274	0.024	8.6	2474	1.806	0.142	7.9	2480	0.624	0.049	7.8	2482	0.297	0.025	8.3
Sysmex XN-Series (RL App)	79	.292	0.025	8.7	78	0.269	0.023	8.7	79	1.814	0.140	7.7	78	0.616	0.051	8.2	78	0.293	0.024	8.2
Sysmex XS (Except RL App)	478	.300	0.024	8.0	482	0.270	0.024	8.9	480	1.825	0.138	7.5	480	0.628	0.051	8.2	480	0.301	0.025	8.2
Sysmex XS-1000iC (RL App)	60	.297	0.027	9.0	60	0.271	0.025	9.0	59	1.805	0.131	7.3	60	0.633	0.048	7.5	59	0.306	0.023	7.4
Sysmex XT-1800i/2000i	94	.282	0.023	8.0	93	0.277	0.023	8.4	94	1.756	0.134	7.6	94	0.659	0.051	7.8	94	0.274	0.028	10.3
Sysmex XT-4000i	74	.277	0.023	8.1	74	0.279	0.022	7.8	75	1.786	0.154	8.6	75	0.651	0.054	8.3	75	0.275	0.023	8.5
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	0.3	0.3	0.3	8	0.3	0.2	0.3	8	1.8	1.6	2.0	8	0.6	0.5	0.7	8	0.3	0.3	0.3

Basophils - %	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	43	67.07	1.33	2.0	43	66.09	1.21	1.8	43	70.40	0.64	0.9	42	64.67	0.94	1.5	43	67.04	1.35	2.0
Sysmex XE-2100 D/L (Bld Ctr)	18	66.18	1.53	2.3	18	66.02	1.68	2.5	17	70.08	0.74	1.1	18	64.57	0.96	1.5	18	66.90	1.34	2.0
Sysmex XE-5000	124	66.97	1.45	2.2	123	66.55	1.54	2.3	123	70.55	0.71	1.0	123	65.02	1.10	1.7	124	67.15	1.35	2.0
Sysmex XN-L Series	357	5.63	0.38	6.7	356	5.62	0.40	7.1	358	6.00	0.35	5.8	357	5.60	0.35	6.2	353	5.64	0.40	7.0
Sysmex XN-Series	2484	4.80	0.17	3.6	2488	4.79	0.17	3.6	2488	4.82	0.12	2.4	2485	4.81	0.13	2.7	2491	4.80	0.17	3.5
Sysmex XN-Series (RL App)	78	4.81	0.14	2.9	79	4.80	0.16	3.4	79	4.83	0.12	2.4	79	4.79	0.14	2.9	79	4.81	0.18	3.8
Sysmex XS (Except RL App)	463	6.24	0.56	8.9	466	6.00	0.53	8.9	467	6.65	0.50	7.5	466	5.93	0.48	8.1	465	6.21	0.53	8.5
Sysmex XS-1000iC (RL App)	61	6.24	0.58	9.2	61	6.05	0.57	9.5	61	6.60	0.53	8.1	61	5.95	0.44	7.3	61	6.26	0.58	9.2
Sysmex XT-1800i/2000i	94	68.64	1.16	1.7	95	65.51	1.41	2.1	95	72.32	0.70	1.0	94	63.57	0.95	1.5	94	68.71	1.14	1.7
Sysmex XT-4000i	79	68.81	1.13	1.6	79	65.45	1.68	2.6	79	72.32	0.77	1.1	78	63.83	0.85	1.3	79	68.70	1.20	1.8
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	66.7	64.5	68.0	8	65.1	62.3	69.0	8	71.0	70.1	71.0	8	65.0	63.8	65.1	8	68.0	64.6	70.3

Basophils x 10E9/L or x 10E3/µl	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV	LABS	MEAN	SD	CV
Sysmex XE-2100,2100 D/L	41	1.893	0.066	3.5	41	1.867	0.063	3.4	40	11.916	0.202	1.7	41	4.195	0.170	4.1	41	1.923	0.059	3.1
Sysmex XE-2100 D/L (Bld Ctr)	18	1.898	0.085	4.5	18	1.862	0.071	3.8	17	11.866	0.296	2.5	18	4.177	0.091	2.2	18	1.918	0.079	4.1
Sysmex XE-5000	123	1.897	0.066	3.5	122	1.870	0.069	3.7	122	11.952	0.273	2.3	122	4.149	0.147	3.5	123	1.919	0.071	3.7
Sysmex XN-L Series	357	0.172	0.013	7.4	360	0.152	0.015	10.1	357	1.028	0.059	5.7	359	0.355	0.025	7.0	354	0.174	0.014	7.8
Sysmex XN-Series	2469	0.141	0.010	7.3	2478	0.127	0.007	5.9	2470	0.800	0.022	2.8	2480	0.296	0.010	3.4	2480	0.141	0.010	7.1
Sysmex XN-Series (RL App)	73	0.140	0.004	3.1	78	0.125	0.008	6.7	79	0.794	0.018	2.3	78	0.293	0.009	3.1	76	0.139	0.010	7.1
Sysmex XS (Except RL App)	477	0.196	0.018	9.2	479	0.170	0.017	9.9	480	1.162	0.090	7.7	479	0.388	0.032	8.3	479	0.196	0.017	8.9
Sysmex XS-1000iC (RL App)	60	0.194	0.017	9.0	60	0.173	0.018	10.6	60	1.165	0.093	8.0	60	0.390	0.029	7.5	60	0.197	0.019	9.8
Sysmex XT-1800i/2000i	92	1.938	0.084	4.4	93	1.847	0.074	4.0	93	12.227	0.392	3.2	93	4.209	0.143	3.4	93	1.943	0.079	4.1
Sysmex XT-4000i	74	1.948	0.085	4.4	75	1.840	0.088	4.8	73	12.249	0.403	3.3	74	4.208	0.158	3.8	74	1.944	0.087	4.5
Data for groups of 3-9	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**	**LABS**	**MEDIAN**	**LOW**	**HIGH**
Sysmex XE-2100C,XE2100DC	8	1.9	1.8	1.9	8	1.8	1.7	1.9	8	11.9	11.6	12.1	8	4.1	4.0	4.3	8	1.9	1.8	2.0

© 2020 College of American Pathologists

Immature Granulocytes (IG)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	29	10.89	0.58	5.3	29	10.93	0.55	5.0	29	12.01	0.51	4.3	29	10.79	0.56	5.2	29	10.93	0.45	4.1
Sysmex XE-5000	119	10.87	0.54	5.0	119	10.97	0.52	4.8	120	11.81	0.51	4.3	120	11.01	0.52	4.7	119	10.96	0.57	5.2
Sysmex XN-L Series	333	10.79	0.40	3.7	331	10.79	0.42	3.9	335	11.56	0.35	3.0	331	10.76	0.37	3.5	331	10.75	0.41	3.8
Sysmex XN-Series	2357	10.81	0.38	3.5	2362	10.89	0.38	3.5	2364	11.62	0.33	2.8	2366	10.80	0.34	3.1	2358	10.80	0.37	3.4
Sysmex XN-Series (RL App)	76	10.82	0.43	3.9	76	10.95	0.38	3.5	77	11.60	0.35	3.0	75	10.83	0.31	2.9	75	10.80	0.42	3.9
Sysmex XT-1800i/2000i	45	12.55	0.67	5.3	45	12.86	0.59	4.6	45	13.60	0.61	4.5	45	12.49	0.51	4.1	45	12.74	0.58	4.5
Sysmex XT-4000i	69	12.70	0.59	4.7	68	12.61	0.59	4.7	70	13.57	0.58	4.3	69	12.58	0.52	4.2	68	12.72	0.55	4.4

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	5	11.0	9.4	12.0	5	11.0	10.9	11.0	5	11.2	11.0	12.1	5	11.1	11.0	11.7	5	11.0	10.4	12.2

Immature Granulocytes (IG) x 10E9/L or x 10E3/µL (Ungraded)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-2100,2100 D/L	32	0.310	0.018	5.7	32	0.310	0.019	6.2	32	2.026	0.093	4.6	32	0.701	0.044	6.3	32	0.315	0.014	4.3
Sysmex XE-5000	116	0.307	0.015	5.0	118	0.308	0.018	5.8	119	2.003	0.101	5.0	119	0.703	0.041	5.8	118	0.313	0.018	5.9
Sysmex XN-L Series	330	0.326	0.015	4.6	329	0.292	0.013	4.6	333	1.977	0.067	3.4	331	0.684	0.027	4.0	328	0.327	0.016	4.8
Sysmex XN-Series	2346	0.318	0.014	4.3	2353	0.291	0.013	4.4	2349	1.930	0.062	3.2	2354	0.665	0.025	3.8	2356	0.319	0.014	4.4
Sysmex XN-Series (RL App)	63	0.314	0.016	4.9	63	0.291	0.012	4.2	64	1.913	0.068	3.6	63	0.665	0.025	3.8	63	0.312	0.015	4.9
Sysmex XT-1800i/2000i	47	0.368	0.025	6.8	47	0.361	0.020	5.6	47	2.395	0.126	5.3	47	0.825	0.043	5.2	47	0.375	0.022	5.8
Sysmex XT-4000i	66	0.377	0.022	5.7	66	0.355	0.021	6.0	67	2.411	0.140	5.8	67	0.834	0.046	5.5	67	0.380	0.023	6.2

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC	5	0.3	0.3	0.3	5	0.3	0.3	0.3	5	1.9	1.8	2.1	5	0.7	0.7	0.7	5	0.3	0.3	0.3

nRBC – % (Ungraded)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV***	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV***
Sysmex XE-2100,2100 D/L																				
eCheck Control	15	100.00	0.00	0.0	15	100.00	0.00	0.0	15	100.00	0.00	0.0	15	100.00	0.00	0.0	15	100.00	0.00	0.0
eCheck XE Control	19	0.00	0.00	0.0	18	5.58	0.62	11.2	18	6.65	0.27	4.0	18	6.87	0.36	5.3	19	0.00	0.00	0.0
Sysmex XE-5000																				
eCheck XE Control	121	0.00	0.00	0.0	121	5.54	0.65	11.7	120	6.67	0.31	4.7	121	7.04	0.41	5.9	122	0.00	0.00	0.0
Sysmex XN-Series																				
XN Check Control	2283	0.08	0.14	*	2316	5.19	0.52	10.1	2310	6.24	0.22	3.4	2312	6.45	0.36	5.6	2346	0.12	0.17	*
Sysmex XN-Series (RL App)																				
XN Check Control	42	0.10	0.16	*	43	5.35	0.55	10.3	41	6.21	0.19	3.1	41	6.35	0.37	5.9	43	0.12	0.15	*

