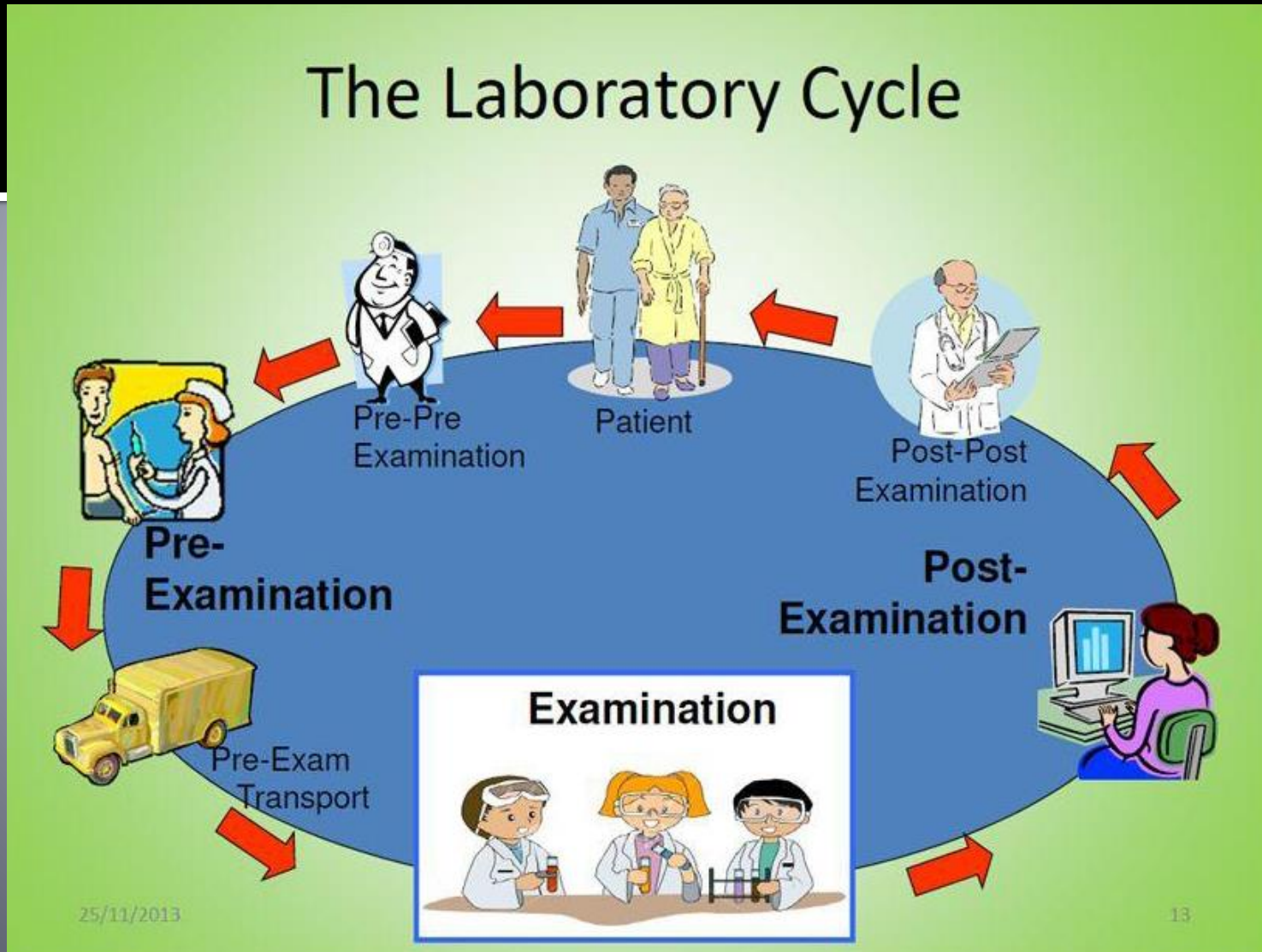
INTERPRETATION OF GRAPHS AND RESULTS OF ADVANCED HEMATOLOGY ANALYSERS PART-1

23th, Nov. 2022
Time: 9:00-13:00

Dr. Toraj Hemmati, CLS PhD
Hematology and Transfusion Medicine Specialist,
Emam Hosein Hospital

Factors affecting the outcome of a test

- Analytical (8-15%)
- Postanalytical (15-25%)
- Preanalytical (60-70%)



1 HISTOGRAM GRAPH IS WORTH 1000 NUMBER

BENIE CONSTANTINO,
CML HEALTHCARE INC., ONTARIO, CANADA

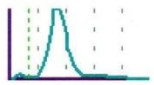
What looks like a CBC in lab??

Name: abolfazl poor
Patient ID: 4546
Sample No.: 4546
Birth 69(Age)

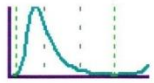
Date : 2019/06/03
Time : 08:03:39
Sex :
Ward :
Dr. :

Parameters					Normal Ranges
WBC	12.94	+	[10^3/uL]		(4.50 - 11.00)
RBC	3.34	-	[10^6/uL]		(4.00 - 5.50)
HGB	9.1	-	[g/dL]		(12.5 - 17.5)
HCT	28.3	-	[%]		(38.0 - 53.0)
MCV	84.7		[fL]		(80.0 - 97.0)
MCH	27.2		[pg]		(26.0 - 34.0)
MCHC	32.2		[g/dL]		(31.0 - 36.0)
RDW-SD	48.6		[fL]		(37.0 - 54.0)
RDW-CV	16.3	+	[%]		(11.0 - 14.5)
PLT	362		[10^3/uL]		(150 - 450)
PDW	12.4		[fL]		(9.0 - 14.0)
MPV	10.1		[fL]		(9.0 - 12.0)
P-LCR	26.3		[%]		(13.0 - 43.0)
PCT	0.37	+	[%]		(0.17 - 0.35)
NEUT	9.62	*	[10^3/uL]	74.2 * [%]	(54.0 - 62.0)
LYMPH	2.00		[10^3/uL]	15.5 - [%]	(25.0 - 35.0)
MONO	1.29	+	[10^3/uL]	10.0 + [%]	(3.0 - 8.0)
EO	0.02	*	[10^3/uL]	0.2 * [%]	(0.0 - 1.0)
BASO	0.01		[10^3/uL]	0.1 [%]	(0.5 - 3.0)

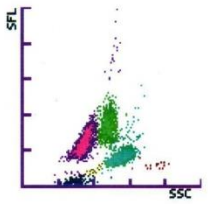
RBC



PLT



DIFF

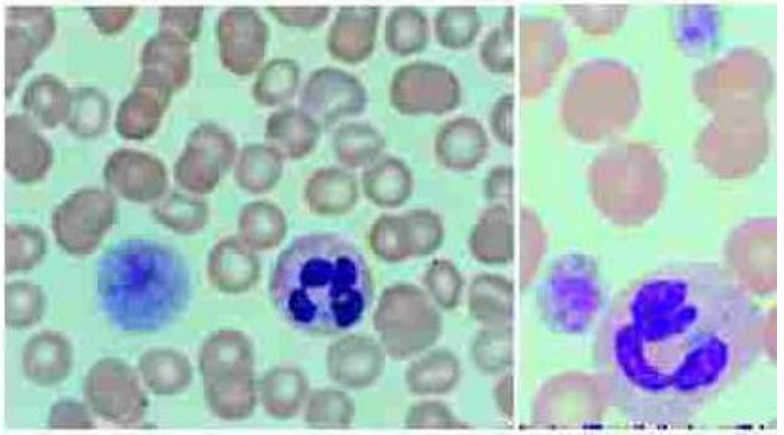


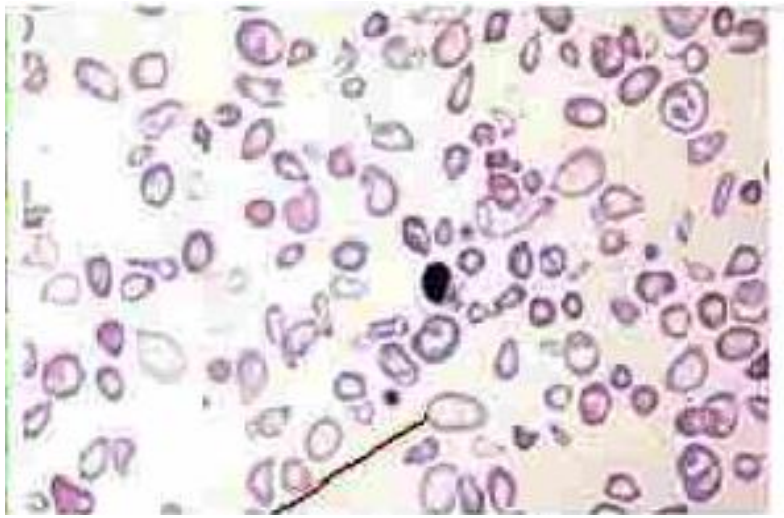
WBC IP Message(s)
Monocytosis
Leukocytosis

RBC IP Message(s)
Anisocytosis
Anemia

PLT IP Message(s)

Left Shift?

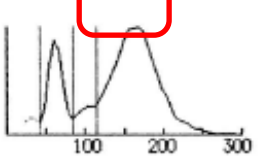




What looks like a CBC in lab??

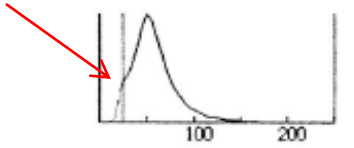
WBC		5.8×10³/μL
RBC	RL*	5.65×10⁶/μL
HGB	-	8.4g/dL
HCT	RL*	32.5%
MCV	RL*	57.5fL
MCH	RL*	14.9pg
MCHC	RL*	25.8g/dL
PLT	PU!	1884×10³/μL

WBC



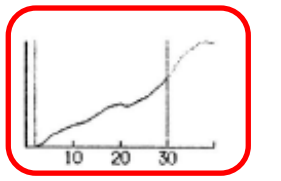
LYM%	21.0%
MXD%	7.2%
NEUT%	71.8%
LYM#	1.2×10³/μL
MXD#	0.4×10³/μL
NEUT#	4.2×10³/μL

RBC

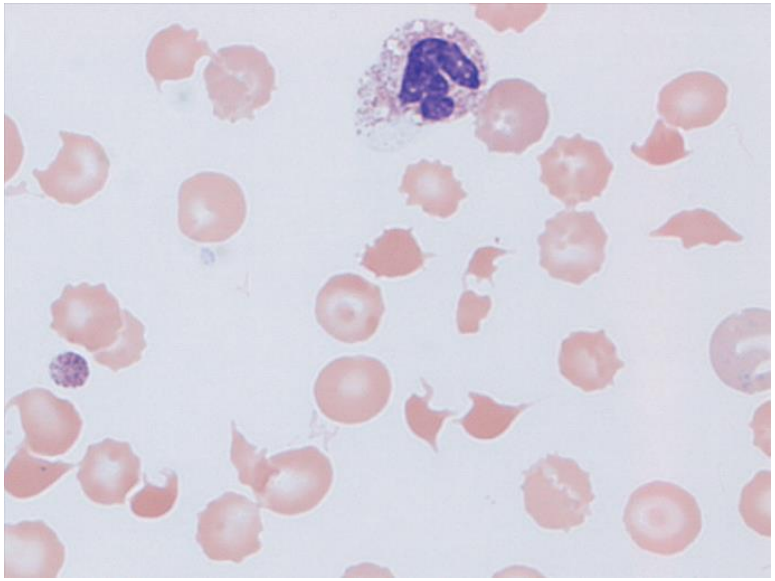


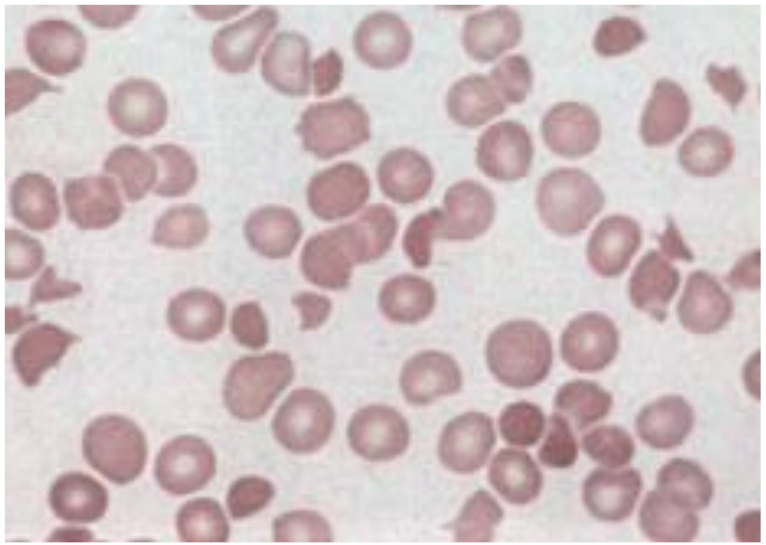
RDW RL* 32.3%

PLT



PDW	DW	---.-fL
MPV	PU	---.-fL
P-LCR	PU	---.-%





New Emerging Hematology Parameters

- CHCM
- CHr
- PCT
- P-LCR
- P-LCC
- MPX
- WBC-P
- IG
- IMG
- LFR
- MFR
- HFR
- IRF
- LUC
- PLT-O
- HDW
- IPF
- Ret-He
- ANC/AGC
- PLT-F

Tailoring your hematology

Productivity

* DI-60 is a registered product of CellaVision AB · **www.cellavision.com**
TOSOH HLC-723 G11 Analyser is a registered product of Tosoh Corporation (Japan) · **www.tosoh.com
***Interrliner XN is a registered product of RR Mechatronics (The Netherlands) · **www.rrmechatronics.com**

Types of hematology analyzers & their development process

از دیدگاه تکاملی آنالیزرهای هماتولوژی را می‌توان به سه دسته و پنج نسل تقسیم نمود:

۱- سل‌کانترهای نیمه اتوماتیک مثل سل‌کانتر CBC5 که در این دستگاه مرحله رقیق سازی در خارج از دستگاه و به روش دستی انجام گرفته و سپس برای شمارش و آنالیز نهایی به دستگاه داده می‌شود.

۲- سل‌کانترهای اتوماتیک: این دستگاه‌ها بین ۸ تا ۱۸ پارامتر هماتولوژی را اندازه‌گیری و محاسبه نموده و قادر هستند شمارش افتراقی سه قسمتی لکوسیت ها را انجام دهند که از این جهت به آنها 3Part هم گفته می‌شود. بیشتر سل‌کانترهای موجود در بازار ایران را این دستگاه‌ها تشکیل می‌دهند که از جمله آنها می‌توان سیسمکس‌های سری K ،Helena ، Hycell، کولتر S-Plus، Mindray و غیره را نام برد.

۳- سل‌کانترهای تمام اتوماتیک: این دستگاه‌ها قادرند تا ۳۲ پارامتر هماتولوژی را اندازه‌گیری و محاسبه نمایند. همچنین امکان شمارش افتراقی پنج تا هفت قسمتی لکوسیت ها را نیز فراهم می‌آورند. از جمله این سل‌کانترها می‌توان تکنیکون‌های سری H1 و Adiva 120، سیسمکس‌های سری XE-2100 و XT-2000i ، کولترهای LH750 و GEN-S و نهایتاً سل‌کانترهای Abott-Cell Dyn اشاره نمود.