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XE-2100C,XE2100DC																				
eCheck Control	3	100.0	100.0	100.0	3	100.0	100.0	100.0	3	100.0	100.0	100.0	3	100.0	100.0	100.0	3	100.0	100.0	100.0
Sysmex XN-Series																				
eCheck Control	6	0.0	0.0	0.3	6	5.1	4.5	5.5	6	6.3	5.9	6.3	6	6.5	6.3	6.8	6	0.2	0.0	0.3
eCheck XE Control	3	0.1	0.0	0.3	3	5.1	0.1	5.3	3	6.0	5.2	6.5	3	6.5	6.1	6.8	3	0.7	0.0	6.3

* When low results are reported on an analyte, a high coefficient of variation (CV) may result. When the mean value is very low, the CV may be exaggerated

© 2020 College of American Pathologists

nRBC – Absolute x 10E9/L or x 10E3/µL (Ungraded)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV***	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV***
Sysmex XE-2100,2100 D/L																				
eCheck Control	18	2.956	0.157	5.3	18	2.671	0.085	3.2	17	16.696	0.518	3.1	18	6.207	0.256	4.1	18	3.036	0.150	4.9
eCheck XE Control	18	0.000	0.000	0.0	18	0.152	0.016	10.7	18	1.062	0.043	4.1	18	0.418	0.029	6.8	18	0.000	0.000	0.0
Sysmex XE-5000																				
eCheck XE Control	115	0.000	0.000	0.0	115	0.148	0.019	12.7	114	1.061	0.050	4.7	115	0.421	0.025	6.1	116	0.000	0.000	0.0
Sysmex XN-Series																				
XN Check Control	2226	0.003	0.005	*	2226	0.139	0.014	10.2	2211	1.037	0.037	3.5	2219	0.397	0.022	5.6	2242	0.004	0.005	*
Sysmex XN-Series (RL App)																				
XN Check Control	38	0.003	0.005	*	38	0.141	0.015	10.6	37	1.023	0.034	3.3	37	0.386	0.020	5.3	39	0.004	0.005	*

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Sysmex XN-Series																				
eCheck Control	6	0.0	0.0	0.0	6	0.1	0.1	0.2	6	1.0	1.0	1.1	6	0.4	0.4	0.4	6	0.0	0.0	0.0
eCheck XE Control	4	0.0	0.0	0.0	4	0.1	0.0	0.1	4	1.0	1.0	1.4	4	0.4	0.4	10.2	4	0.0	0.0	3.9

Immature Platelet Fraction (IPF) or Reticulated Platelet (RP) – % (Ungraded)	FH9-06				FH9-07				FH9-08				FH9-09				FH9-10			
INSTRUMENT	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**	**LABS**	**MEAN**	**SD**	**CV**
Sysmex XE-5000	102	21.57	0.91	4.2	102	21.62	0.99	4.6	103	21.72	1.06	4.9	103	21.79	1.04	4.8	102	21.62	0.97	4.5
Sysmex XN-Series	1812	20.01	0.62	3.1	1817	20.02	0.58	2.9	1815	20.02	0.76	3.8	1817	20.03	0.71	3.5	1814	20.00	0.63	3.1
Sysmex XN-Series (RL App)	34	20.07	0.64	3.2	34	19.93	0.50	2.5	34	19.91	0.74	3.7	34	19.92	0.62	3.1	34	19.99	0.62	3.1

Data for groups of 3-9	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH	LABS	MEDIAN	LOW	HIGH
Microhematocrit (all PCV) Waived	6	20.1	19.1	21.5	6	20.5	19.5	21.9	6	20.0	19.2	21.0	6	20.1	19.1	20.4	6	19.7	19.1	21.7
Sysmex XE-2100C, XE-2100DC	8	21.1	20.6	23.6	8	21.4	20.2	23.8	8	20.6	20.1	23.5	8	22.7	20.4	23.7	8	22.6	20.0	23.6
Sysmex XN-L Series	3	19.7	19.4	19.8	3	20.3	19.3	20.3	3	21.0	18.9	21.1	3	19.6	19.1	20.3	3	19.2	18.9	19.6

* When low results are reported on an analyte, a high coefficient of variation (CV) may result. When the mean value is very low, the CV may be exaggerated

© 2020 College of American Pathologists

Red cell distribution width (RDW-SD vs. RDW-CV) discussion:
The red cell distribution width (RDW) is a calculated value which quantitatively reflects the degree of anisocytosis, or variation in red blood cell size, in a given blood sample. The RDW, in conjunction with the mean cell volume (MCV) and other red cell indices, may be a useful parameter in the laboratory evaluation of anemia and other hematologic conditions. An elevated RDW generally conveys increased variation in red blood cell size, and is seen in a variety of clinical settings including iron deficiency, autoimmune hemolysis, and in some patients with myelodysplastic syndrome.

Many modern automated hematology analyzers produce two distinct RDW measurements. The most commonly used and reported in clinical practice is the coefficient of variation RDW (RDW-CV), which is based on the coefficient of variation of the red blood cell distribution volume. The RDW-CV is calculated using the formula below, and the reference range in adults is typically 11.0 - 15.0%.

$$\text{RDW-CV} = \frac{1\text{SD}}{\text{MCV}} \times 100$$

Another way of expressing the RDW is the red cell distribution width-standard deviation, or RDW-SD. The RDW-SD is an actual measurement of the width of the red cell distribution curve and provides an absolute value in femtoliters (fL). The RDW-SD more accurately reflects red cell anisocytosis because it is directly measured and is not influenced by the MCV. The reference range for RDW-SD in adults is typically 36 - 47 fL.

The RDW-CV and RDW-SD are different expressions of the RDW, and laboratories should exercise caution so as not to confuse them for purposes of clinical reporting as well as proficiency testing.

Maria Vergara-Lluri, MD
Hematology and Clinical Microscopy Committee

References:

1. Constantino, BT. The red cell histogram and the dimorphic red cell population. *LabMedicine*. 2011; 42(5):300-308.
2. Kjeldsberg CR, Perkins SL, eds. *Practical Diagnosis of Hematologic Disorders*. 5th ed. Singapore: American Society for Clinical Pathology; 2010.
3. MediaLab, Inc. Website. http://www.medialabinc.net/spg579122/red_blood_cell_distribution_width_rdw_definition_a.aspx. Accessed June 3, 2013.

© 2020 College of American Pathologists

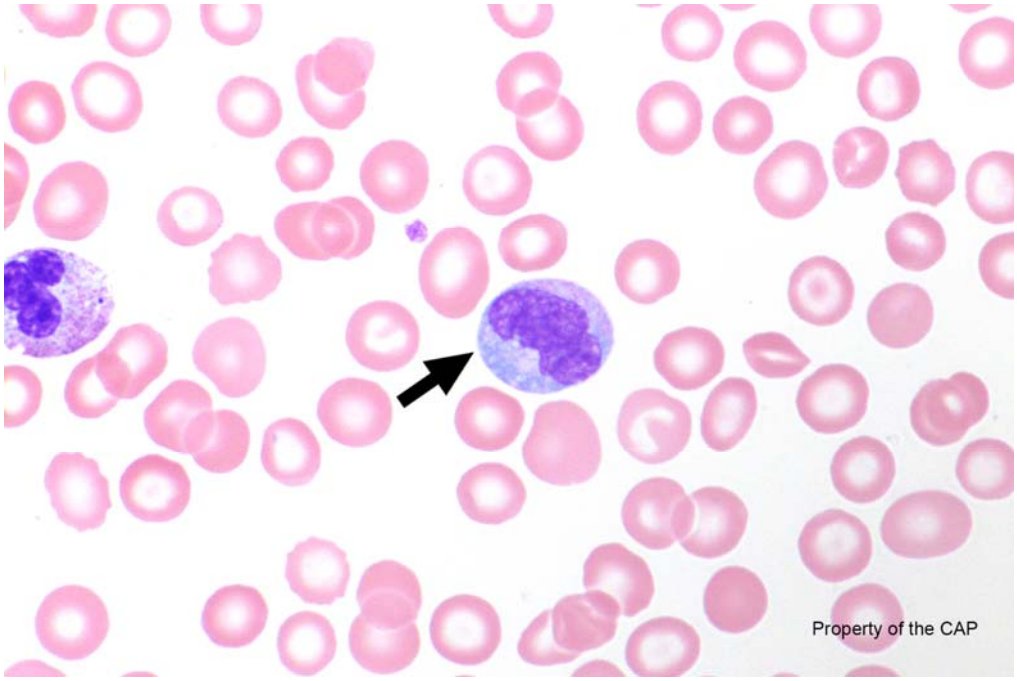
Blood Cell Identification – Graded

Case History
This peripheral blood smear is from an 81-year-old woman with septic shock. Laboratory data includes: WBC = 15.6 x 10E9/L; RBC = 3.01 x 10E12/L; HGB = 9.3 g/dL; HCT = 28.5%; MCV = 95 fL; MCHC = 32.6 g/dL; PLT = 32 x 10E9/L; and RDW = 16.0%; Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

To access the online Hematology Glossary, please click the hyperlink below:
https://documents.cap.org/documents/2020-hematology-clinical-microscopy-glossary.pdf

BCP-11



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Monocyte	161	94.7	4746	89.4	Good
Neutrophil, metamyelocyte	4	2.4	266	5.0	Unacceptable
Monocyte, immature (promonocyte, monoblast)	2	1.2	120	2.3	Unacceptable
Neutrophil, segmented or band	2	1.2	47	0.9	Unacceptable

The arrowed cell is a monocyte, as correctly identified by 94.7% of the referees and 89.4% of the participants. Monocytes are slightly larger than neutrophils, ranging from 12 to 20 µm in diameter. The majority of monocytes are round with smooth edges, but some may have pseudopod-like cytoplasmic extensions. The cytoplasm is abundant, with a gray or gray-blue ground-glass appearance, and may contain vacuoles or fine, evenly distributed azurophilic granules. The nuclear-to-cytoplasmic (N:C) ratio ranges from 4:1 to 2:1. The nucleus is usually indented, often resembling a three-pointed hat, but it can also be folded or band-like. The chromatin is condensed but is usually less dense than that of a neutrophil or lymphocyte. Nucleoli are generally absent, but occasional monocytes may contain a small, inconspicuous nucleolus.

© 2020 College of American Pathologists

BCP-11, cont'd

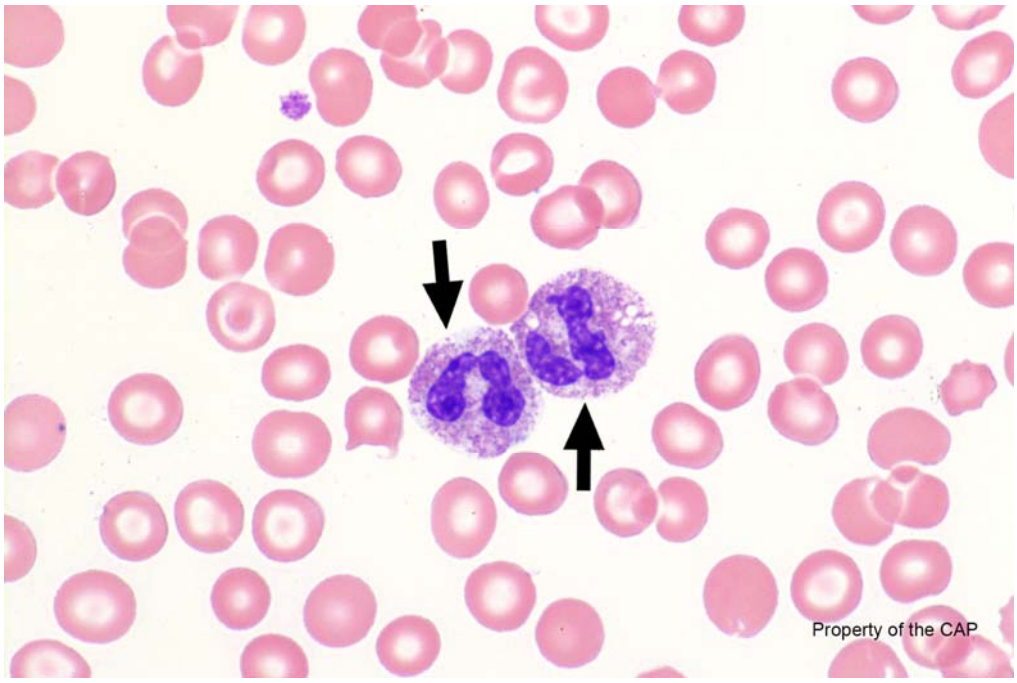
The arrowed cell was incorrectly identified as a neutrophil, metamyelocyte by 2.4% of the referees and 5.0% of the participants. Metamyelocytes are the first of the postmitotic myeloid precursors. They constitute 15% to 20% of nucleated cells in the bone marrow and may be seen in the blood in pathologic states and in response to stress. They are approximately 10 to 18 μm in diameter. They are round to oval with a N:C ratio of 1.5:1 to 1:1. The nuclear chromatin is condensed, and the nucleus is indented to less than half of the maximal nuclear diameter (ie, the indentation is smaller than half of the distance to the farthest nuclear margin). The cytoplasm is amphophilic containing rare azurophilic or purple (primary) granules and many fine lilac or pale orange/pink specific granules. The cell in question here does not have the nuclear shape or the many specific granules in the cytoplasm characteristic of a metamyelocyte.

The arrowed cell was incorrectly identified as a monocyte, immature (promonocyte, monoblast) by 1.2% of the referees and 2.3% of the participants. For the purposes of proficiency testing, selection of the response "monocyte, immature (promonocyte, monoblast)" should be reserved for malignant cells in the context of acute and has finely dispersed chromatin and distinct nucleoli. The cytoplasm is blue to gray-blue and may contain small, scattered azurophilic granules. Some monoblasts cannot be distinguished morphologically from other blast forms. Promonocytes have nuclear and cytoplasmic characteristics that are between those of monoblasts and mature monocytes. They are generally larger than mature monocytes, but they have similar-appearing gray-blue cytoplasm that often contains uniformly distributed, fine azurophilic granules. Cytoplasmic vacuolization is not a typical feature. The nuclei show varying degrees of lobulation, usually characterized by delicate folding or creasing of the nuclear membrane, in contrast to the rounder nuclear profile of monoblasts. Nucleoli are present but may not be as distinct as in monoblasts. The chromatin pattern of the arrowed cell is not fine, and therefore, not consistent with promonocytes or monoblasts.

© 2020 College of American Pathologists

Blood Cell Identification – Graded

BCP-12



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Neutrophil, toxic (to include toxic granulation and/or Döhle bodies, and/or toxic vacuolization)	124	72.9	3898	73.4	Good
Neutrophil, segmented or band	44	25.9	1355	25.5	Acceptable
Neutrophil with Pelger-Huët nucleus (acquired or congenital)	2	1.2	31	0.6	Unacceptable

The arrowed cells are toxic neutrophils, as correctly identified by 72.9% of the referees and 73.4% of the participants. Toxic changes in neutrophils include toxic granulation, toxic vacuolization, and Döhle bodies. Toxic granulation and Döhle bodies each may be present in an individual cell without the other finding, and either change alone is sufficient to designate a neutrophil as toxic. The arrowed cells show mild toxic granulation and cytoplasmic vacuoles without distinct Döhle bodies. Classification as neutrophils (non-toxic), as identified by 25.9% of referees and 25.5% of participants, was also deemed acceptable given that the granulation is only mildly exaggerated and that definite Döhle bodies are not present.

Toxic granulation is defined by the presence of large, purple or dark blue cytoplasmic granules in neutrophils, bands, and metamyelocytes. Vacuoles within the cytoplasm of these same cells also define toxic vacuolization. The vacuoles are variable in size and may coalesce, sometimes distorting the neutrophil cytoplasm to form pseudopodia. Ethylenediaminetetraacetic acid (EDTA) blood collection may produce degenerative vacuolization; in this context, only a few, small, punched-out-appearing vacuoles may be found. However, as it may be difficult to distinguish toxic from degenerative vacuoles, neutrophil vacuoles should not be labeled as toxic vacuoles unless accompanied by other toxic changes.

© 2020 College of American Pathologists

BCP-12, cont'd

Döhle bodies appear as single or multiple blue or gray-blue inclusions of variable size (0.1 to 5.0 µm) and shape (round or elongated or crescent-shaped) in the cytoplasm of neutrophils, bands, or metamyelocytes. They are often found at the periphery of the cytoplasm, near the cell membrane. These inclusions represent parallel strands of rough endoplasmic reticulum.

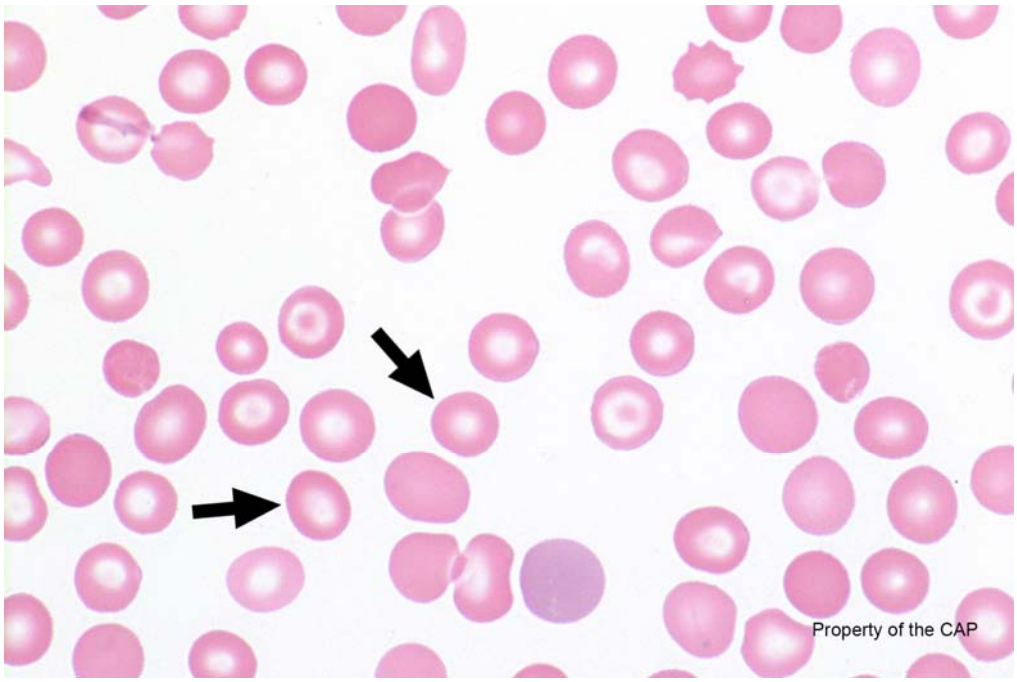
Toxic changes result from the action of cytokines released in response to infection, burns, trauma, and granulocyte colony stimulating factor (G-CSF), and they indicate a shortened maturation time and activation of post-mitotic neutrophil precursors.

In the May-Hegglin anomaly, inclusions that resemble Döhle bodies are seen. Unlike Döhle bodies, however, the May-Hegglin inclusion is due to aggregates of non-muscle myosin heavy chain IIA. Also seen in concert with neutrophil abnormalities are thrombocytopenia and giant platelets. The May-Hegglin anomaly is inherited in an autosomal dominant fashion, owing to mutations in *MYH9*.