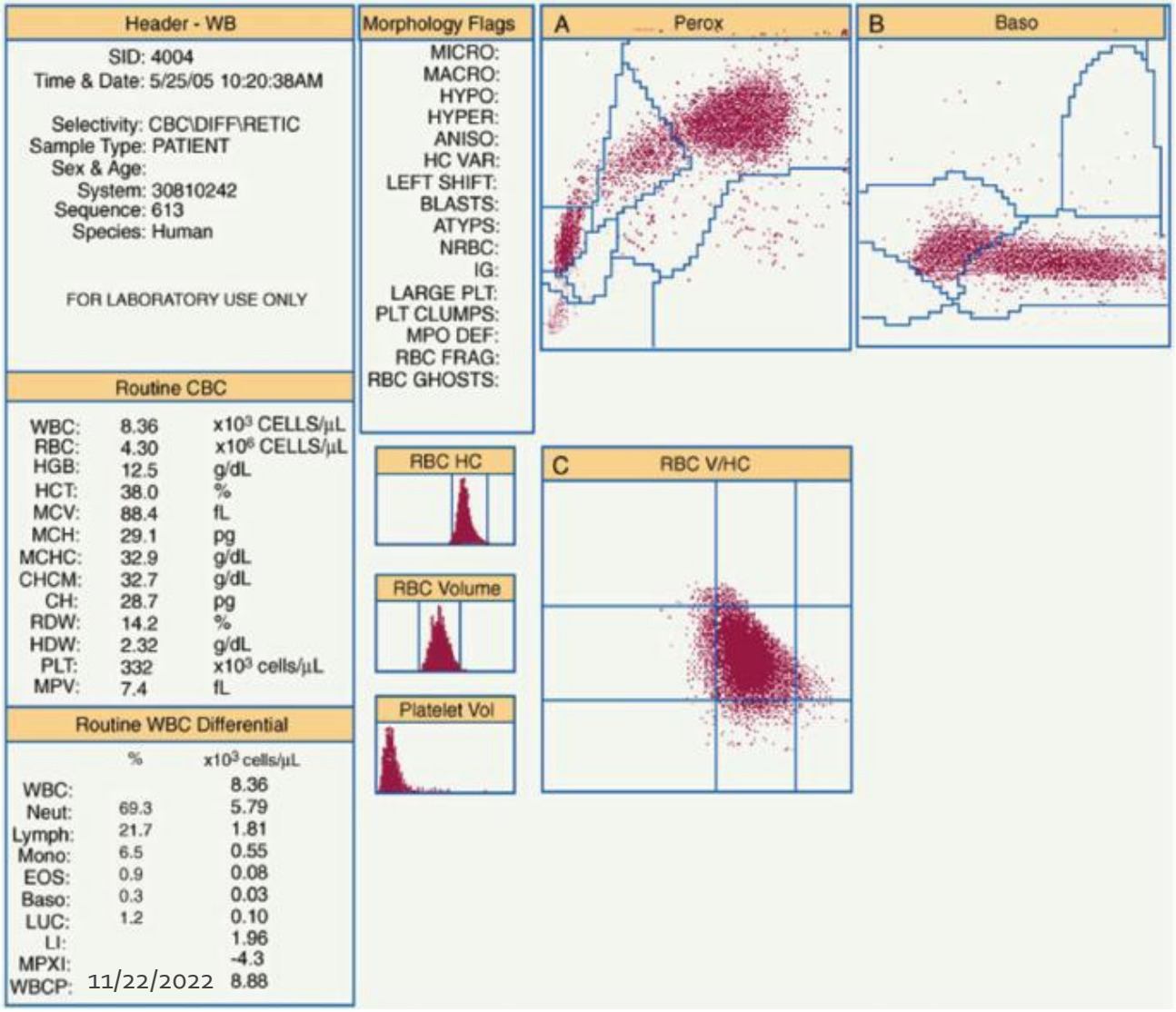
سل‌کانترهای هماتولوژی شمارش تام و افتراقی سلول‌های خونی را براساس ویژگی‌هایی نظیر اندازه، تراکم، غلظت و حجم سلولی، تراکم و لوبولاریتی هسته، خواص بیوشیمیایی و آنزیماتیک سیتوپلاسم، رسانایی الکتریکی سلول، وضعیت گرانول‌ها و پراکنش نور تابشی به آنها انجام می‌دهند. از نظر اصول کار و روش ارزیابی سلول‌ها، دو روش عمده در سل‌کانترهای هماتولوژی وجود دارد [۱۱]:

الف- تغییر در هدایت الکتریکی (امپدانس) همراه یا بدون کاپاسیتانس (یا رادیوفرکانس)

ب- روش‌های اوپتیکال یا نوری که خود به سه دسته MAPSS (مثل Cell Dyne و Cell Tac)، PANDA (مثل H1-3 و Advia)، Fluorscence (مثل سیسمکس و میندری) و LARC (مثل سیستم کوباس و کورنینگ) تقسیم می‌شوند.

Kinds of hematology analyzer we have in the hematology Lab.

An example of a CBC result from the advanced Advia 120R cell counter



Header - WB

SID: 4004
Time & Date: 5/25/05 10:20:38AM

Selectivity: CBC\DIFF\RETIC
Sample Type: PATIENT
Sex & Age:
System: 30810242
Sequence: 613
Species: Human

FOR LABORATORY USE ONLY

Routine CBC

WBC:	8.36	x10³ CELLS/µL
RBC:	4.30	x10⁶ CELLS/µL
HGB:	12.5	g/dL
HCT:	38.0	%
MCV:	88.4	fL
MCH:	29.1	pg
MCHC:	32.9	g/dL
CHCM:	32.7	g/dL
CH:	28.7	pg
RDW:	14.2	%
HDW:	2.32	g/dL
PLT:	332	x10³ cells/µL
MPV:	7.4	fL

Routine WBC Differential

	%	x10³ cells/µL
WBC:		8.36
Neut:	69.3	5.79
Lymph:	21.7	1.81
Mono:	6.5	0.55
EOS:	0.9	0.08
Baso:	0.3	0.03
LUC:	1.2	0.10
LI:		1.96
MPXI:		-4.3
WBCP:		8.88

Morphology Flags

MICRO:
MACRO:
HYPO:
HYPER:
ANISO:
HC VAR:
LEFT SHIFT:
BLASTS:
ATYPS:
NRBC:
IG:
LARGE PLT:
PLT CLUMPS:
MPO DEF:
RBC FRAG:
RBC GHOSTS:

A Perox

B Baso

RBC HC

RBC Volume

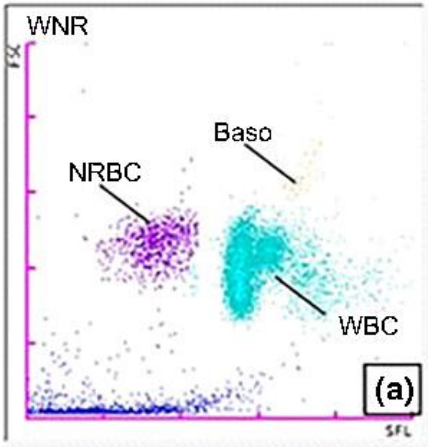
Platelet Vol

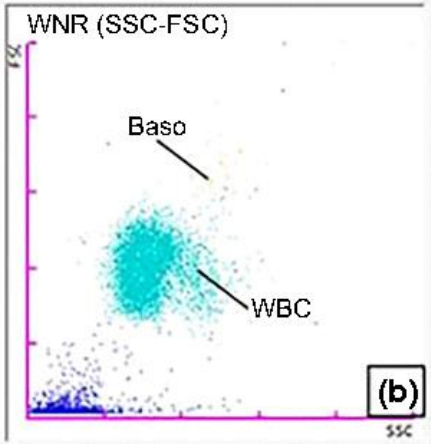
C RBC V/HC

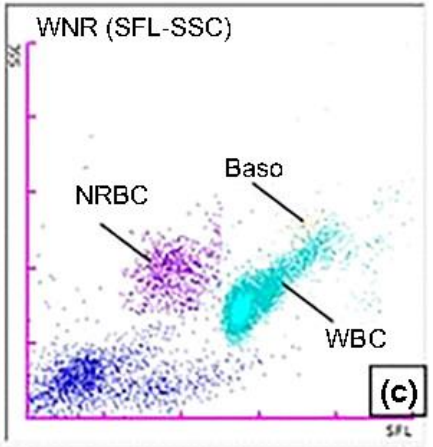
Morphology Flags

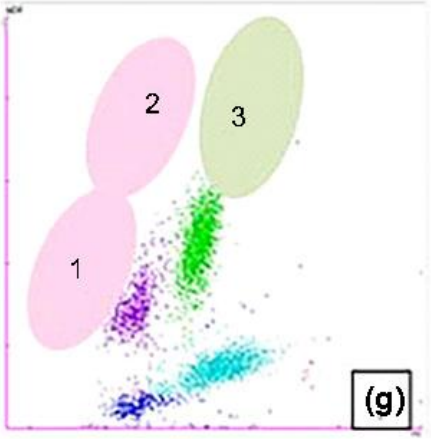
MICRO:
MACRO:
HYPO:
HYPER:
ANISO:
HC VAR:
LEFT SHIFT:
BLASTS:
ATYPS:
NRBC:
IG:
LARGE PLT:
PLT CLUMPS:
MPO DEF:
RBC FRAG:
RBC GHOSTS:

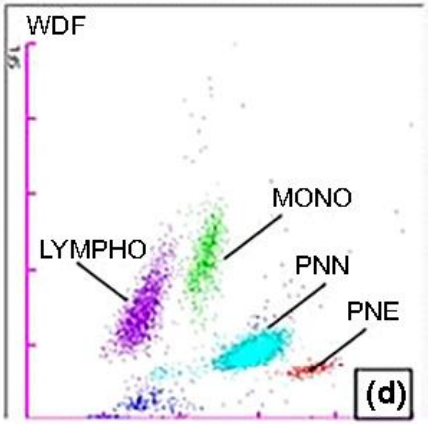
An example of a CBC result from the advanced Sysmex XN 1000 cell counter

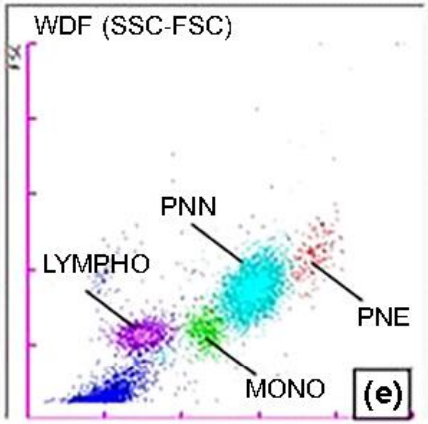


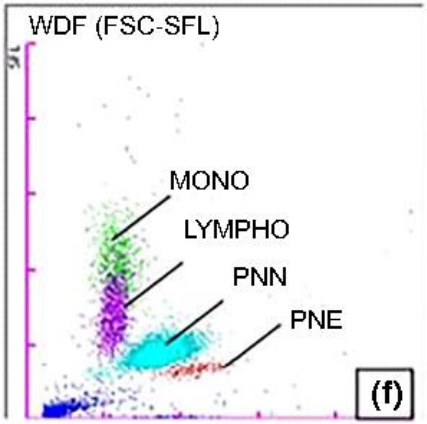












1° Blast/Abn Lympho, Atypical Lympho

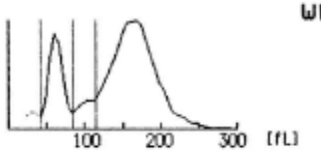
2° Atypical Lympho

3° Blast/Abn Lympho

Report of an advanced cell counter vs partial diff one

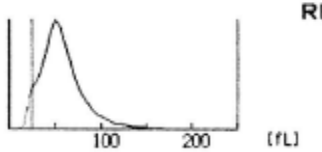
WBC		5.8×10³/μL
RBC	RL*	5.65×10⁶/μL
HGB	-	8.4g/dL
HCT	RL*	32.5%
MCV	RL*	57.5fL
MCH	RL*	14.9pg
MCHC	RL*	25.8g/dL
PLT	PU!	1884×10³/μL

WBC



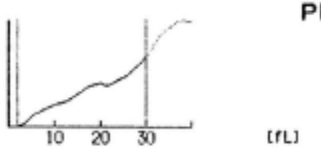
LYM%	21.0%
MXD%	7.2%
NEUT%	71.8%
LYM#	1.2×10³/μL
MXD#	0.4×10³/μL
NEUT#	4.2×10³/μL

RBC



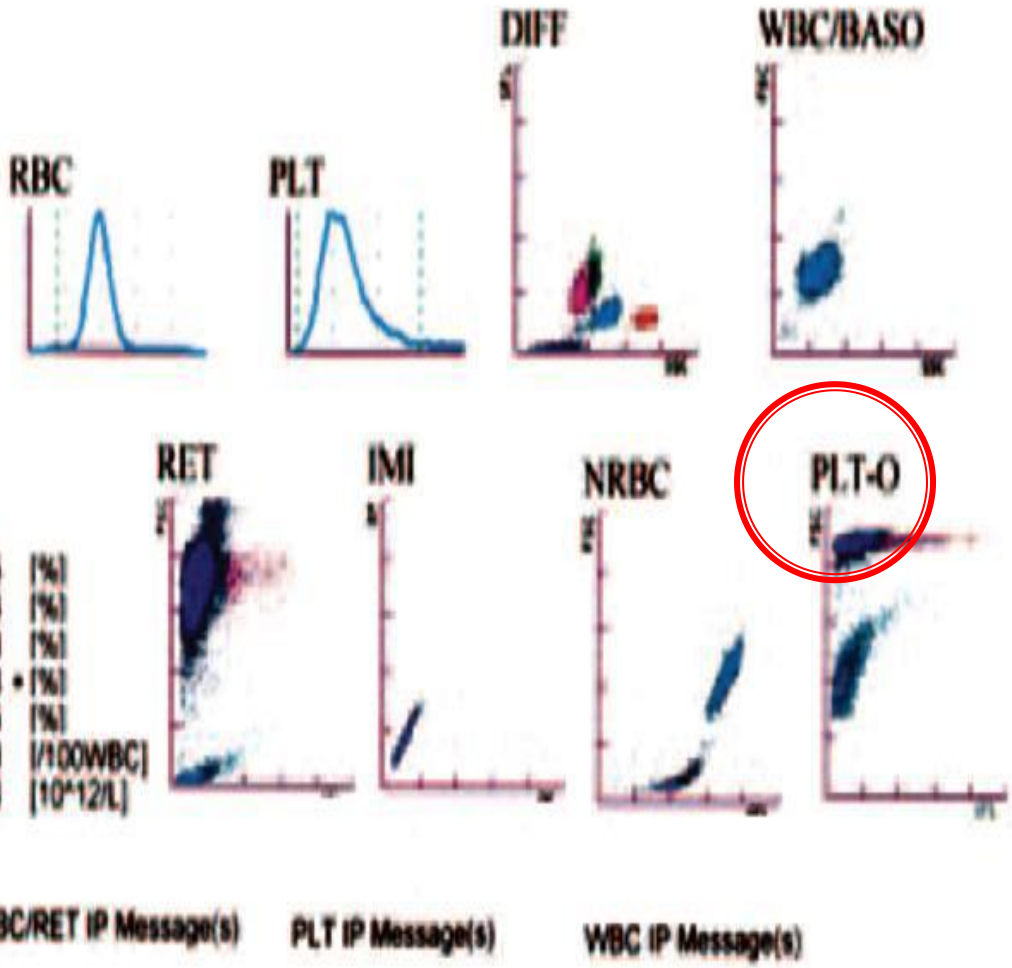
RDW RL* 32.3%

PLT



PDW	DW	---.-fL
MPV	PU	---.-fL
P-LCR	PU	---.-%

WBC	7.51	[10^9/L]	
RBC	4.01	[10^12/L]	
HGB	13.2	[g/dL]	
HCT	39.6	[%]	
MCV	98.8	[fL]	
MCH	32.9	[pg]	
MCHC	33.3	[g/dL]	
PLT	178	[10^9/L]	
RDW-SD	51.9	[fL]	
RDW-CV	14.4	[%]	
PDW	15.8	[fL]	
MPV	12.9	[fL]	
P-LCR	49.3 *	[%]	
PCT	0.23	[%]	
NEUT	4.61	[10^9/L]	61.5 [%]
LYMPH	1.76	[10^9/L]	23.4 [%]
MONO	0.55	[10^9/L]	7.3 [%]
EO	0.55 *	[10^9/L]	7.3 * [%]
BASO	0.04	[10^9/L]	0.5 [%]
NRBC	0.00	[10^9/L]	0.0 [/100WBC]
RET	1.28	[%]	0.0513 [10^12/L]
IRF	7.5	[%]	
LFR	92.5	[%]	
MFR	7.1	[%]	
HFR	0.4	[%]	



شکل ۲۴-۱۱: نمونه‌ای از یک گزارش نهایی سیسمکس XE-2100

Advanced Clinical Hematology Parameters

What are these ***NEW*** tests?