© 2020 College of American Pathologists

Blood Cell Identification – Graded

BCP-13



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Erythrocyte, normal	155	91.2	4892	92.2	Good
Hypochromasia	10	5.9	277	5.2	Unacceptable
Microcyte (with increased central pallor)	5	2.9	127	2.4	Unacceptable

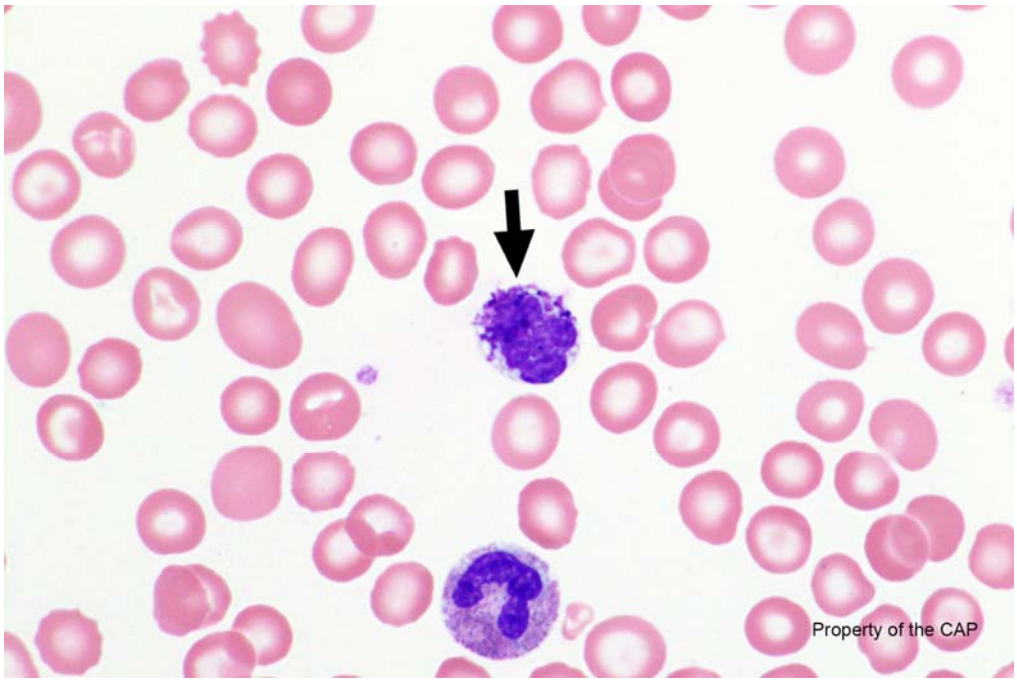
The arrowed cells are normal erythrocytes, as correctly identified by 91.2% of the referees and 92.2% of the participants. An erythrocyte is a mature, non-nucleated biconcave disc-shaped cell of fairly uniform diameter (6.7 to 7.8 µm) with a uniform round area of central pallor. It contains hemoglobin and stains uniformly pink red. The zone of central pallor is due to the biconcavity of the cell and occupies approximately one third (2 to 3 µm) of the cell diameter. Normal erythrocytes circulate in the peripheral blood for approximately 120 days before they undergo catabolism or destruction in the spleen.

The arrowed cells have normal central pallor. Hypochromasia, identified by 5.9% of the referees and 5.2% of the participants, is characterized by increased pallor (usually greater than 50% of the cell diameter) and is thus incorrect. Similarly, microcytes also often have increased pallor and are also smaller the normal erythrocytes (less than 6 microns). For these reasons, microcyte (with increased central pallor) identified by 2.9% of the referees and 2.4% of the participants, is also incorrect.

© 2020 College of American Pathologists

Blood Cell Identification – Graded

BCP-14



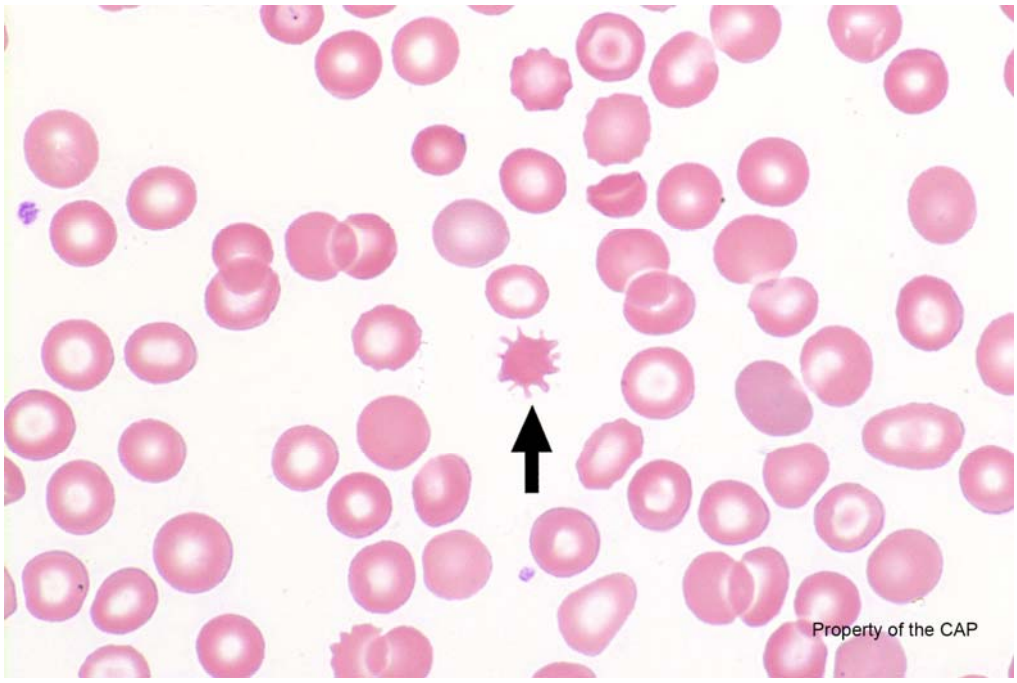
Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Basophil, any stage	168	98.8	5210	98.2	Good
Leukocyte with intracellular bacteria	1	0.6	10	0.2	Unacceptable
Neutrophil, toxic (to include toxic granulation and/or Döhle bodies, and/or toxic acuolization)	1	0.6	21	0.4	Unacceptable

The arrowed cell is a basophil, as correctly identified by 98.8% of the referees and 98.2% of the participants. Basophils have a maturation sequence analogous to neutrophils. The earliest basophil precursors can be identified in bone marrow at the myelocyte stage, when specific granules begin to develop. All basophils, from the basophilic myelocyte to the mature segmented basophil, are characterized by the presence of numerous coarse and densely stained granules of varying sizes and shapes. The granules are larger than the granules of neutrophils and most are roughly spherical. The granules are typically blue-black, but some may be purple-red when stained using Wright-Giemsa preparations. The granules are unevenly distributed and frequently overly and obscure the nucleus. Basophils are comparable in size to neutrophils, ie, 10 to 15 µm in diameter, and the N:C ratio ranges from 1:2 to 1:3. Basophilia may be seen in several contexts, including in association with myeloproliferative neoplasms, hypersensitivity reactions, hypothyroidism, iron deficiency, and renal disease.

© 2020 College of American Pathologists

Blood Cell Identification – Graded

BCP-15



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Acanthocyte (spur cell)	147	86.5	4587	86.4	Good
Echinocyte (burr cell, crenated cell)	23	13.5	708	13.3	Unacceptable

The arrowed cell is an acanthocyte, as correctly identified by 86.5% of the referees and 86.4% of the participants. Acanthocytes are densely stained, spheroidal red blood cells that lack central pallor and have multiple (usually three to 20), irregularly distributed, thorn-like spicules of variable size, often with drumstick ends. Spicules may occasionally have branches. Acanthocytes are classically described in association with hereditary abetalipoproteinemia (hereditary acanthocytosis). In addition, these cells are often seen in significant numbers in end-stage liver disease, post splenectomy, hepatorenal failure, infant pyknocytosis, McLeod phenotype, anorexia nervosa, and chronic starvation. In the latter two disorders, they appear as irregularly shaped erythrocytes with multiple blunt projections imparting an “animal cracker-like” appearance. A small number of acanthocytes may be seen in forms of severe hemolytic anemia, particularly after splenectomy. Acanthocytes are rarely encountered in otherwise normal blood smears (one or two per smear). In such smears, they represent older, senescent red blood cells approaching their end of life (120 days). It is logical, therefore, that acanthocytes should be more readily found in blood smears in the post-splenectomy state because of diminished splenic activity in removal of such poikilocytes.

The arrowed cell was incorrectly identified as an echinocyte by 13.5% of the referees and 13.3% of the participants. Echinocytes are red blood cells with 10 - 30 uniform, short, blunt projections distributed evenly that impart a serrated appearance to the red blood cell surface. The red blood cells retain central pallor and are the same size or slightly smaller than normal red blood cells. The irregular distribution of the projections as well as lack of central pallor are not compatible with echinocytes, and therefore excludes this identification.

© 2020 College of American Pathologists

BCP-15, cont'd

Echinocyte appearance is often the result of an improperly prepared smear (slow drying, thick smears, aged blood and pH alteration of glass slide). Echinocytes that are not artifacts may be indicative of disease, such as uremia or pyruvate kinase deficiency, and are seen post splenectomy, in hepatitis of the newborn, and phosphoglycerate kinase deficiency. Under such circumstances, they should be visible in wet preparations.

© 2020 College of American Pathologists

Clinical Presentation:

This peripheral blood smear is from an 81-year-old woman with septic shock. Laboratory data includes: WBC = 15.6 x 10E9/L; RBC = 3.01 x 10E12/L; HGB = 9.3 g/dL; HCT = 28.5%; MCV = 95 fL; MCHC = 32.6 g/dL; PLT = 32 x 10E9/L; and RDW = 16.0%.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

Case Discussion: Bacterial Sepsis

Septic shock refers to low blood pressure and dysfunction of multiple organs caused by full-body inflammatory response to an infection. Typically caused by bacteria in the bloodstream, septic shock may also be triggered by infection with other organisms (eg, viruses, fungi, parasites) in other organs and tissues (eg, kidney, heart, brain, skin and soft tissue). Occasionally certain organisms, including bacteria, may be visible on a peripheral blood smear or other infected body fluids.

Complete blood count (CBC) values from the patient in this case demonstrate mild leukocytosis, thrombocytopenia, and anemia that is normocytic (normal MCV). The leukocytosis is characterized by increased neutrophils, many of which show toxic changes including toxic granulation, toxic vacuolization, and Döhle bodies. This combination of features is often seen in patients with septic shock: neutrophils are “activated” to help fight the infection, leading to the morphologic changes referred to as “toxic” features. Bone marrow production of other hematopoietic elements may be suppressed by the infection and/or the body’s inflammatory response, resulting in anemia and thrombocytopenia.

Leukocytosis in septic shock and other reactive conditions may be so high as to mimic leukemia, then referred to as a leukemoid reaction. Infection, trauma (eg, burn, tissue injury), underlying cancer (termed a paraneoplastic reaction), and drug effects (eg, granulocyte-colony stimulating factor, G-CSF, other bone marrow growth factors, certain chemotherapies) may cause leukemoid reactions. The differential diagnosis of neutrophilia also includes some myeloproliferative neoplasms, including chronic myeloid leukemia (CML) and the rare atypical CML (aCML) and chronic neutrophilic leukemia (CNL). Careful attention to cytologic characteristics of the neutrophils (eg, toxic features) and presence of an accompanying left shift as well as to clinical and laboratory features (eg, infection, trauma, neoplasm, drug effect) is required to arrive at the correct interpretation of the peripheral smear findings.

Alexandra E. Kovach, MD
Hematology and Clinical Microscopy Committee

References:

1. Glassy EF, ed. *Color Atlas of Hematology: An Illustrated Field Guide Based on Proficiency Testing*, 2nd ed. Peripheral Blood. College of American Pathologists; 2018.
2. George TI. Malignant or benign leukocytosis. *Am Soc Hematol Ed Program.* 2012:475-484.
3. Chabot-Richards DS, George TI. Leukocytosis. *Int J Lab Hematol.* 2014;36:279-288.

© 2020 College of American Pathologists

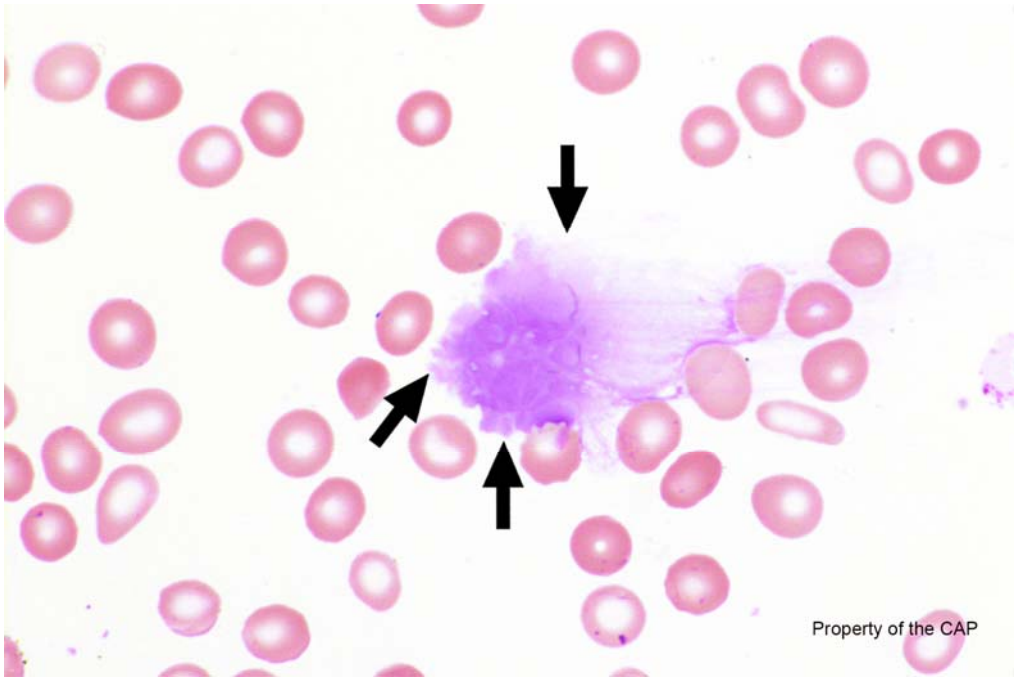
Blood Cell Identification – Ungraded

Case History
This peripheral blood smear is from a 15-year-old boy who presented with fevers, headaches, night sewats, and pancytopenia. He underwent a bone marrow biopsy and was subsequently diagnosed with acute megakaryoblastic leukemia. Laboratory data include: WBC = 0.5 x 10E9/L; RBC = 2.24 x 10E12/L; HGB = 6.3 g/dL; HCT = 18.1%; MCV = 81 fL; PLT = 7 x 10E9/L; and RDW = 18%. Identify the arrowed object(s) on each image.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

To access the online Hematology Glossary, please click the hyperlink below:
https://documents.cap.org/documents/2020-hematology-clinical-microscopy-glossary.pdf

BCP-16



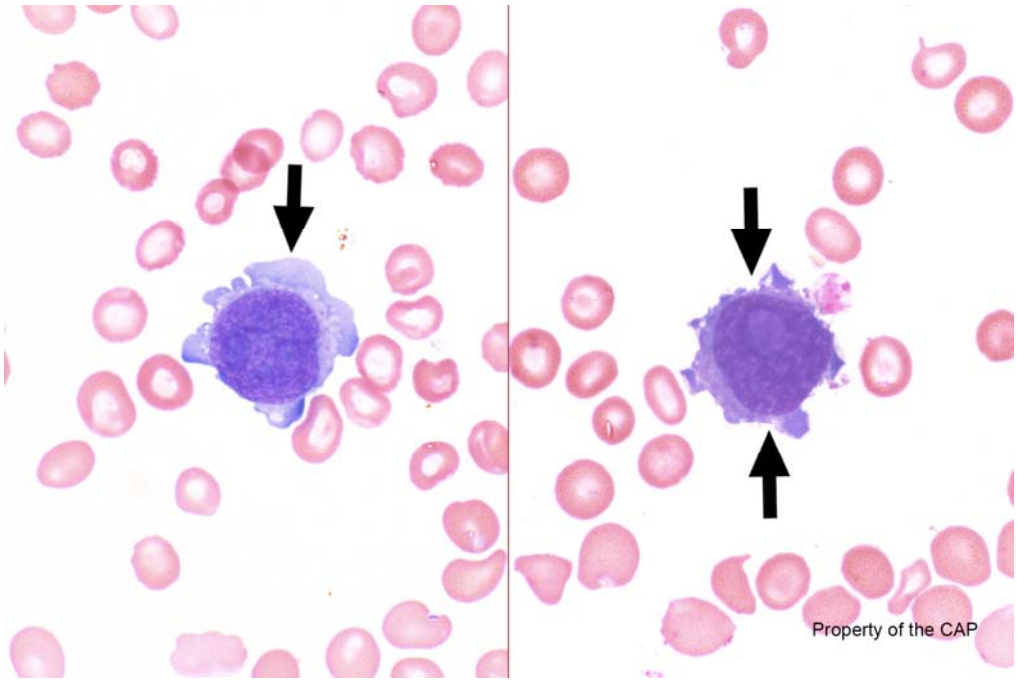
Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Basket cell/smudge cell	167	98.8	5182	98.5	Educational
Stain precipitate	1	0.6	27	0.5	Educational
Immature or abnormal cell, would refer for identification	1	0.6	12	0.2	Educational

The arrowed cell is a basket cell or smudge cell, as correctly identified by 98.8% of referees and 98.5% of participants. A basket cell or smudge cell is most commonly associated with cells that are fragile and easily damaged in the process of making a peripheral blood smear. The basket cell cytoplasm is indistinct, and chromatin strands spread out from a condensed nuclear remnant, giving the appearance of a basket.

© 2020 College of American Pathologists

Blood Cell Identification – Ungraded

BCP-17



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Blast cell	68	40.2	1721	33.2	Educational
Megakaryocyte (normal, abnormal, or nuclear fragment)	71	42.0	2420	46.6	Educational
Lymphocyte, reactive (includes plasmacytoid and immunoblastic forms)	9	5.3	377	7.3	Educational
Malignant lymphoid cell (other than blast)	4	2.4	312	6.0	Educational
Lymphocyte	2	1.2	30	0.0	Educational
Monocyte, immature (promonocyte, monoblast)	2	1.2	29	0.0	Educational
Plasma cell, morphologically mature/abnormal/containing inclusion (eg, Dutcher body, Russell body)	2	1.2	27	0.0	Educational
Immature or abnormal cell, would refer for identification	11	6.5	252	4.9	Educational

The arrowed cells are blasts, as correctly identified by 40.2% of the referees and 33.2% of participants. Blasts are large, round-to-oval cells, with high nuclear-to-cytoplasmic ratios, often with large nuclei demonstrating lacy or reticular (immature) chromatin.

The arrowed cells were incorrectly identified as a megakaryocyte (normal, abnormal or nuclear fragment) by 42.0% of the referees and 46.6% of the participants. While the arrowed cells do demonstrate features suggestive of megakaryocytic lineage, namely the cytoplasmic coloration and blebbing, the immaturity of the nuclear

© 2020 College of American Pathologists

BCP-17, cont'd
chromatin and prominence of the nucleoli suggest immaturity. As such, the classification as blast is more appropriate than megakaryocyte (normal, abnormal or nuclear fragment).

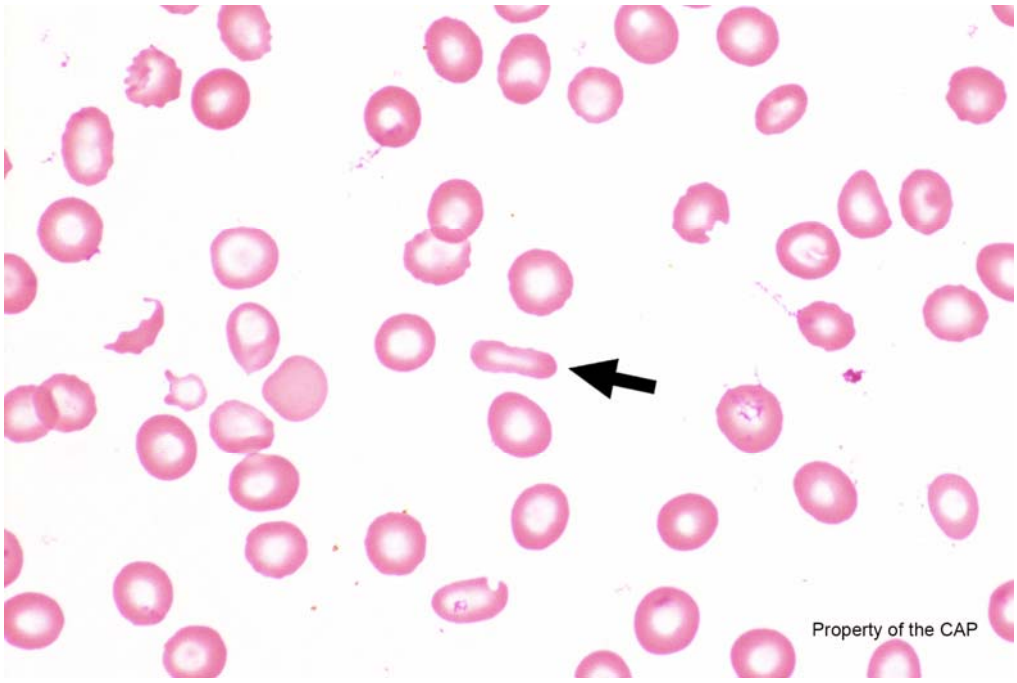
The arrowed cells were incorrectly identified as a lymphocyte, reactive (includes plasmacytoid and immunoblastic forms) by 5.3% of the referees and 7.3% of the participants. Reactive lymphocytes tend not to demonstrate such prominent blebbing or features of nuclear immaturity, making this selection an inappropriate one.