Advanced
Clinical
Parameters

White Blood Cells

IG (Immature Granulocyte)

Red Blood Cells

Retic-Comprehensive

1) Retic
2) IRF (Immature Retic Fraction)
3) ***RET-He*** (Reticulocyte Hemoglobin Equivalent)

NEW!

AUTOMATED!

Platelets

IPF (Immature Platelet Fraction)

Hematology is closer to the clinical setting than is thought.

Advanced Clinical Parameters

IG

ITR and **Neonatal Infection**

- Infection / sepsis

RET-He

- Anemia Management
- Improved Iron / EPO utilization
- Improved transfusion practice
- Prevent readmission

IPF

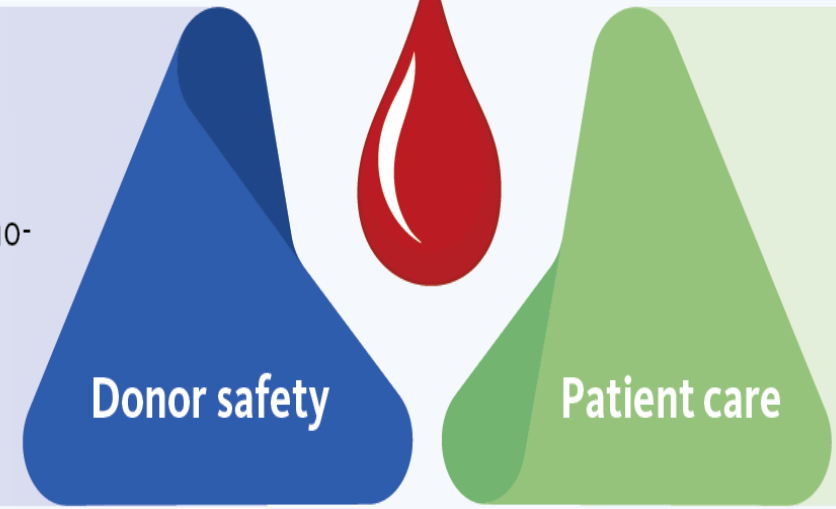
- Mechanism of Thrombocytopenia
- Decrease unnecessary bone marrow biopsies
- Improve transfusion practices

ITR: immature neutrophils to total neutrophils ratio

Hematology is closer to the clinical setting than is thought.

The Blood Bank mode

- measures residual white and red blood cells in blood components.
- determines RBC and platelet concentrations in blood products.



The parameters

- HGB (haemoglobin)
- RET-He (reticulocyte haemoglobin equivalent)

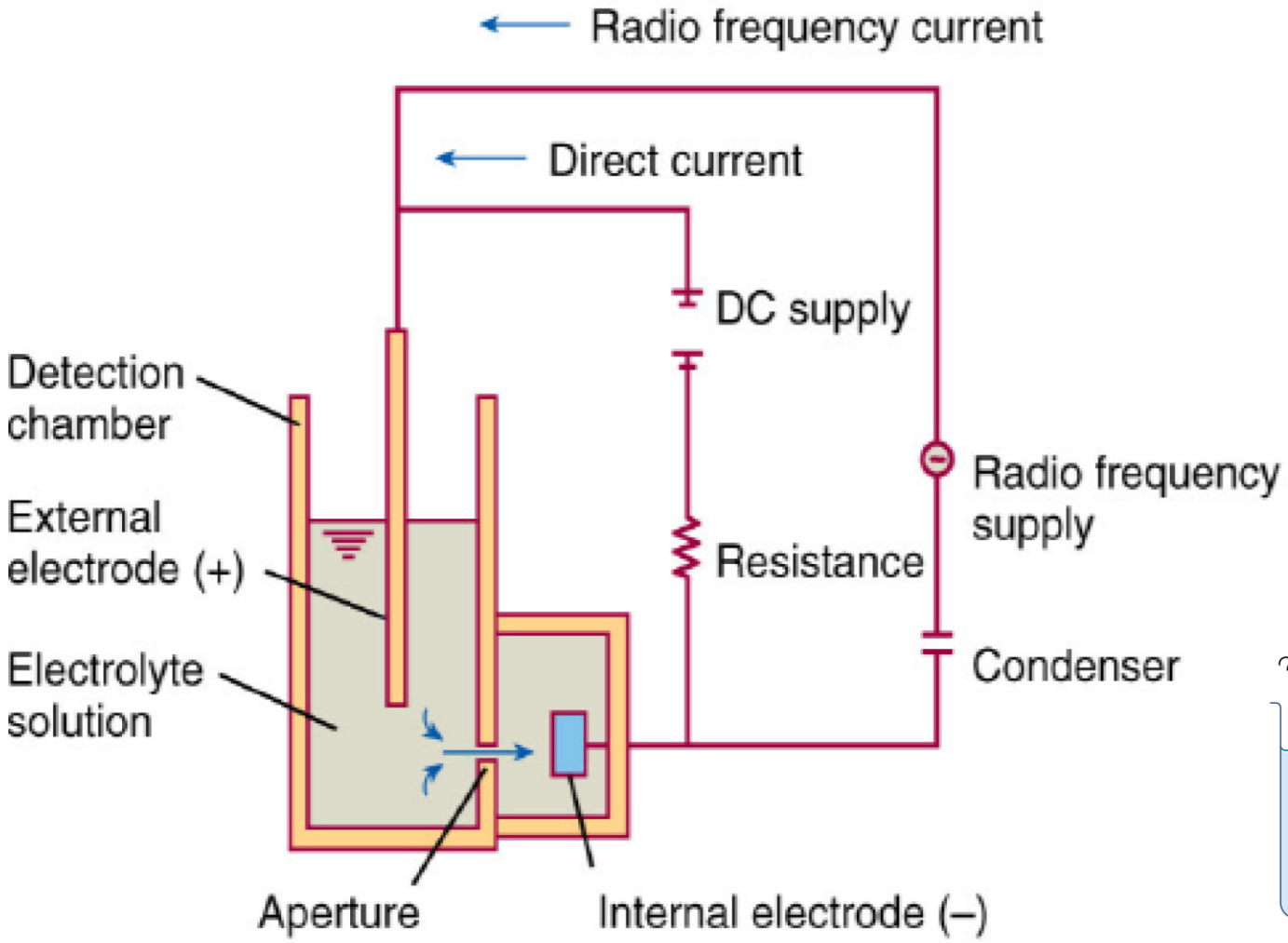
help to evaluate the donor's blood status.

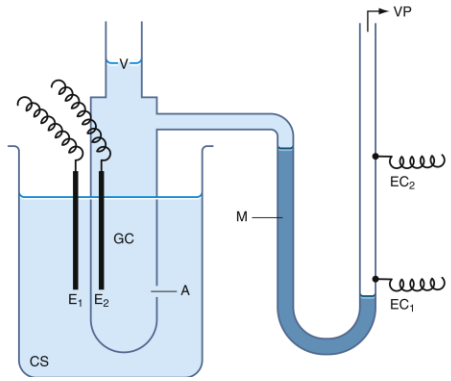
The advanced clinical parameters

- RET-He
- IPF (immature platelet)

are used for monitoring the patients.

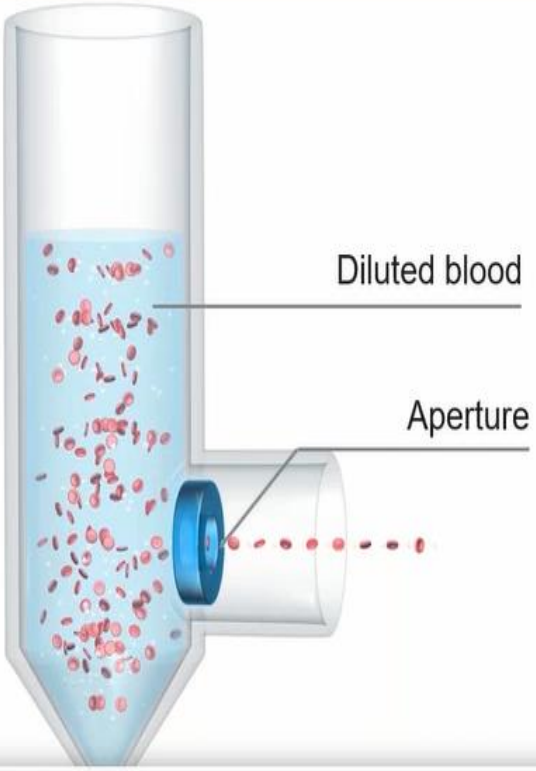
Mechanism of cell counting, cell volume determination and histogram formation





Volumetric Counting: DC detection method

- The cell-counting detector consists of an electrostatic field, limited by an aperture.
- When blood cells pass through the aperture, an electrolyte volume equivalent to that of the blood cell is displaced. This causes changes in resistance, which are detected as a measurable variable.



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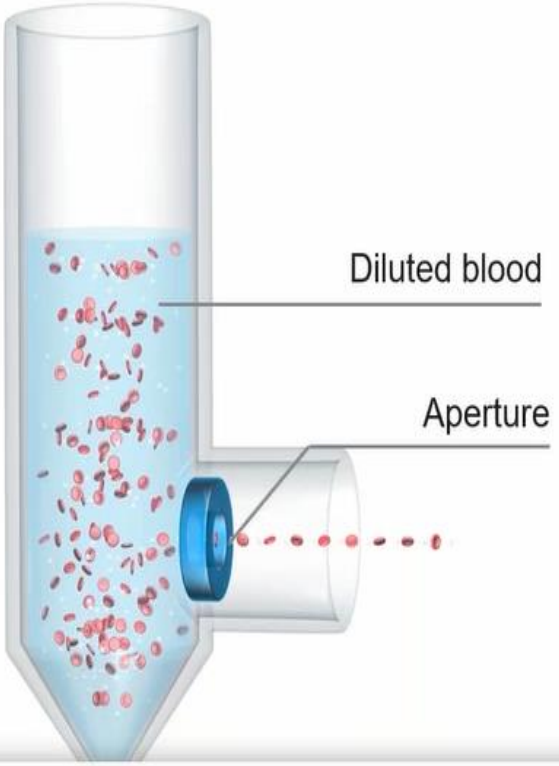
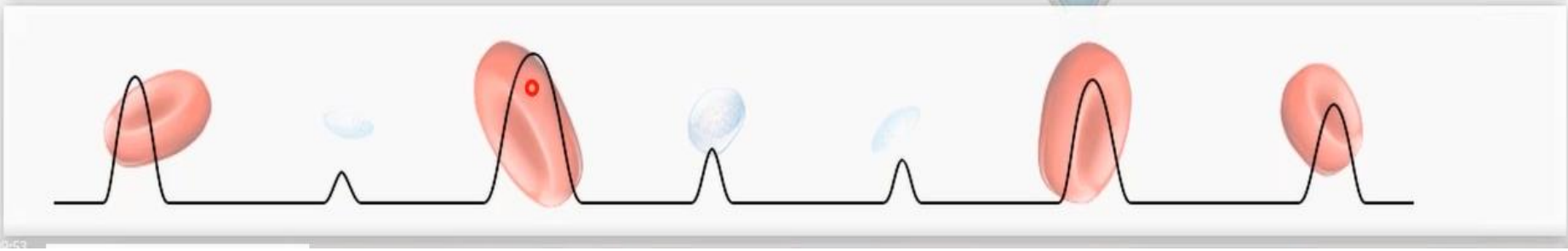
- When blood cells pass through the aperture, an electrolyte volume equivalent to that of the blood cell is displaced. This causes changes in resistance, which are detected as a measurable variable.

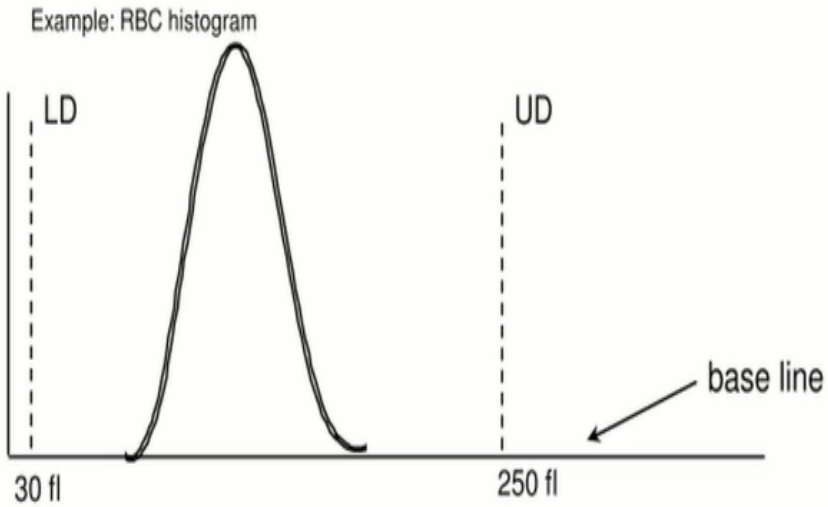




What is a Histogram & How is formed

LD: lower discriminator

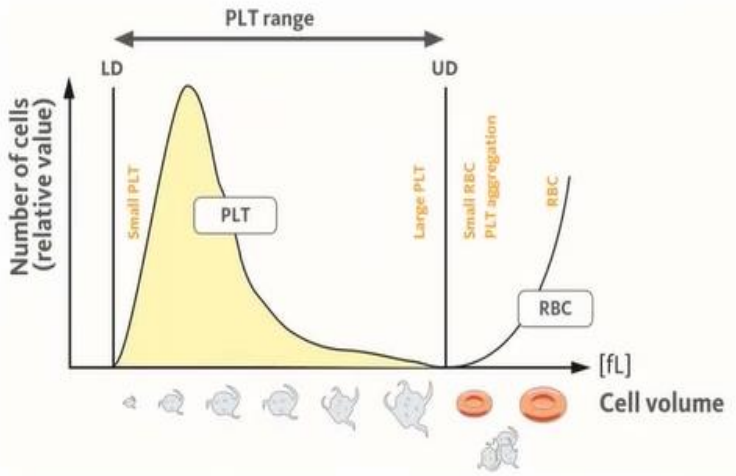
UD: upper discriminator

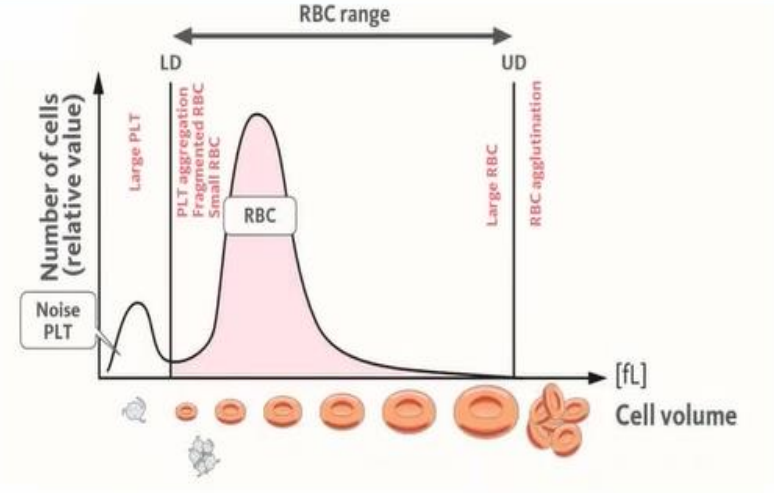


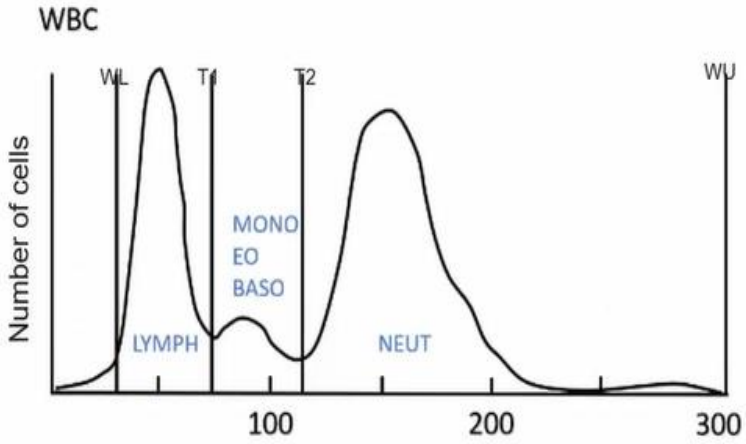
Histogram curves

- Start and end at the baseline
- Curve between upper and lower discriminator
- PLT, RBC and WBC histograms