Finally, the arrowed cells were incorrectly identified a malignant lymphoid cell (other than blast) by 2.4% of the referees and 6.0% of the participants. Indeed, some malignant lymphoid cells can demonstrate prominent blebbing (as, for example, in some T-cell lymphomas), however, the nuclear features are not suggestive of a mature lymphoid process, rendering this selection inappropriate.

© 2020 College of American Pathologists

Blood Cell Identification – Ungraded

BCP-18



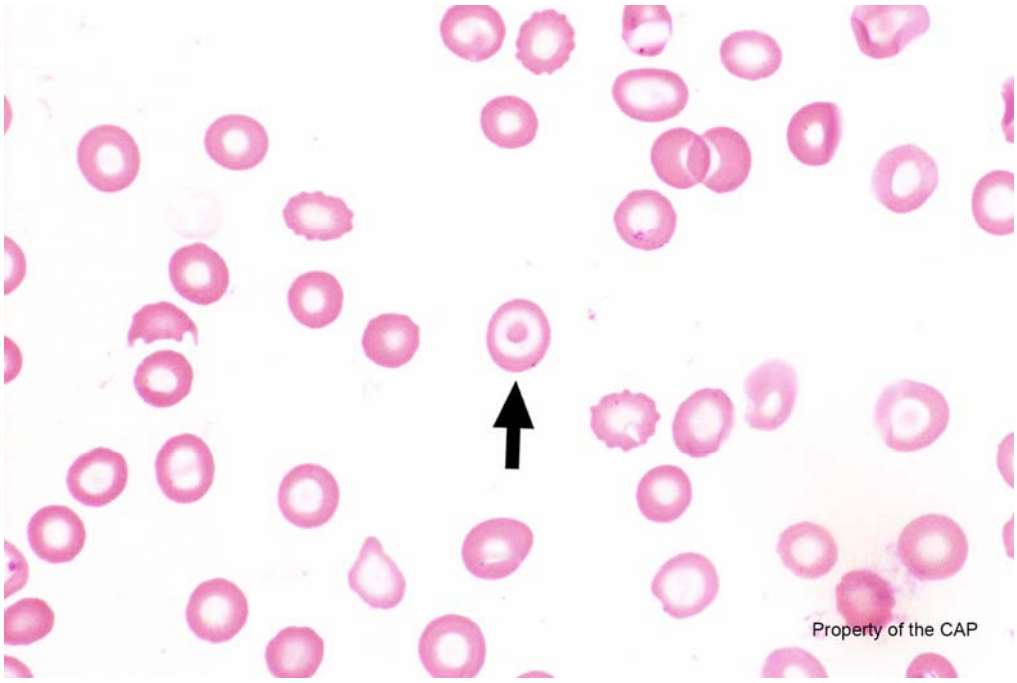
Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Ovalocyte (elliptocyte)	167	98.8	5158	99.4	Educational
Fragmented red blood cell (schistocyte, helmet cell, keratocyte, triangular cell)	1	0.6	3	0.1	Educational
Stomatocyte	1	0.6	13	0.3	Educational

The arrowed cell is an elliptocytes/ovalocytes, as correctly identified by 98.8% of referees and 99.4% of participants. The terms ovalocyte and elliptocyte are interchangeably used to describe elongated red blood cells with blunt ends and parallel sides. A small number of elliptocytes/ovalocytes may be present on the smears of normal individuals (< 1%), whereas a moderate to marked elliptocytosis/ovalocytosis (> 25%) is observed in patients with hereditary elliptocytosis, an abnormality of erythrocyte cytoskeletal proteins. Elliptocytes are also commonly increased in number in iron deficiency and in the same states in which teardrop cells may be seen.

© 2020 College of American Pathologists

Blood Cell Identification – Ungraded

BCP-19



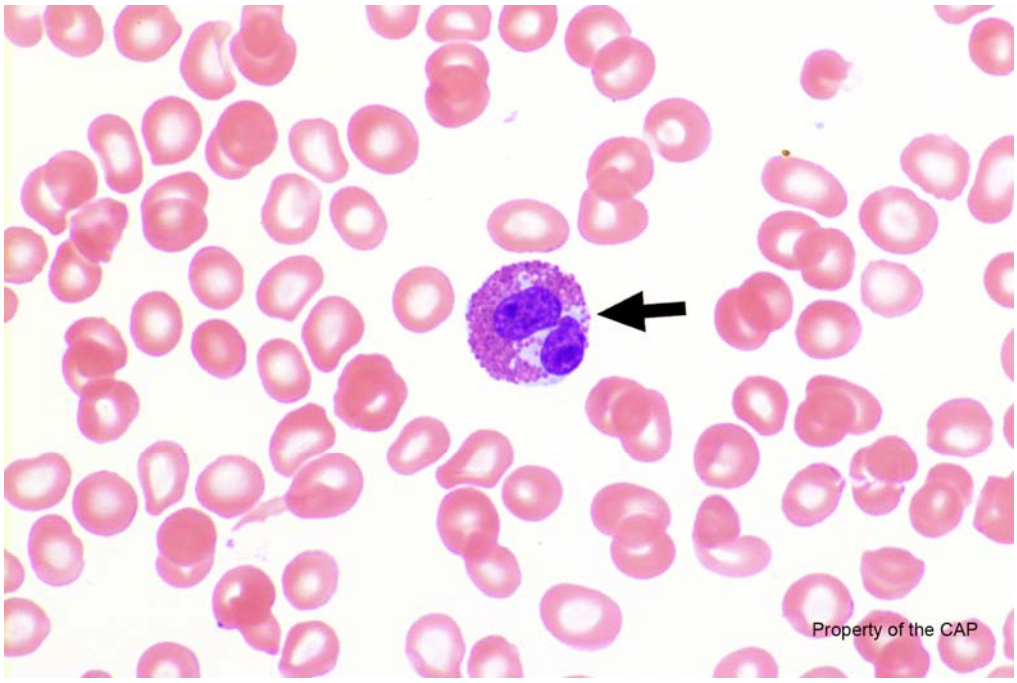
Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Target cell (codocyte)	169	100.0	5174	99.7	Educational

The arrowed cell is a target cell (codocyte), as correctly identified by 100.0% of referees and 99.7% of participants. Target cells have a characteristic appearance, consisting of a ring of pallor encircling a central zone of hemoglobinization, together reminiscent of a “bull’s-eye.” The target cell appearance results from an abnormally increased cell membrane-to-volume ratio, purported to result either from abnormal cell membrane lipid content or reduced cytoplasmic hemoglobin content. Relating to the former context, target cells may be seen in patients with biliary or liver disease, in which abnormal cholesterol metabolism may be a contributing factor. Relating to the latter, target cells may be seen in patients with iron deficiency or thalassemia. Of note, target cells may also be encountered post-splenectomy and rarely as an artifact of slide preparation (in the latter context, target cells are usually very few in number).

© 2020 College of American Pathologists

Blood Cell Identification – Ungraded

BCP-20



Identification	Referees		Participants		Evaluation
	No.	%	No.	%	
Eosinophil, any stage	168	99.4	5116	98.6	Educational
Neutrophil, toxic (to include toxic granulation and/or Döhle bodies, and/or toxic vacuolization)	1	0.6	20	0.4	Educational

The arrowed cell is an eosinophil, as correctly identified by 99.4% of referees and 98.6% of participants. Eosinophils are comparable in size to neutrophils, but demonstrate characteristic coarse, orange-red granules of uniform size; these granules are generally refractile under light microscopy. Eosinophils exhibit the same nuclear characteristics and the same stages of development as neutrophils; in contrast to neutrophils, however, eosinophils demonstrate a bilobed nuclear appearance in the vast majority of cases.

© 2020 College of American Pathologists

Actions Laboratories Should Take when a PT Result is Not Graded

The CAP uses exception reason codes that signify the proficiency testing (PT) for an analyte has not been graded. The exception reason code is located on the evaluation report in brackets to the right of the result. Your laboratory must identify all analytes with an exception reason code, review, and document the acceptability of performance as outlined below and retain documentation of review for at least 2 years. The actions laboratories should take include, but are not limited to:

Code	***Exception Reason Code Description***	***Action Required***
11	Unable to analyze	Document why the specimens were not analyzed (eg, instrument not functioning or reagents not available). Perform and document alternative assessment (ie, split samples) for the period that commercial PT was not tested to the same level and extent that would have been tested.
20	Response was not formally graded due to insufficient peer group data. Please see the participant summary for additional information.	Applies to a response that is not formally evaluated when a peer group is not established due to fewer than 10 laboratories reporting. Document that the laboratory performed a self-evaluation using the data presented in the participant summary and compared its results to a similar method, all method, all participant statistics, or data tables for groups of 3-9 laboratories, if provided. Perform and document the corrective action of any unacceptable results. If self-evaluation is not possible, it is up to the laboratory director/designee to determine an alternative performance assessment.
21	Specimen problem	Document that the laboratory has reviewed the proper statistics supplied in the participant summary. Perform and document alternative assessment for the period that commercial PT was not tested to the same level and extent that would have been tested. Credit is not awarded in these cases.
22	Result is outside the method/ instrument reportable range	Document the comparison of results to the proper statistics supplied in the participant summary. Verify detection limits. Perform and document the corrective action of any unacceptable results.
24	Incorrect response due to failure to provide a valid response code	Document the laboratory's self-evaluation against the proper statistics and evaluation criteria supplied in the participant summary. Perform and document the corrective action of any unacceptable results. Document corrective action to prevent future failures.
25	Inappropriate use of antimicrobial	Document the investigation of the results as if they were unacceptable and review the proper reference documents to gain knowledge of the reason your response is not appropriate.
26	Educational challenge	Review participant summary for comparative results and document performance accordingly. Evaluation criteria are not established for educational challenges. Laboratories should determine their own evaluation criteria approved by their laboratory director for self-evaluation. Response to the CAP is not required.
27,31	Lack of participant or referee consensus	Document that the laboratory performed a self-evaluation and compared its results to the intended response when provided in the participant summary. If comparison is not available, perform and document alternative assessment (ie, split samples) for the period that commercial PT reached non-consensus to the same level and extent that would have been tested.
28	Response qualified with a greater than or less than sign; unable to quantitate	Applies to a response that is not formally evaluated when a less than or greater than sign is reported. Document that the laboratory performed a self-evaluation and compared its results to the proper statistics supplied in the participant summary. Verify detection limits. Perform and document the corrective action of any unacceptable results.
30	Scientific committee decision	Applies to a response that is not penalized based on scientific committee decision. Document that the laboratory has reviewed the proper statistics supplied in the participant summary.