RBC, PLT and WBC Histograms





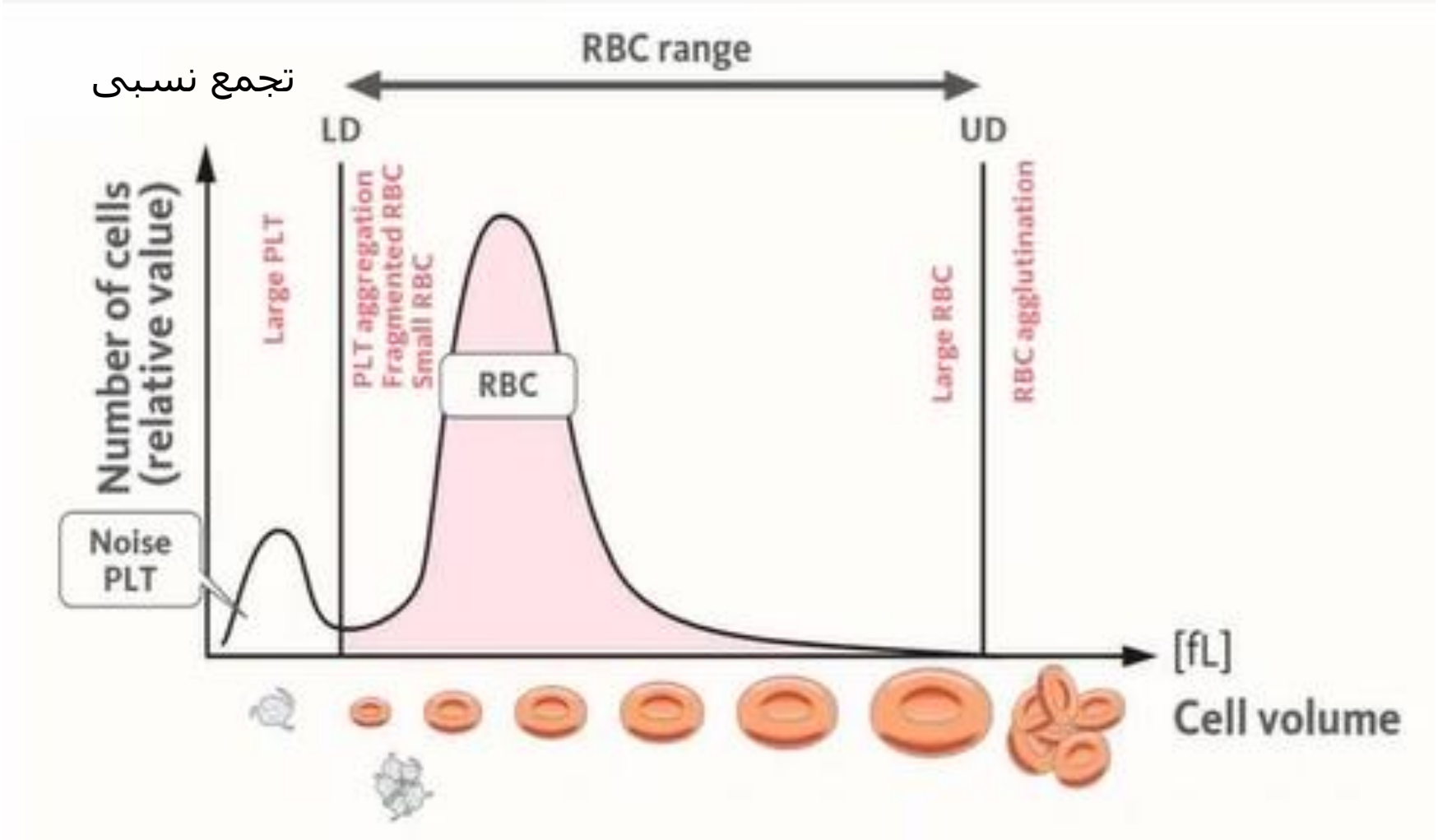


گلبول های قرمز و پلاکت در یک کانال شنارش می شوند و منحنی واحدی را ایجاد می کنند که برای سهولت بررسی بصورت ۲ منحنی توسط دستگاه ارئه می شوند.

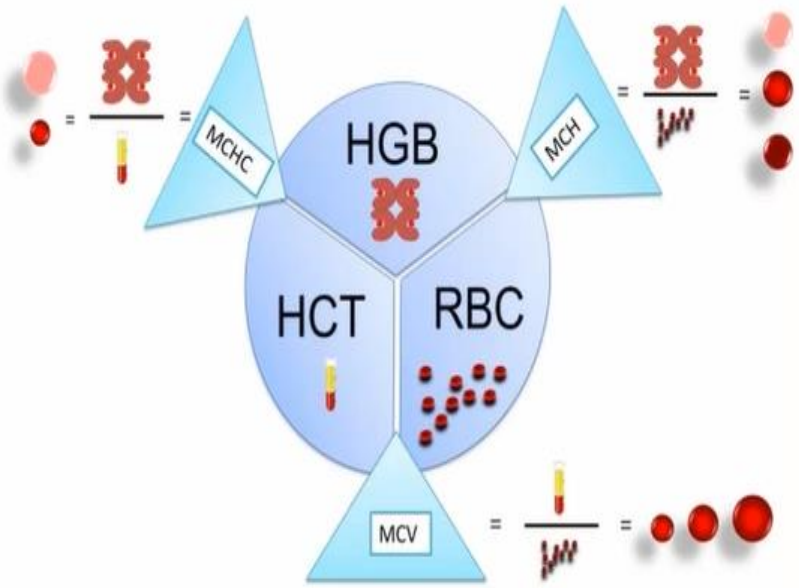
Analysers counting channels

- **کانال-۱**: شمارش RBC و PLT
- Debris & Bacteria & Noise=0-2 fL
- PLT=2-30 fL
- RBC=25-200 fL
- **کانال-۲**: شمارش WBC و Diff و اندازه گیری Hgb
- Small cell(Lymph)=35-90 fL
- Mid cell=90-160 fL
- Large cell=160-300 fL

RBC Histograms



Calculation of RBC Indices



Parameter	Function / meaning	Calculation
MCV (mean corpuscular volume)	Size or volume of one average RBC	= HCT / RBC
MCH (mean corpuscular haemoglobin)	Content of HGB in one average RBC	= HGB / RBC
MCHC (mean corpuscular haemoglobin concentration)	Average concentration of HGB in RBC	= HGB / HCT

Wintrobe indices

MCV = (HCT/RBC) x 10

MCH = (HGB/RBC) x 10

MCHC = (HGB/HCT) x 100

Rutzky Rules
(Rule of 3)

Rule #1	Hb × 3 = Hct ±2
Rule #2	RBC × 3.3 = Hgb±1.5
Rule #3	RBC × 9 = Hct±3
Rule #4	MCH ×3= MCV±3

قوانین روتزکی فقط در افراد سالم ، طبیعی و بعضی موارد در افراد کم خون از نوع نورموسیت-نورموکروم صدق می کند و برای کنترل اولیه نتایج و پیشگیری از خطا و اشتباهات دفتری کاربرد دارد.

WINTROBE INDICES AND THE RULES OF 3 (Rutzky Rules)

MCV = (HCT/RBC) x 10

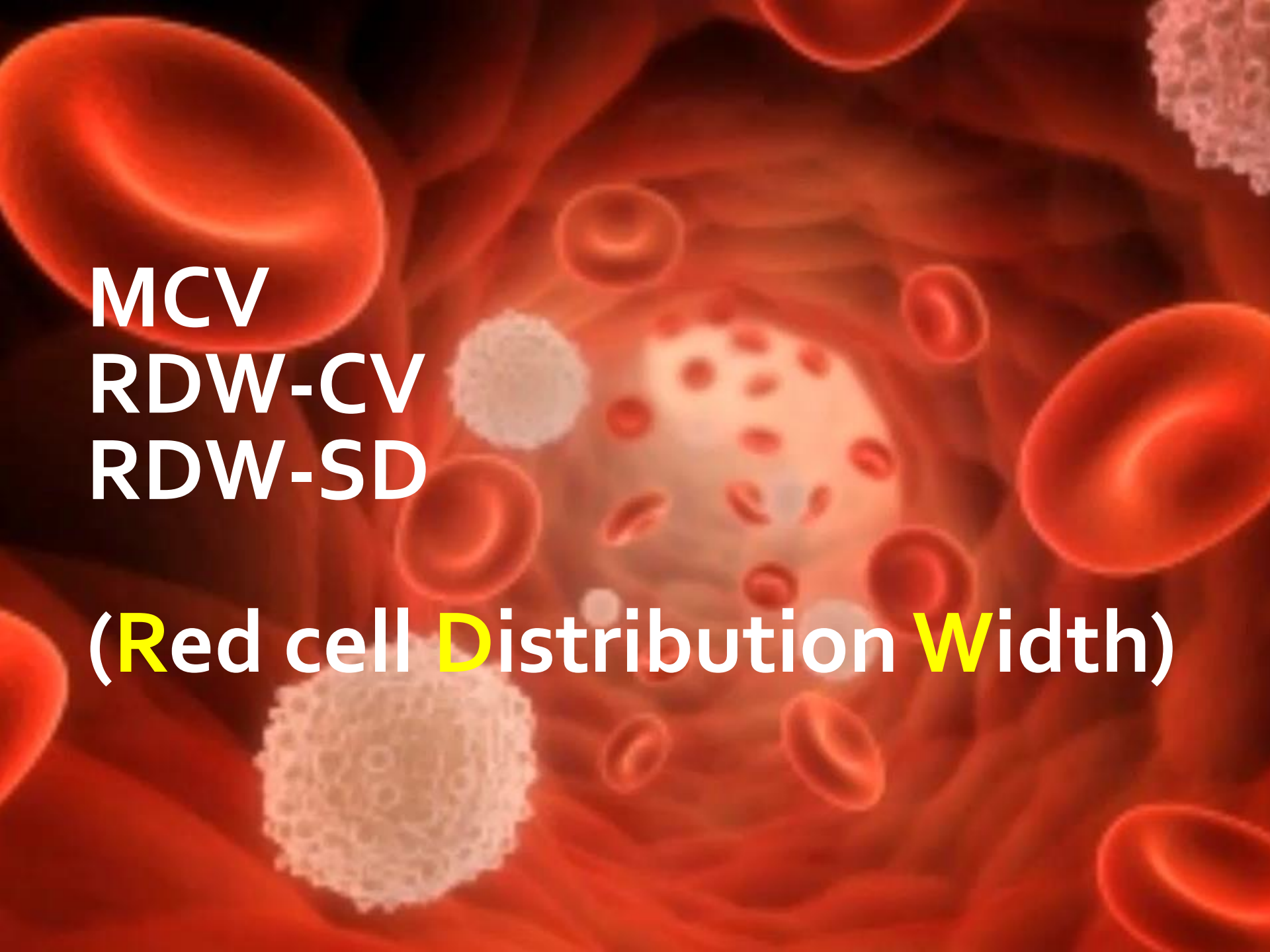
RBC X 9 = HCT +/- 3%

MCH = (HGB/RBC) x 10

RBC X 3.3 = HGB +/- 1.5 gm/dl

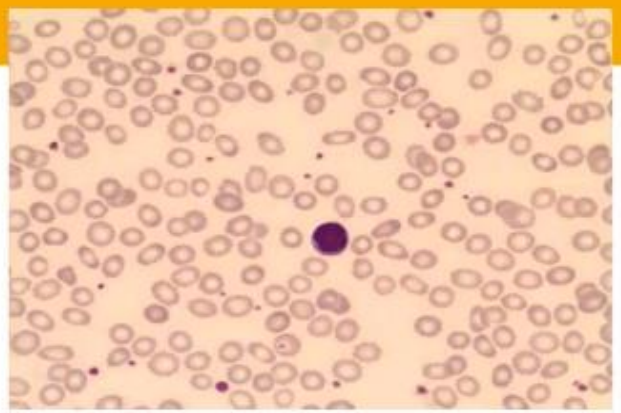
MCHC = (HGB/HCT) x 100

HGB X 3 = HCT +/- 3%


MCV
RDW-CV
RDW-SD
(Red cell Distribution Width)

MCV

- Definition :MEAN CELL VOLUME
- 80-94 FL
- **<80 :MICROCYTE**
- **NEW BORN : 104-120 FL,,,less than 94 is considered microcytic of newborn**
- <10 Y : 70 + AGE



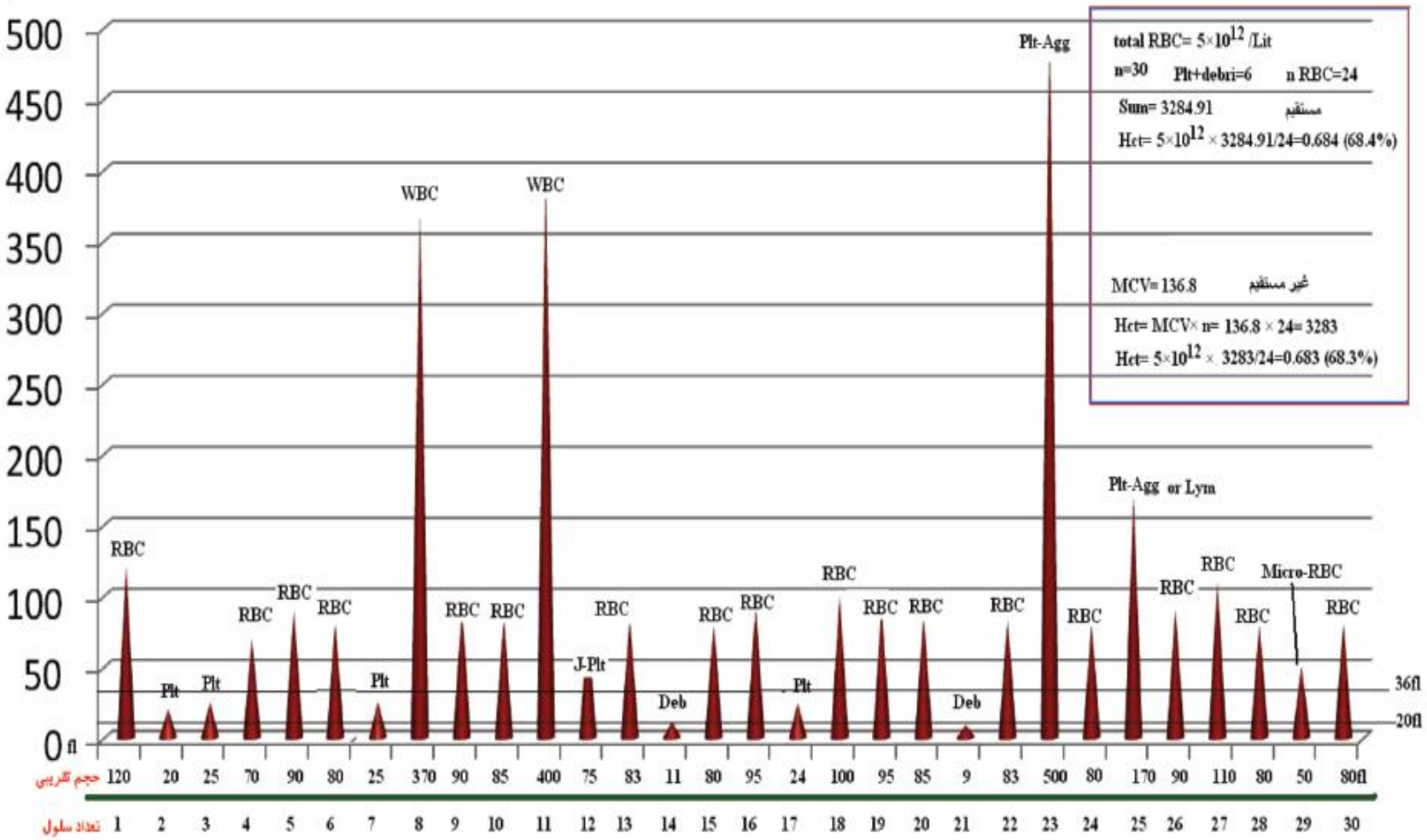
MCV & Age

Age	Lowest Normal Hb (g/dL)	Normal Red Blood Cell Size Mean Corpuscular Volume (fL)	Fetal Hb (%)
Birth	14.0	100–130	55–90
1 mo	12.0	90–110	50–80
2 mo	10.5	80–100	30–55
3–6 mo	10.5	75–90	5–25
6 mo–1 yr	11.0	70–85	<5
1–4 yr	11.0	70–85	<2
4 yr–puberty	11.5	75–90	<2
Adult female	12.0	80–95	<2
Adult male	14.0	80–95	<2

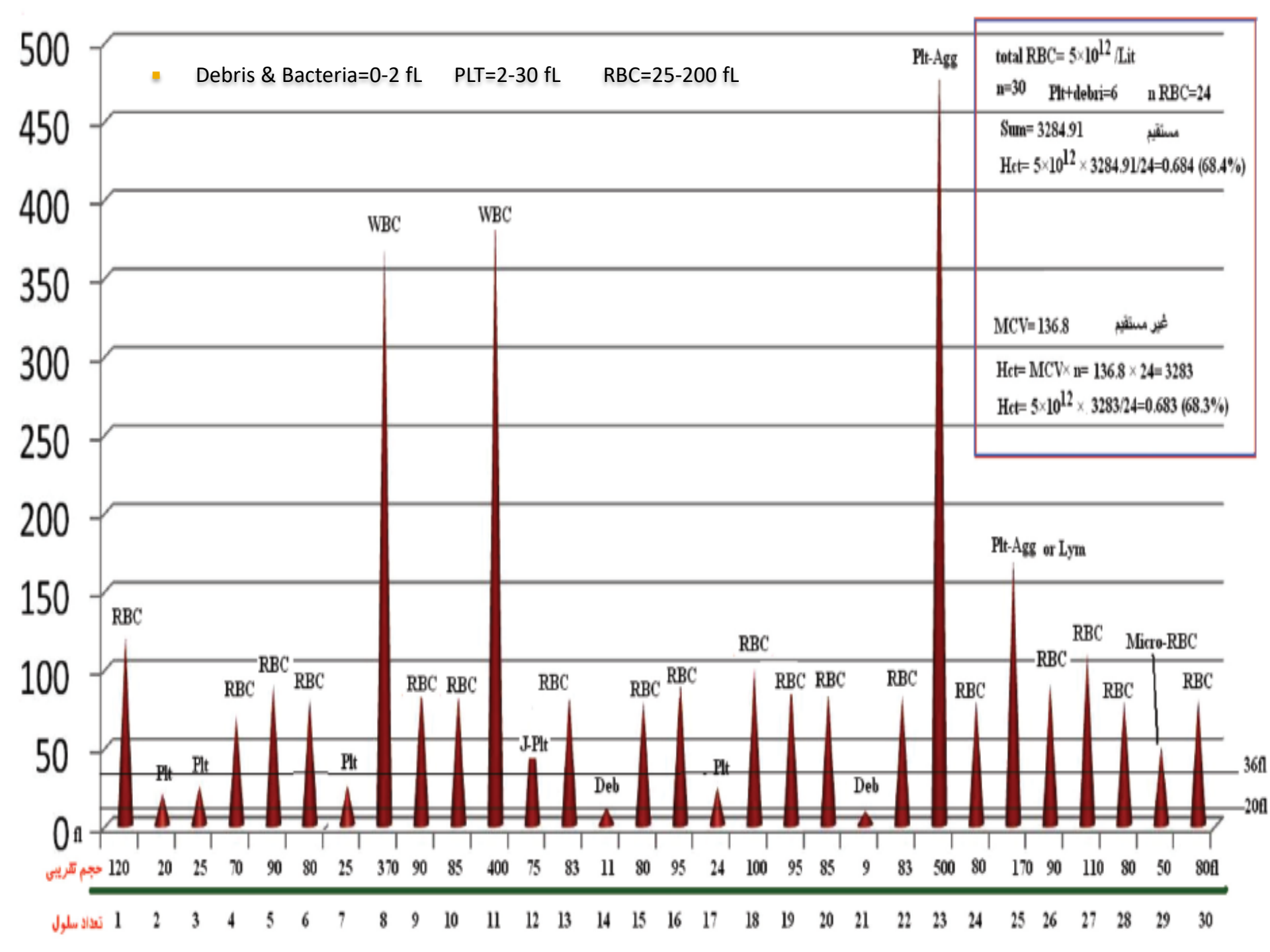
Hb>22 g/dl is considered **neonatal polycythemia** and is dangerous because it slows down brain blood supply

MCV & RDW in Histogram

MCV & RBC Histogram



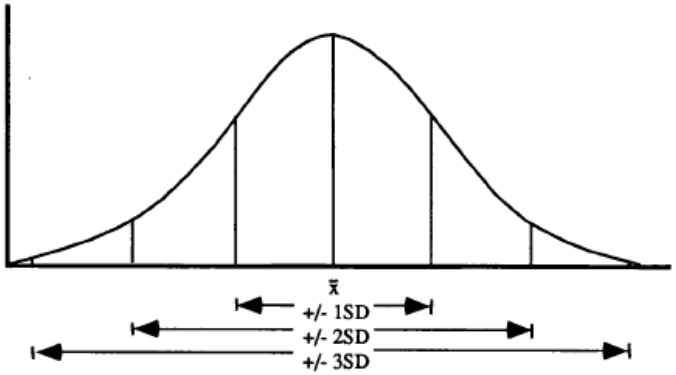
- Debris & Bacteria & Noise=0-2 fL PLT=2-30 fL RBC=25-200 fL


Debris & Bacteria=0-2 fL PLT=2-30 fL RBC=25-200 fL
total RBC= 5×10^12 /Lit
n=30 Plt+debri=6 n RBC=24
Sum= 3284.91 مستقیم
Hct= 5×10^12 × 3284.91/24=0.684 (68.4%)
MCV= 136.8 غیر مستقیم
Hct= MCV× n= 136.8 × 24= 3283
Hct= 5×10^12 × 3283/24=0.683 (68.3%)
500
450
400
350
300
250
200
150
100
50
0 fl
36fl
20fl
WBC
WBC
Plt-Agg
Plt-Agg or Lym
Micro-RBC
J-Plt
Deb
Deb
Plt
RBC
حجم تقریبی 120 20 25 70 90 80 25 370 90 85 400 75 83 11 80 95 24 100 95 85 9 83 500 80 170 90 110 80 50 80fl
تعداد سلول 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

MCV & RDW in Histogram

دامنه یا پهنای انتشار حجم گلبول‌های قرمز (RDW):

حجم و اندازه گلبول‌های قرمز خون با هم برابر نبوده و هنگام گزارش نتایج نیز نمی‌توان حجم تک تک سلول‌ها را اعلام نمود، از این رو میانگین آنها را به صورت پارامترMCV گزارش می‌کنند. اندازه سلول‌ها در شرایط طبیعی می‌تواند کمتر یا بیشتر از میانگین کل آنها باشد که در این صورت الگوی پراکندگی آنها از توزیع طبیعی زنگوله‌ای شکلی تبعیت می‌کند که به آن نمودار گوسین (Gaussian Distribution) گفته می‌شود. در این نمودار ٪۶۸/۲ سلول‌ها در محدوده ±1SD، ٪۹۵/۵ سلول‌ها در محدوده ±2SD و ٪۹۹/۷ سلول‌ها در محدوده ±3SD قرار می‌گیرند که از نظر استانداردهای هماتولوژی محدوده X±2SD با ٪۵ احتمال خطا، به‌عنوان محدوده نرمال نتایج آزمایشات هماتولوژی مدنظر قرار گرفته و از خطای ۵ درصدی مذکور چشم پوشی می‌شود.



شکل ۵۴-۱۰: نمودار زنگوله‌ای شکل از توزیع طبیعی اریتروسیت‌ها در سه محدوده 1SD، 2SD و 3SD که از نظر استانداردهای هماتولوژی، ضریب اطمینان ٪۹۵ (معادل ضریب خطای ٪۵) با میزان خطای ±2SD مطابقت دارد.

MCV در حقیقت یک میانگین بوده و لذا تغییرات و پراکندگی اعداد حول میانگین را نشان نمی‌دهد. به عبارتی، واحد میانگین، مقدار MCV سه سلول ۹۰، ۱۰۰ و ۱۱۰ فمتولیتری و مقدارMCV سه سلول ۹۹، ۱۰۰ و ۱۰۱ فمتولیتری را یکسان و برابر ۱۰۰fl نشان می‌دهد ولی انحراف معیار (SD) سنجشی از درجه پراکندگی در یک جمعیت با پراکندگی نرمال (مثل جمعیت اریتروسیتی) است که در مثال فوق SD اولی ±۱۰ و SD دومی ±۱ محاسبه می‌شود. همان‌طوری که مشاهده می‌شود، SD فقط مقدار پراکندگی را نشان می‌دهد و بزرگی آن را نشان نمی‌دهد. برای مثال SD=2 را در نظر بگیرید، عدد ۲ در برابر عدد ۱۰، رقمی بزرگ ولی در برابر عدد ۱۰۰، رقمی کوچک محسوب می‌شود، از این رو برای بزرگی نسبی تغییرات فوق از پارامتر ضریب تغییرات (CV) استفاده می‌شود که درصد SD از مقدار میانگین را نشان می‌دهد، مثلاً CV=5 یعنی اینکه، تغییرات SD از نظر بزرگی، حدود ٪۵ از مقدار میانگین را تشکیل می‌دهد.

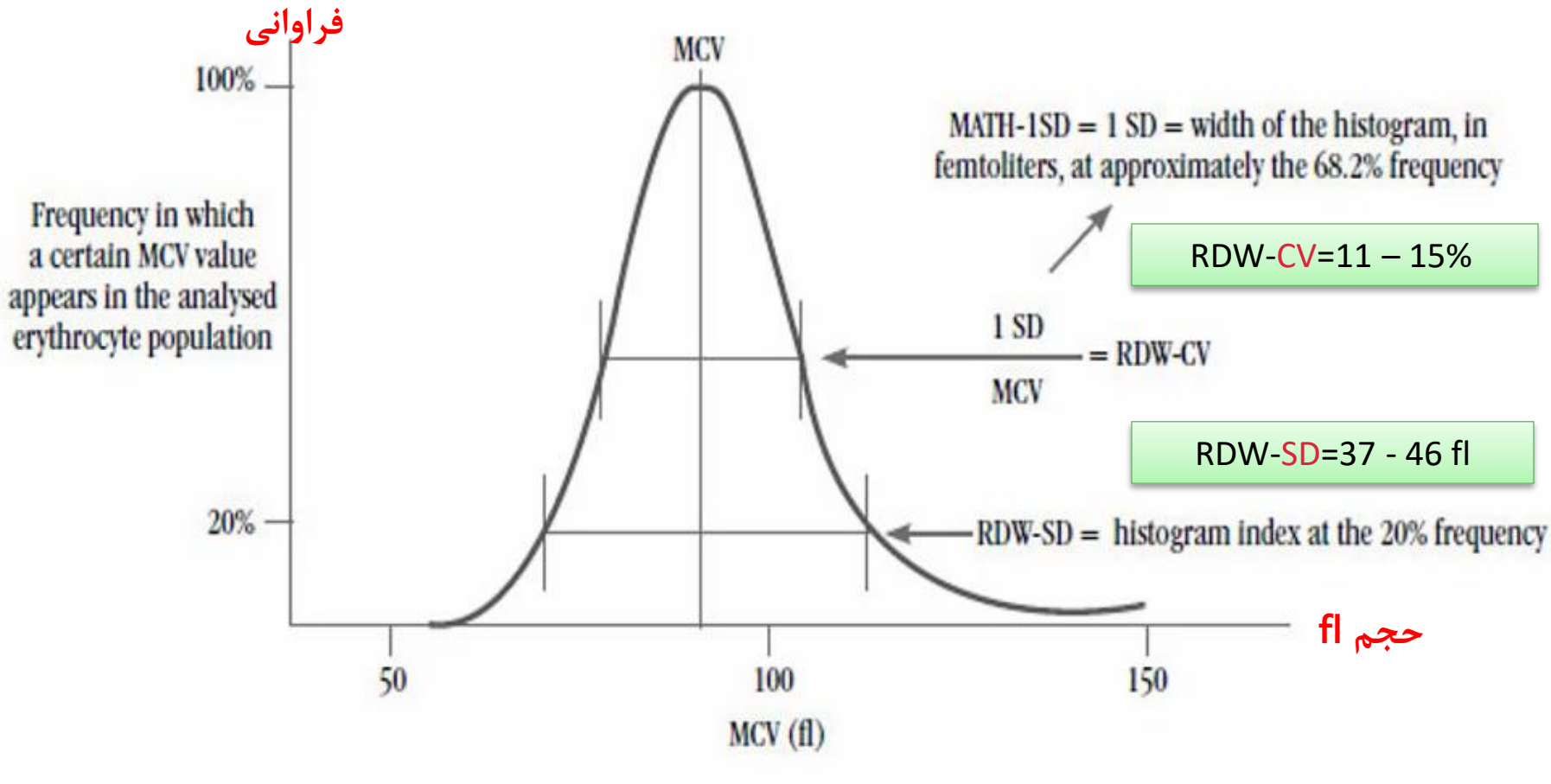
RDW : Why we need to

- MCV
- RDW-CV
- RDW-SD
- Anisocytosis

Red Cell Distribution Width

دامنه یا پهنای انتشار حجم گلبول‌های قرمز (RDW)

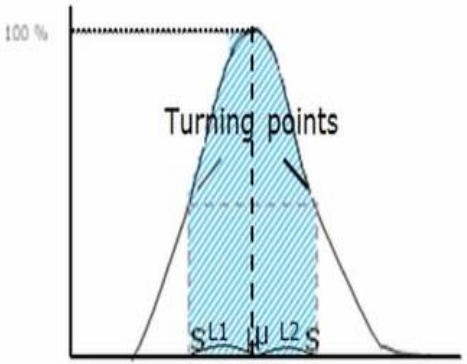
RDW (CV & SD)



شکل ۵۶-۱۰: در واقع RDW-SD به نوعی پهنای هیستوگرام RBC در ارتفاع یا فراوانی ۲۰٪ بوده و RDW-CV نسبت پهنای هیستوگرام RBC در فراوانی ۶۸٪ به مقدار MCV می‌باشد.