© 2020 College of American Pathologists

Actions Laboratories Should Take when a PT Result is Not Graded

The CAP uses exception reason codes that signify the proficiency testing (PT) for an analyte has not been graded. The exception reason code is located on the evaluation report in brackets to the right of the result. Your laboratory must identify all analytes with an exception reason code, review and document the acceptability of performance as outlined below and retain documentation of review for at least 2 years. The actions laboratories should take include but are not limited to:

Code	***Exception Reason Code Description***	***Action Required***
33	Specimen determined to be unsatisfactory after contacting the CAP	Document that the laboratory has contacted the CAP and no replacements specimens were available. Perform and document alternative assessment (ie, split samples) for the period that commercial PT was not tested to the same level and extent that would have been tested.
40 41	Results for this kit were not received. Results for this kit were received past the evaluation cut-off date.	Document why results were not received, corrective action to prevent recurrence and the laboratory's self-evaluation of the results by comparing results to the proper statistics and evaluation criteria supplied in the participant summary. If PT specimens were not analyzed, perform and document alternative assessment (ie, split samples) for the period that commercial PT was not tested to the same level and extent that would have been tested.
42	No credit assigned due to absence of response	The participant summary indicates which tests are graded (see evaluation criteria) and which tests are not evaluated/educational. Updates to grading will also be noted. If a test is educational, the laboratory is not penalized for leaving a result(s) blank. If a test is graded (regulated and non-regulated analytes) and your laboratory performs that test, results cannot be left blank. The laboratory is required to submit results for **all** challenges within that test or use an appropriate exception code or indicate test not performed/not applicable/not indicated. Exceptions may be noted in the kit instructions and/or the result form. Document corrective actions to prevent future failures.
44	This drug is not included in our test menu. Use of this code counts as a correct response.	Verify that the drug is not tested on patient samples and document to ensure proper future reporting.
45	Antimicrobial agent is likely ineffective for this organism or site of infection	Document that the laboratory performed a self-evaluation of written protocols and practices for routine reporting of antimicrobial susceptibility reports to patient medical records. Document that routine reporting of this result to clinicians for patient care is compliant with specific recommendations of relevant medical staff and committees (eg, infectious diseases, pharmacy and therapeutics, infection control). Response to the CAP is not required.
77	Improper use of the exception code for this mailing	Document the identification of the correct code to use for future mailings.
91	There was an insufficient number of contributing challenges to establish a composite grade.	Document the investigation of the result as if it were an unacceptable result. Perform and document the corrective action if required.
35, 43, 46, 88, 92	Various codes	No action required.

© 2020 College of American Pathologists

COLLEGE of AMERICAN PATHOLOGISTS

Don’t Miss Out On This Opportunity to Earn Continuing Education Credit

***** Enter the information below and distribute to your laboratory staff. *****

Program Mailing and Year:	FH (1-4, 6, 9-10,13)-B 2020
Activity Start Date:	June 22, 2020
Activity Expiration Date:	June 21, 2021

How to Access Your Online Education Activities

1. **Access Your Account**
   a. Go to cap.org and click **Login**.
   b. **If you are associated with one laboratory** that purchased kits for this activity, the system will register you into the activity. A kit will be associated to your registration.
   c. **If you are associated with more than one laboratory** that purchased kits for this activity, you will need to select the laboratory by clicking the **Select or Change Laboratory** button. The system will register you into the activity. A kit will be associated to your registration.
   d. **If you are not associated with a laboratory**, you need to add a laboratory affiliation by following these steps:
      - Under the Login menu, click **Update My Profile**.
      - Click the **Business/Professional** tab.
      - Click **+ Add Affiliation.**

2. **Access Your Online Education Activities**
   a. Go to cap.org and click **Login**.
   b. Click on the **Learning** tab.
   c. Enter the Program code in the Search box (eg, BMD, CGL), then click the binoculars icon.
   d. Click **Register**.
   e. After reviewing the Activity Details page, click **Register.**
   f. Click **Resume** to access the Activity.
   g. Click the confirmation checkbox at the bottom of the Activity Overview page, then click **Continue**.
   h. If you choose to return to the activity later, it can be found on the In-Progress Learning tab. Click the activity title to return to the activity.

Important: Before viewing review the System Requirements page on cap.org. Pop-up blockers must be turned off to complete the activity.

For assistance, call the Customer Contact Center at 800-323-4040 or 847-832-7000, option 1.

© 2020 College of American Pathologists

FH(1-4, 6, 9-10, 13)-B 2020: Acute Megakaryoblastic Leukemia

Continuing Education Information

CE (Continuing Education for non-physicians)
The CAP designates this educational activity for a maximum of 1 credit of continuing education. Participants should only claim credit commensurate with the extent of their participation in the activity.

The American Society for Clinical Pathology (ASCP) Board of Certification (BOC) Certification Maintenance Program (CMP) accepts this activity to meet the continuing education requirements.

This activity is approved for continuing education credit in the states of California and Florida.

Disclosure Statement

The following authors/planners have no financial relationships to disclose:
Etienne Mahé, MD, MSc, FRCPC, FCAP; Stephanie A. Salansky, MEd, MS, MT(ASCP)

The following In-Kind Support has been received for this activity:
None

The following Commercial Support has been received for this activity:
None

All speakers/authors of a CAP educational activity must disclose to the program audience any proprietary entity producing, marketing, reselling or distributing health care goods or services consumed by, or used on patients that may be discussed in the educational activity or with any proprietary entity producing, marketing, reselling, or distributing health care goods or services consumed by, or used on patients that is directly competitive with a product discussed in the presentation. Relevant financial relationships are considered to be any financial relationships in any amount occurring within the past 12 months that create a conflict of interest.

The College of American Pathologists does not view the existence of these interests or uses as implying bias or decreasing the value to participants. The CAP feels that this disclosure is important for the participants to form their own judgment about each presentation.

All College educational activities hold to the highest standards of educational quality and are dedicated to promoting improvement in healthcare quality and not a specific proprietary business interest of a commercial interest. All recommendations and/or planning criteria involving clinical medicine are based on evidence that is accepted within the profession of medicine as adequate justification for this indication and contraindication in the care of patients.

Learning Objectives

Upon completing the reading and answering the learning assessment questions, you should be able to:

1. Describe the salient aspects of classification of acute myeloid leukemia (AML) with megakaryocytic features.
2. Describe some of the epidemiological features of acute megakaryoblastic leukemia (AMKL).
3. Describe the characteristic morphological features of AMKL and other myeloid entities with megakaryocytic features.
4. Describe the utility of common ancillary tests used to confirm and further investigate cases of potential AMKL.

© 2020 College of American Pathologists

All material is © 2020 College of American Pathologists, all rights reserved

FH(1-4, 6, 9-10, 13)-B 2020: Acute Megakaryoblastic Leukemia

Case Presentation

This peripheral blood smear is from a 15-year-old boy who presented with fevers, headaches, night sweats, and pancytopenia. He underwent a bone marrow biopsy and was subsequently diagnosed with acute megakaryoblastic leukemia. Laboratory data include: WBC = 0.5 × 10E9/L; RBC = 2.24 × 10E12/L; HGB = 6.3 g/dL; HCT = 18.1%; MCV = 81 fL; PLT = 7 × 10E9/L; and RDW = 17.6%.

(PERIPHERAL BLOOD, WRIGHT-GIEMSA)

INTRODUCTION

Acute megakaryoblastic leukemia (AMKL) is a specific subtype of acute myeloid leukemia (AML), classified according to the World Health Organization's (WHO) classification of tumours of haematopoietic and lymphoid tissues under the larger category of AML, not otherwise specified.[1] The criteria for classification in this subcategory are quite strict, requiring a sufficient number of blasts (at least 20%) of megakaryoblastic lineage (at least 50%), an absence of other class-defining recurrent genetic abnormalities, an absence of features diagnostic of AML with myelodysplasia-related changes, and an absence of an underlying diagnosis of Down syndrome.

Published data relating to AMKL are limited, owing in part to the rarity of this entity, but also to changes in the accepted AML classification standards. While early AML classification systems were centered mainly around morphological and cytochemical features, the more recent WHO classification system includes a far more detailed assessment that includes immunophenotypic and molecular genetic parameters. As such, data gathered under the aegis of earlier classification systems, in particular the French-American-British (FAB), may not provide a complete picture of disease-specific characteristics relative to current standards (see, for example, a comparison of the various acute leukemia classification systems by Behm).[2] This is indeed the case in AMKL, and part of the reason for the narrow criteria required for its diagnosis.

EPIDEMIOLOGY & CLINICAL FEATURES

A handful of high-quality studies of AMKL and morphologically related AML subtypes are available. A recent Surveillance, Epidemiology, and End Results (SEER) registry study suggested that AMKL accounted for only 0.7% of AML cases.[3] Comparable low relative incidence rates have been recognized in other trial-based cohorts.[4,5] SEER data suggest a broad adult age range at diagnosis, with a median age of 67.5 years.[3] Published SEER-informed data are limited to patients of adult age range, however.