RBC Distribution Width-RDW

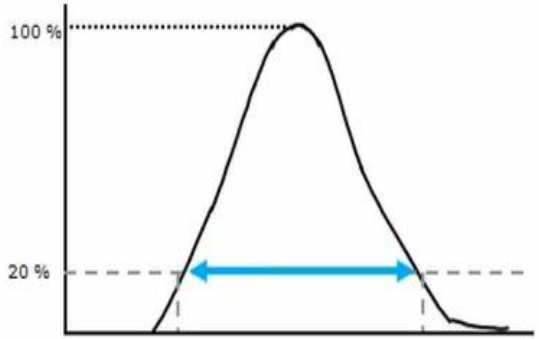
- RDW-CV: Red Blood Cell distribution width-Coefficient Variation



$$RDW\text{-}CV = \frac{L2-L1}{L2+L1} \times 1000$$

+/- single standard- deviation equivalent to 68.26 % of the distribution area.

- RDW-SD: Red Blood Cell distribution width-Standard Deviation



RDW-SD is calculated in 20 % of the total height of the distribution curve.

We need to MCV, both RDWs because:

- Considering that (**MCV**) only shows the average or mediocrity of a population if the RDW (SD & CV) is not taken into account, the correct clinical interpretation of the RBC volume distribution status is not obtained
- **RDW-SD** takes measurements in "fL" and basically measures the width of red cells size distribution histogram – it calculates the width at the 20% height level of the histogram.
- **RDW-CV** is expressed in percentage (%) and is calculated from MCV and 1SD
- The reference range for RDW is as follows:
  - RDW-SD 37-46 fL in adult
  - RDW-CV 11-15% in adult
  - RDW-SD 47-70 fL in neonates
  - RDW-CV 13.6-18.0% in neonates

نقص MCV در چیست؟
نقش RDW-SD چیست؟

نقص MCV در چیست؟ فرض کنید:

MCV=99, MCV=100, MCV=101…..Mean(MCV)=100 SD±1

MCV=95, MCV=100, MCV=105….. Mean(MCV)=100 SD±5

MCV=50, MCV=100, MCV=150….. Mean(MCV)=100 SD±50

MCV=1, MCV=100, MCV=199…. Mean(MCV)=100 SD±99

MCV چون میانگین را نشان می دهد بین این جمعیت ها نمی تواند فرقی قائل شود.

RDW-SD به کمک می آید

RDW-CV

5-10-15---------- mean(MCV)=10…….SD=5 CV= **50%**

95-100-105--------- mean(MCV) 100…..SD=5 CV= **5%**

995-1000-1005---- mean(MCV) 1000…SD=5 CV= **0.5%**

آیا SD می تواند معیار کاملی باشد؟ خیر

پس ما به یک اندکس دیگر نیاز داریم تا نقص SD و MCV را پوشش دهد :

RDW-CV

Rules of using RDW & disadvantage of RDWs

- ضعف RDW-SD این است که زمانیکه RBC افزایش می یابد ، RDW-SD بطور کاذب کاهش می یابد مانند موارد تالاسمی مینور
- ضعف RDW-CV این است که زمانیکه MCV افزایش می یابد ، RDW-CV بصورت کاذب کاهش می یابد مانند آنمی های ماکروسیتیک و مگالوبلاستیک

$$SD = \sqrt{\frac{\sum (V - MCV)^2}{RBC}}$$

RDW-CV= (RDW-SD×0.28×100)/MCV

قانون استفاده از RDW

RDW-CV در میکروسیتوز و نرموسیتوز معیار تشخیص آنیزو است

RDW-SD در ماکروسیتوز و مگالوسیتوز(MCV>100) معیار آنیزو است

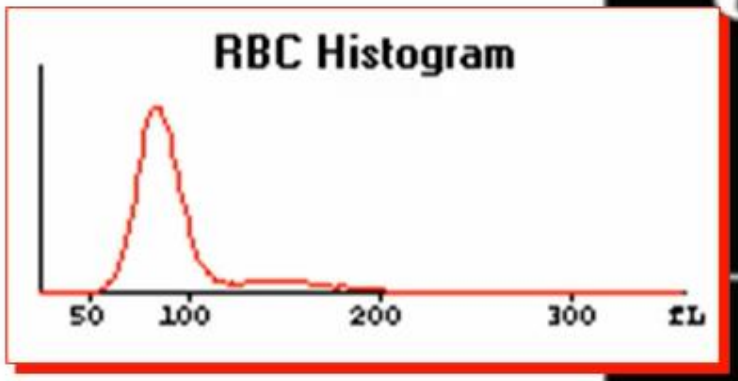
به عبارت دیگر یک جمعیت RBC با MCV بالا ممکن است در هیستوگرام بصورت پهن مشاهده شود اما RDW-CV نرمال باشد

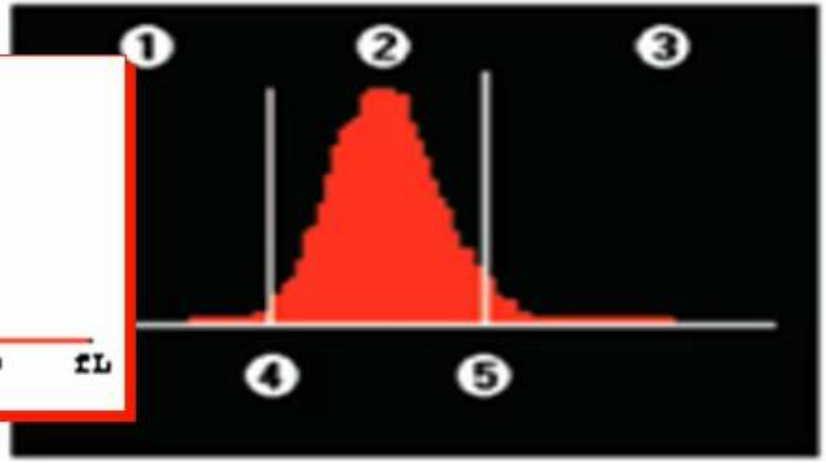
در نقطه مقابل در جمعیت میکروسیت با MCV پائین، منحنی باریک(کوچک) اما RDW-CV افزایش یافته باشد.

RDW -Clinical applications

- *"RDW is likely a independent marker for chronic processes leading ultimately to a fatal outcome in patients and the general population."*

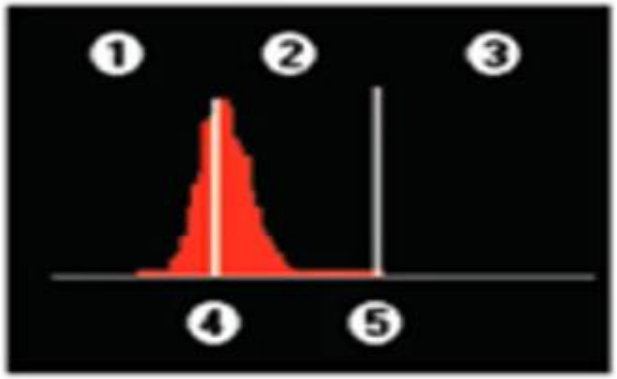
  - Elavated RDW has been associated with:
    - Decreased eGFR in CRF patients
    - Overall increased myocardial infarction rate in CHDs
    - Overall cancer mortality rate
    - .....



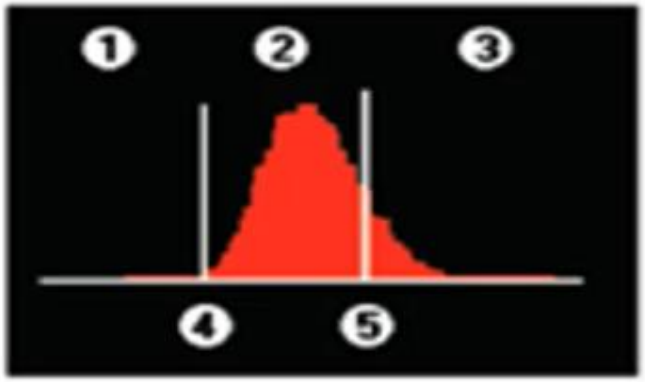


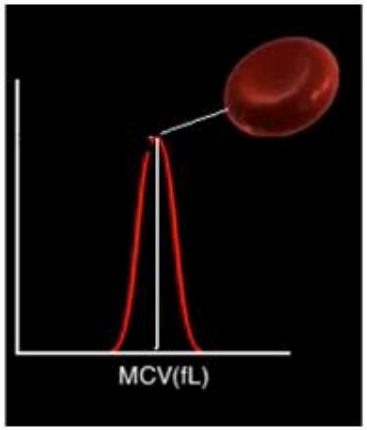
1 Microcytic region
2 Normocytic region
3 Macrocytic region
4 60 fL marker
5 120 fL marker

(microcytic sample)

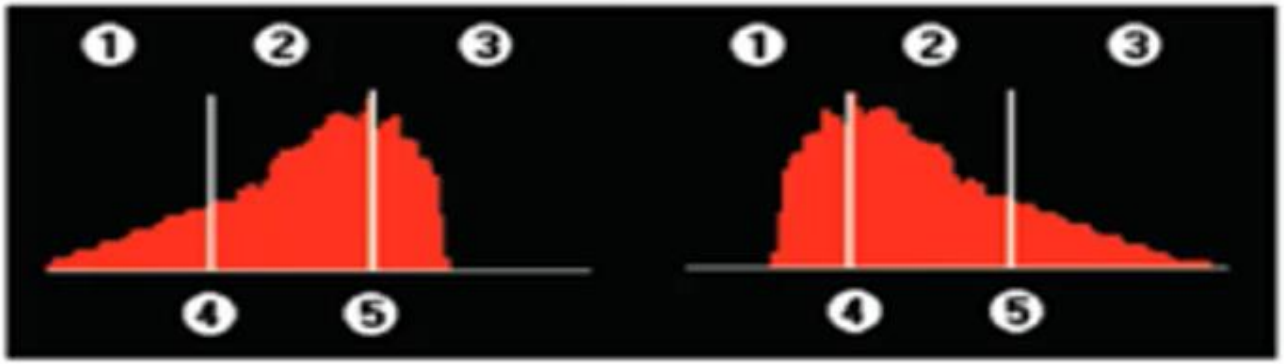


(macrocytic sample)

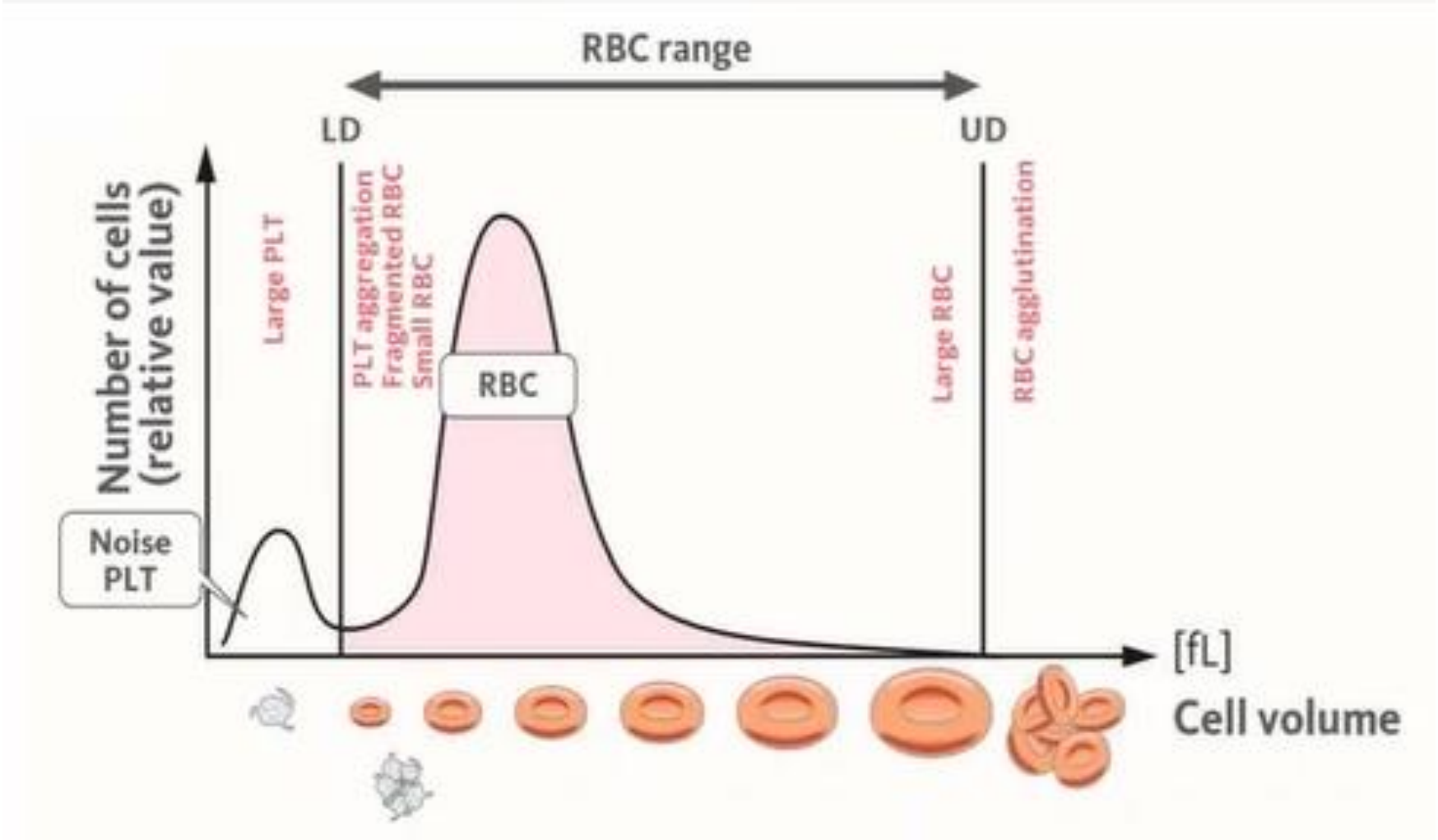




RBC Volume histogram (anisocytosis)



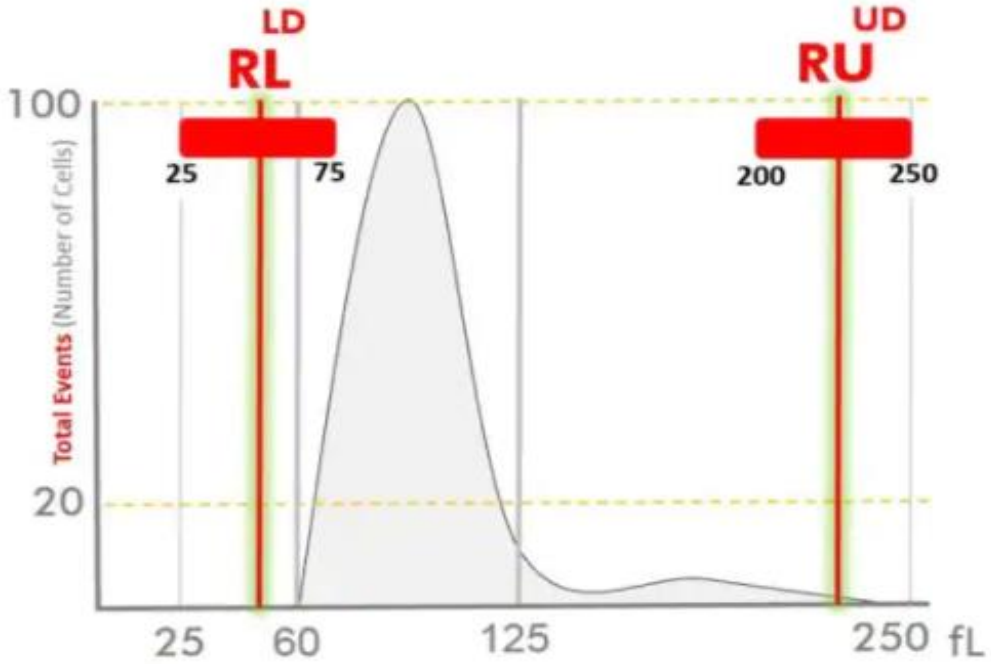
RBC Histograms



RBCs Histogram

Volume Histogram

Red Cell **Discriminators**



RBCs Histogram

Volume Histogram

The RBC histogram has **2** **Flexible** discriminators that discriminate RBC curve from other curves.

RL (**RBC** **Low** Discriminator)

Fluctuates between **25** and **75** fL

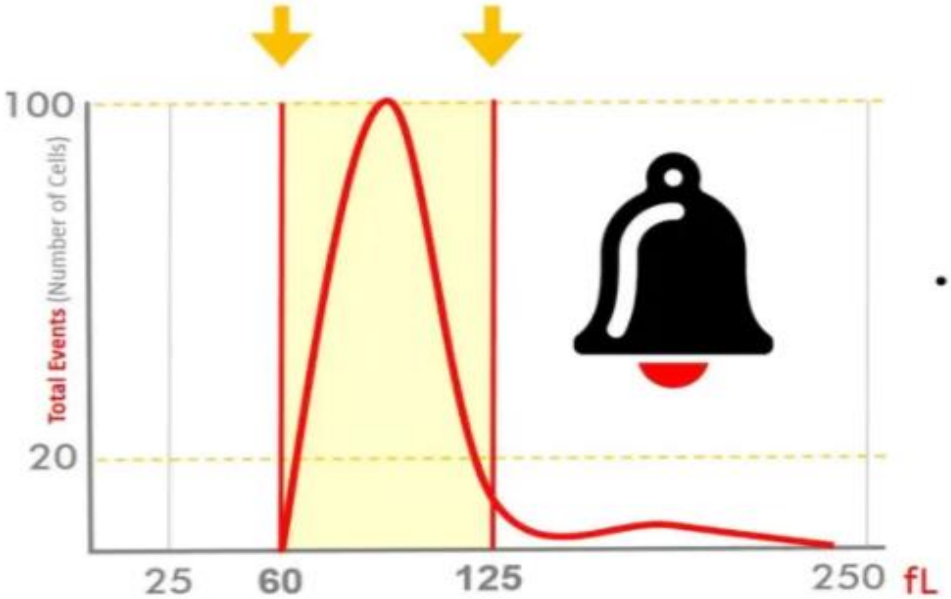
RU (**RBC** **Upper** Discriminator)

Fluctuates between **200** and **250** fL

RBCs Histogram

Volume Histogram

In a homogeneous cell population, the RBC curve assumes a **symmetrical bell-shaped** or **Gaussian distribution**.



RBCs Histogram

Volume Histogram

- The area of the peak is used to calculate the **MCV** and **RDW**. This area represents **60** fL to **125** fL.

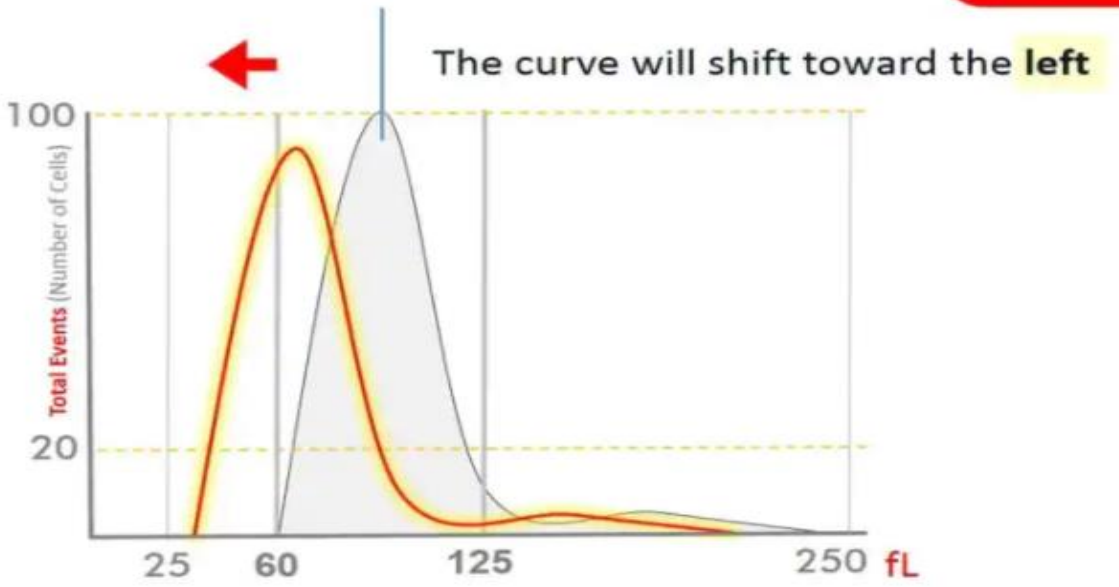
RBCs Histogram

Volume Histogram

If The RBCs are **smaller** than normal (= **Micro**cytic)

RBCs Histogram

Volume Histogram



RBCs Histogram

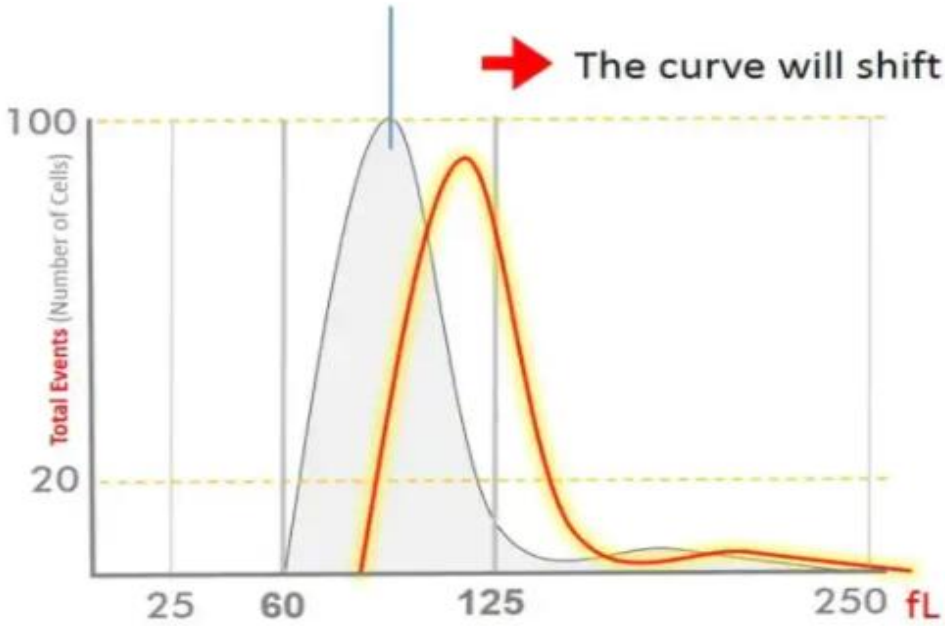
Volume Histogram

If The RBCs are **larger** than normal (= **Macro**cytic)

RBCs Histogram

Volume Histogram

The curve will shift towards the **Right**

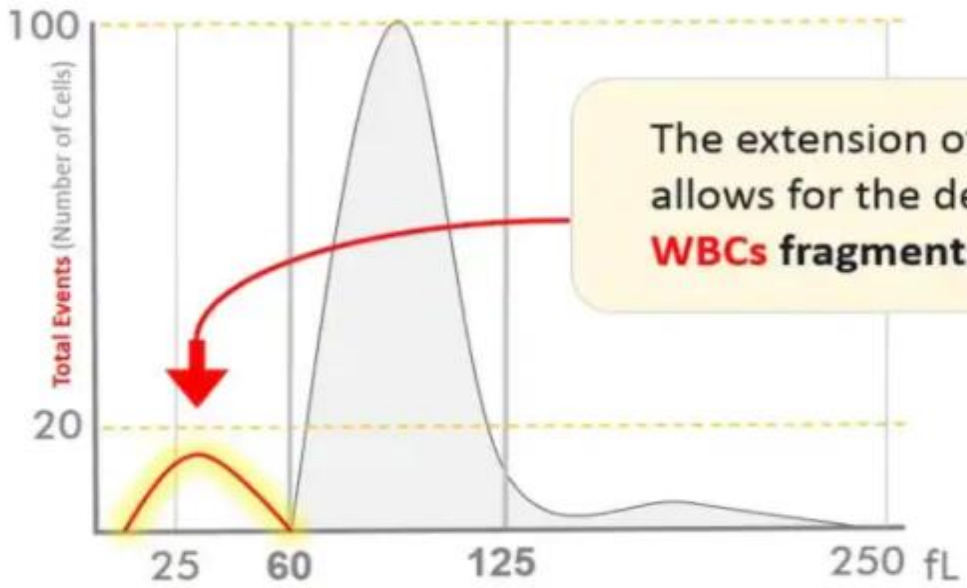


RBCs Histogram

Volume Histogram

RBCs Histogram

Volume Histogram



The extension of the lower end of the scale allows for the detection of **RBCs fragments**, **WBCs fragments** and **large platelets**.

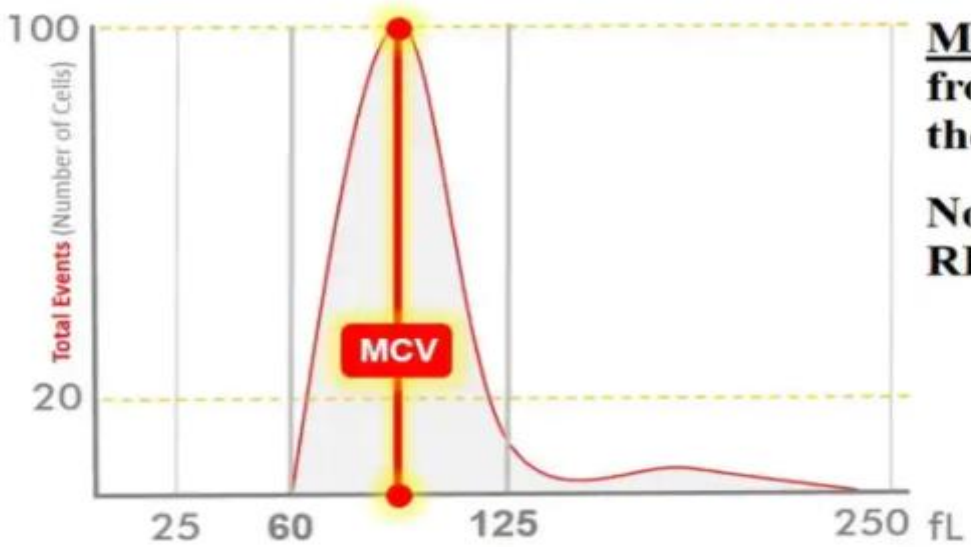
RBCs Histogram

Volume Histogram

RBCs Histogram

Volume Histogram

The **MCV** is calculated from the area **under** the peak



MCV is perpendicular line from **peak** of the curve to the **base**

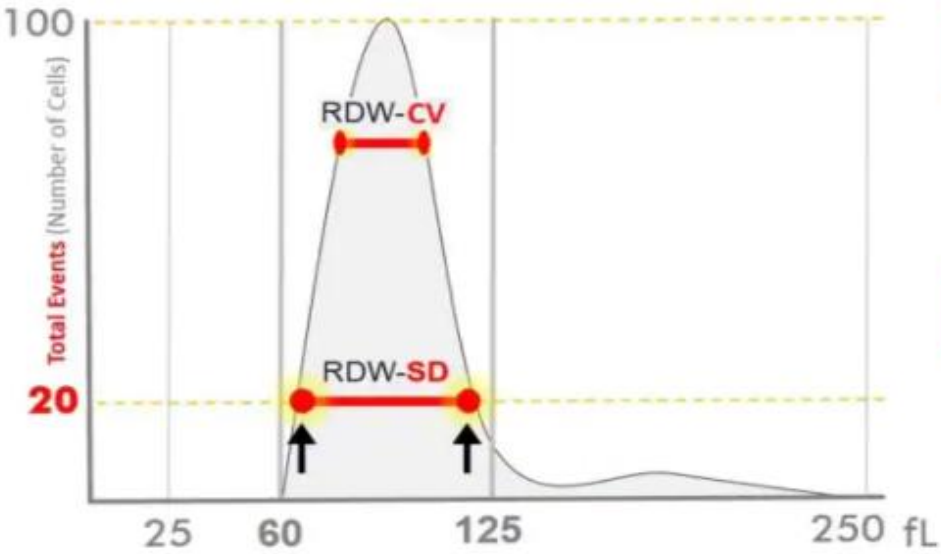
Normal RBC histogram→ RBC located between 55-125 fl

RBCs Histogram

Volume Histogram

The Red cell Distribution Width RDW

An important parameter for measurement of degree of **variation in RBCs size.**



RBCs Histogram

Volume Histogram

RDW has **2** forms:

1 RDW-CV %

- **Coefficient** of variation percentage
- **Calculated** by **SD/MCV** x 100
- The normal range is **11.5%** to **14.5%**

2 RDW-SD fL

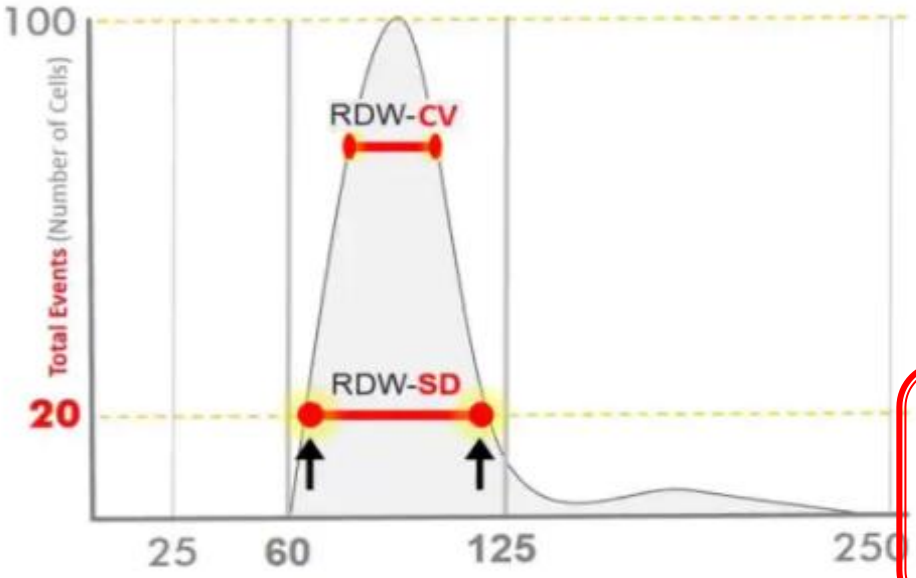
- **Standard Deviation**
- Obtained by drawing an arbitrary line at a **height** of **20%** on the y-axis in fL.
- The normal range is **35 – 45 fL**

RBCs Histogram

Volume Histogram

The Red cell Distribution Width RDW

An important parameter for measurement of degree of **variation in RBCs size**.