When cases are considered based solely on the presence of megakaryocytic features (ie, excluding cytogenetic features, myelodysplasia-related changes, and Down syndrome-related cases), the incidence of acute leukemia with megakaryocytic features demonstrates substantial early-age bias. In their fairly rigorous retrospective study, Duchayne et al. reported 57% of cases of acute leukemia with megakaryocytic features were identified in patients under age 18, with a median childhood age of only 12 months.[6] When they further segregated their cohort based on cytogenetic parameters, only 20% of their cohort met the criteria for AMKL, with most cases (64%) identified in the pediatric age range.[6] Indeed, in stark contrast to the SEER-informed adult dataset, when a broad age range is

All material is © 2020 College of American Pathologists, all rights reserved.

© 2020 College of American Pathologists

considered, the data from Duchayne et al. suggest a median age of two years for AMKL patients, even when cases of Down syndrome and t(1;22) subtypes are excluded.

Available data do not suggest an AMKL-specific bias of sex or ethnic background.[3,4,6] Some studies suggest a relatively high proportion of cases presenting with organomegaly.[4,6] There are also reports of a peculiar association between AMKL and mediastinal germ cell tumors in young adult males.[1,7]

DIAGNOSIS & LABORATORY PARAMETERS

As with all cases of putative acute leukemia, a complete bone marrow study (including peripheral smear review), flow cytometric assessment, cytogenetic analysis, and molecular profiling are strongly recommended.[1]

The complete blood count (CBC) & peripheral blood evaluation
Patients typically present with cytopenia(s). The observation of thrombocytopenia is typical, but thrombocytosis and leukocytosis have also been documented.[1,4,6] Dysplastic features may be identified, typified by neutrophil dysplasia, but also by atypia of platelets and (if present) erythroid precursors.[1] Circulating megakaryocytes (including dysplastic forms) may be seen, but are not considered blast equivalents.[1] Circulating blasts may be identified.[4,6]

Bone marrow evaluation
Although not specifically required according to the WHO rubric, most cases will demonstrate a preponderance of blasts with megakaryocytic morphological features.[1,6] Megakaryoblasts are relatively large-sized blasts, with immature nuclear features (often with prominent nucleoli), with typically basophilic cytoplasm and distinct cytoplasmic blebs.[1]

In their exhaustive cytological study of acute leukemias with megakaryocytic features, Duchayne et al. reported three general categories of megakaryoblasts: blast cells with clear and typical megakaryocytic features (eg, large size, cytoplasmic blebs); an immature cell contingent including an admixture of typical megakaryoblasts and otherwise morphologically undifferentiated blasts; and cases consisting entirely of morphologically undifferentiated blasts, for which ancillary immunophenotypic studies were required for lineage confirmation.[6] This study serves to highlight the need for rigorous immunophenotypic analysis to ascertain blast lineage.

The presence of micromegakaryocytes and/or other dysplastic features may be present but should not be of sufficient prominence for a diagnosis of AML with myelodysplasia-related changes. AMKL cases may demonstrate extensive bone marrow fibrosis, which often limits the availability or quality of aspirate materials.

Cytochemistry, flow cytometry, & immunophenotyping
Although infrequently required, it bears noting that certain cytochemical studies can be informative in the workup of a putative AMKL. In particular, AMKL cases should be myeloperoxidase negative in the blast cells of interest.[1]

For confirmation of megakaryocytic lineage, otherwise undifferentiated blasts must express at least one of the lineage-defining platelet glycoprotein markers CD41, CD61, and/or CD42b.[1,8] Owing to the potential for nonspecific positivity due to platelet-adherence to blasts, identification of intracytoplasmic CD41, CD61, and/or

All material is © 2020 College of American Pathologists, all rights reserved.

© 2020 College of American Pathologists

CD42b positivity is considered more specific.[1] Other nonspecific myeloid markers such as CD13 and CD33 may also be positive; CD45, CD34, and HLA-Dr are typically negative, but CD117 is reported to be variably positive.[1,8] MPO and other markers of granulocytic lineage should be negative.[1] CD36 is characteristically positive, but is not specific, as this marker can be positive in erythroid leukemia.[1]

If aspirate materials are limited, as may be the case in situations of extensive fibrosis, immunohistochemical stains with the above (or alternative) antibodies can be performed. FVIII antibodies are typically readily available for immunohistochemical techniques.

Cytogenetic analysis

AMKL demonstrates no specific cytogenetic features. Other megakaryoblastic acute leukemias have been described with specific cytogenetic features. AML (megakaryoblastic) with t(1;22)(p13.3;q13.1) is considered by the WHO as its own subtype of AML with recurrent genetic abnormalities. Patients with Down syndrome should also not be classified as AMKL, but rather under the category of myeloid proliferations associated with Down syndrome. Finally, while the initial FAB M7 category included many cases with complex cytogenetic features, or other cytogenetic aneuploidies or partial aneuploidies, the current WHO classification would subclassify the majority of these cases as AML with myelodysplasia-related changes.

DIFFERENTIAL DIAGNOSIS

While the differential diagnosis of AMKL includes a number of specific subtypes of other AML, many can be excluded by way of careful review of the clinical history and with the aid of a robust cytogenetic workup. Cases of AMKL can show some morphologic resemblance to acute panmyelosis with myelofibrosis, especially if the available materials are limited. This equally rare entity, in contrast, is characterized by a proliferation of admixed marrow elements from all three myeloid lineages, rather than one biased toward megakaryoblastic proliferation. The differential diagnosis may also include AML with myelodysplasia-related changes. If the latter cannot be excluded by way of cytogenetic studies, careful review of the clinical history for evidence of myelodysplasia, as well as a careful assessment of the overall burden of dysplasia, is required.

THERAPY AND PROGNOSIS

The aggressive nature of AMKL is highlighted in all published studies. In their SEER-informed dataset, for example, Giri, et al. compared AMKL to other non-AMKL cases, demonstrated an inferior survival, even after excluding cytogenetically good-risk cases (such as core-binding factor subtypes and cases of acute promyelocytic leukemia).[3] Similar data, albeit centered around the FAB M7 classification (ie, acute leukemia with megakaryocytic features), have been demonstrated in other retrospective datasets, including a relatively robust cohort from MD Anderson.[9] The latter study suggests that the mere presence of predominant megakaryocytic features is an adverse overall survival parameter.[9] It should be noted, however, that AML with t(1;22) and Down syndrome associated myeloid neoplasms do fare much better than cases of AMKL.[1]

Most studies reporting treatment outcome data in adults with AMKL record approximately 50% response rates to aggressive chemotherapy, but with subsequent rapid relapses and relatively brief overall survival.[4-6,9] The GIMEMA dataset reports a median survival of only 40 weeks, with a five-year overall survival rate of only 10%.[4]

All material is © 2020 College of American Pathologists, all rights reserved.

© 2020 College of American Pathologists

In stark contrast, however, children with AML t(1;22) or Down syndrome-associated myeloid neoplasms demonstrate far better outcomes. Patients with Down syndrome associated myeloid neoplasms are typically treated with reduced intensity regimens (sometimes only requiring supportive care); children with AML t(1;22) treated with intensive chemotherapy respond well to treatment and demonstrate relatively long disease-free survival.[6]

SUMMARY

AMKL is a rare subtype of AML, NOS, characterized by a predominance of megakaryoblasts (or blasts of megakaryocytic lineage). This entity is often a diagnosis of exclusion, once other more common (and biologically and prognostically distinct) entities are excluded. The optimal workup in cases putative AMKL is extensive and should include morphological, immunophenotypic and cytogenetic studies.

REFERENCES

1. *WHO classification of tumours of haematopoietic and lymphoid tissues*. Revised 4th edition. Lyon: International Agency for Research on Cancer 2017.
2. Behm F. Classification of Acute Leukemias. In: *Treatment of Acute Leukemias: New Directions for Clinical Research*. Humana Press 2003.43–58.
3. Giri S, Pathak R, Prouet P, et al. Acute megakaryocytic leukemia is associated with worse outcomes than other types of acute myeloid leukemia. *Blood* 2014;124:3833–3834.
4. for the GIMEMA, Pagano L, Pulsoni A, *et al.* Acute megakaryoblastic leukemia: experience of GIMEMA trials. *Leukemia* 2002;**16**:1622–1626.
5. Tallman MS, Neuberg D, Bennett JM, et al. Acute megakaryocytic leukemia: the Eastern Cooperative Oncology Group experience. *Blood* 2000;**96**:2405–2411.
6. Duchayne E, Fenneteau O, Pages M-P, et al. Acute Megakaryoblastic Leukaemia: A National Clinical and Biological Study of 53 Adult and Childhood Cases by the Groupe Français d'Hématologie Cellulaire (GFHC). *Leukemia & Lymphoma* 2003;44:49–58.
7. Nichols CR, Roth BJ, Heerema N, et al. Hematologic neoplasia associated with primary mediastinal germ-cell tumors. *N Engl J Med* 1990;322:1425–1429.
8. Olsen RJ, Chang C-C, Herrick JL, et al. Acute leukemia immunohistochemistry: a systematic diagnostic approach. *Arch Pathol Lab Med* 2008;132:462–475.
9. Oki Y, Kantarjian HM, Zhou X, et al. Adult acute megakaryocytic leukemia: an analysis of 37 patients treated at M.D. Anderson Cancer Center. *Blood* 2006;107:880–884.

AUTHOR'S BIOGRAPHY

Etienne Mahé, MD, MSc, FRCPC, FCAP, is a Clinical Assistant Professor in the Division of Hematology, Department of Pathology & Laboratory Medicine, and Hematology & Hematologic Malignancies, Department of Medicine, at the University of Calgary. Dr. Mahé has authored several articles, abstracts, and educational activities and serves as a member of the Hematology and Clinical Microscopy Committee for the College of American Pathologists.

All material is © 2020 College of American Pathologists, all rights reserved.

© 2020 College of American Pathologists

NOTES

© 2020 College of American Pathologists

NOTES

© 2020 College of American Pathologists

NOTES

© 2020 College of American Pathologists

This concludes the report.

COLLEGE of AMERICAN PATHOLOGISTS

325 Waukegan Road
Northfield, IL 60093-2750
800-323-4040
847-832-7000 (Country code: 001)