RBCs Histogram

Volume Histogram

RDW has **2** forms:

1 RDW-CV %

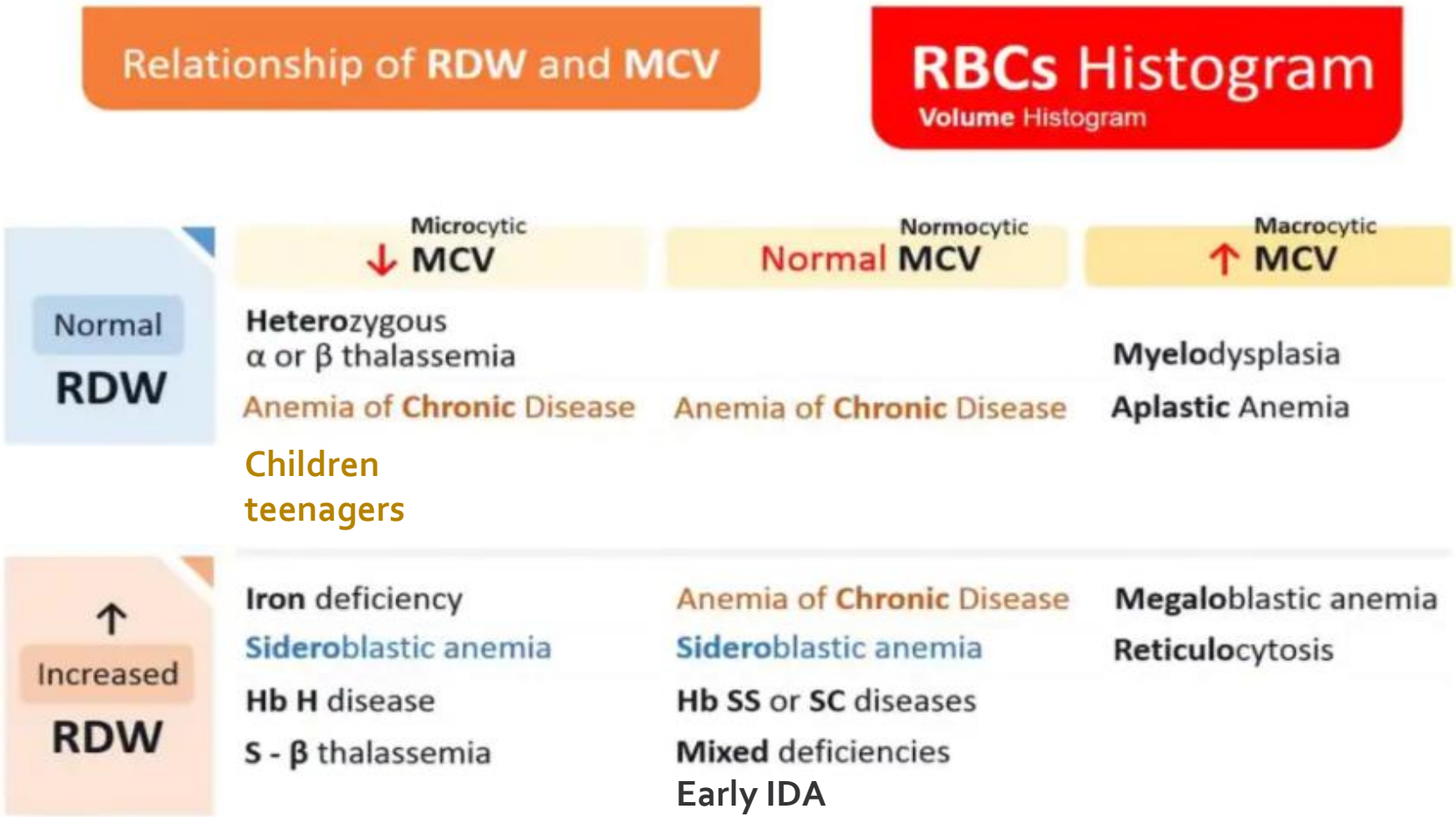
- **Coefficient** of variation percentage
- **Calculated** by **SD/MCV** x 100
- The normal range is **11.5%** to **14.5%**

2 RDW-SD fL

To avoid interference in the calculations of RDW, the information < 20% of scale on RBCs histogram are excluded:

- **Aperture artifacts**
- **RBC agglutinates, right**
- **Giant PLts, left**

Clinical application of MCV & RDW

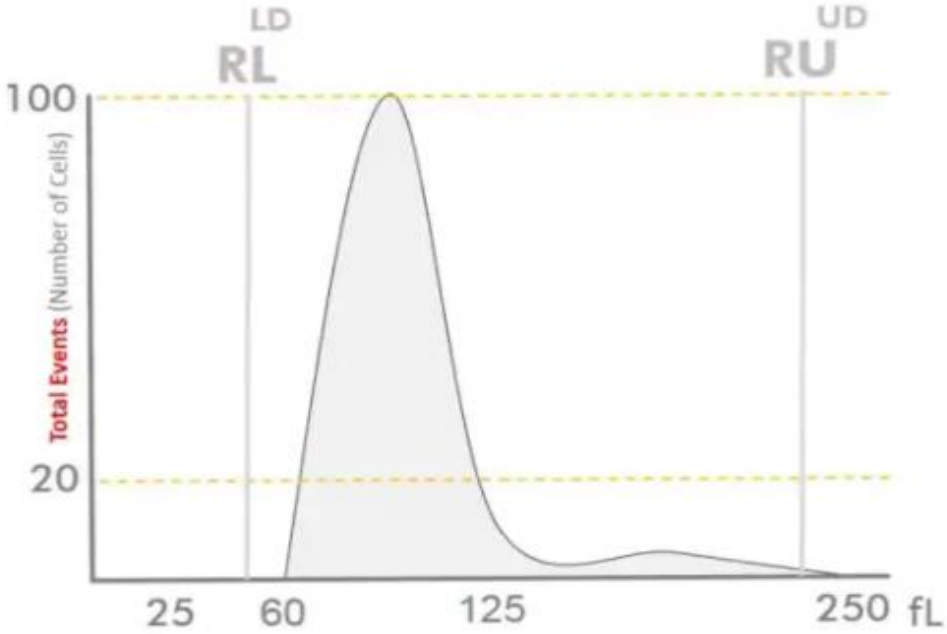


RBCs Histogram

Volume Histogram

RBCs Histogram

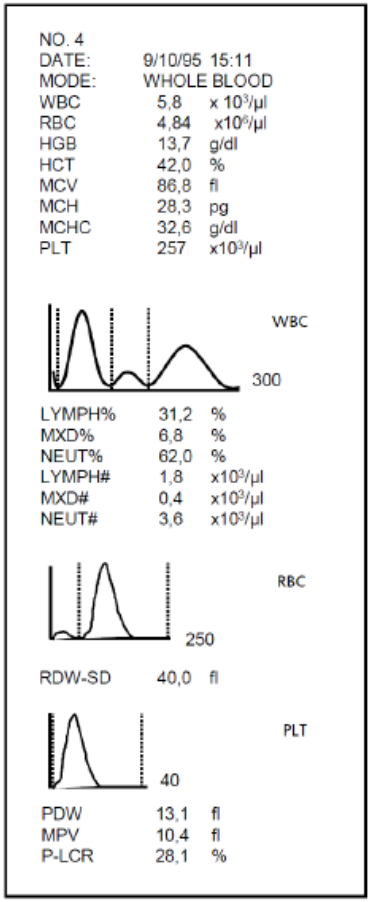
Volume Histogram



Flags

RBCs Histogram

Volume Histogram



WL: Abnormal height at lower discriminator of WBC Histogram (LD)
WU: Abnormal height at upper discriminator of WBC Histogram (UD)
T1: Valley 1 not found
T2: Valley 2 not found
F1, F2, F3: Abnormal height at the points **T1** or **T2**; adjacent fractions are marked

Flags of WBC

RL: Abnormal height at lower discriminator of RBC Histogram (LD)
RU: Abnormal height at upper discriminator of RBC Histogram (UD)
MP: Multiple peaks: Distinguish ?? of two RBC Populations
DW: The distribution (RDW) can not be detected because the Histogram does not cross the 20 % limit twice.

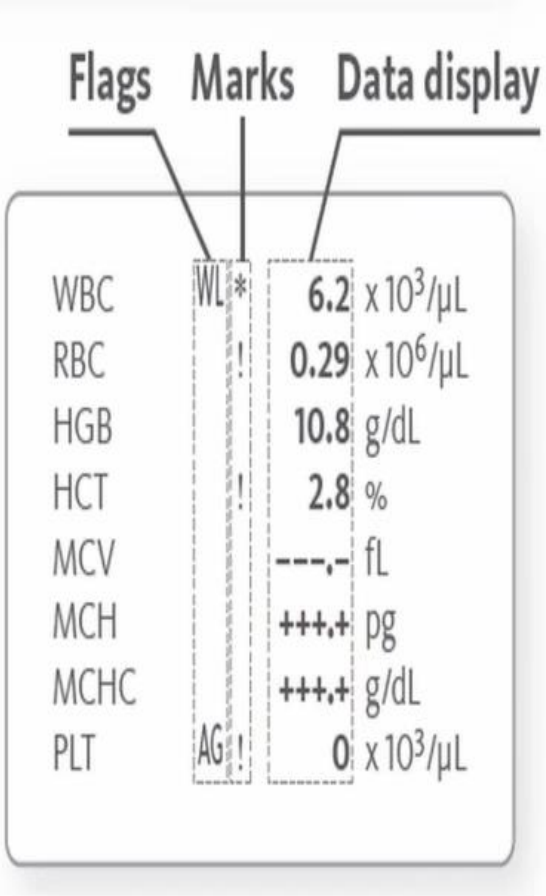
Flags of RBC

PL: Abnormal height at lower discriminator of PLT Histogram (LD)
PU: Abnormal height at upper discriminator of PLT Histogram (UD)
MP: Multiple Peaks found
DW: The distribution (PDW) can not be detected because the Histogram does not cross the 20 % limit twice.

Flags of PLT

AG: The particle count equal to or less than the LD exceeds a prescribed range. Probable cause is platelet agglutination, which does not alter WBC count but may result in decreased platelet count. Therefore, this flag is added to the PLT parameter.

Flags, Marks and data display



Marks	Meaning
!	Data outside the range of guaranteed linearity
+	Data above the upper limit set for normal assessment
-	Data above the lower limit set for normal assessment
*	Data of low reliability

Display	Meaning
+++.+	Data outside the display range
*** *	Impossible to calculate the value due to abnormality in measurement
---.- / ----	Value could not be calculated due to data error. The analysis was performed in pre-diluted mode and for this reason the particle distribution analysis parameters could not be calculated

RBC Histogram Error Flags

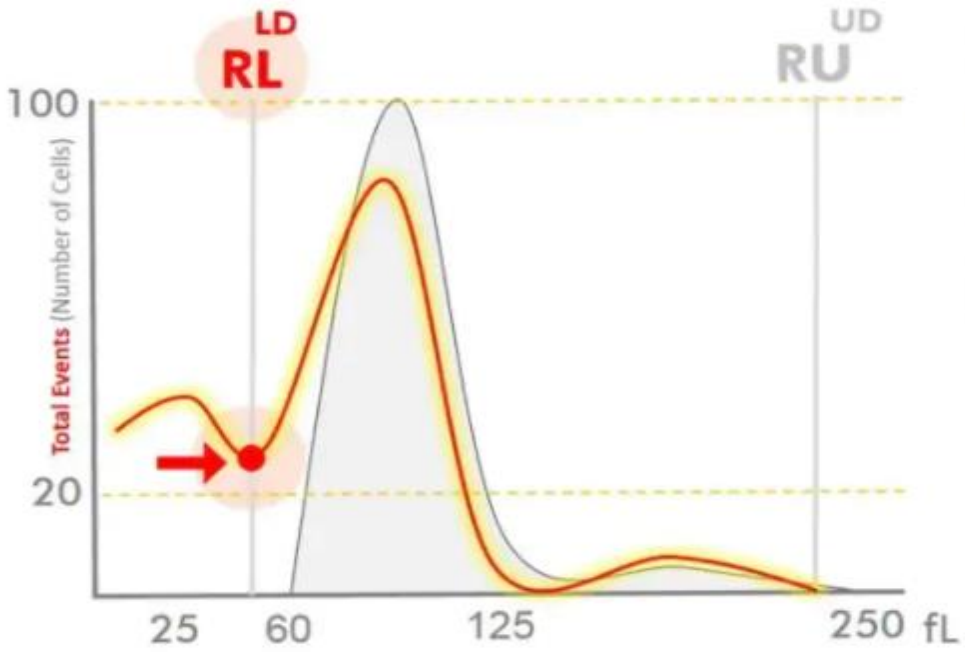
List of RBC error flags in order of priority	
RL	Relative frequency for LOWER discriminator (LD) exceeds the range. May be caused by changes in red blood cell morphology, platelet clumps, or electrical noise.
RU	Relative frequency for UPPER discriminator (UD) exceeds the range. May be caused by electrical noise.
MP	Two or more peaks in the histogram.
DW	Particle distribution width error when the 20% frequency does not cross the histogram two times. The peak is taken as 100%.

RBCs Histogram

Volume Histogram

Flag 1 **RL Flag**

LD Flag



RBCs Histogram

Volume Histogram

- **Abnormal** Height at **LD**
- The LD exceeds the preset height by **> 10 %**

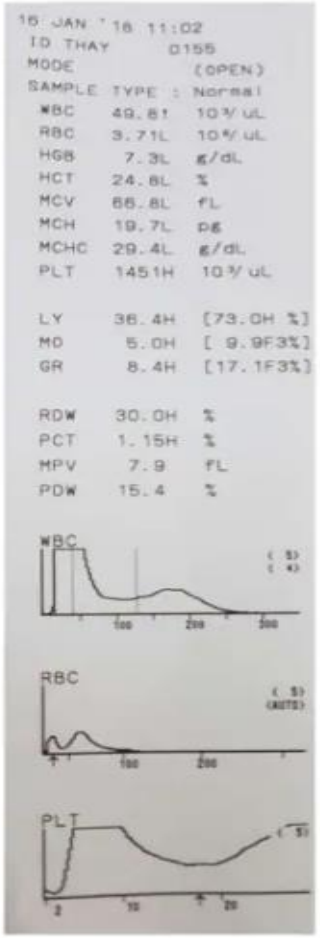
Possible Causes :

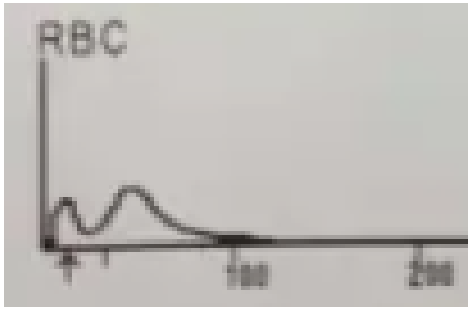
- **Platelet** Clumps
- **RBCs** fragments
- Giant **Platelets**
- Micro **RBCs**
- Noise

RBC morphology

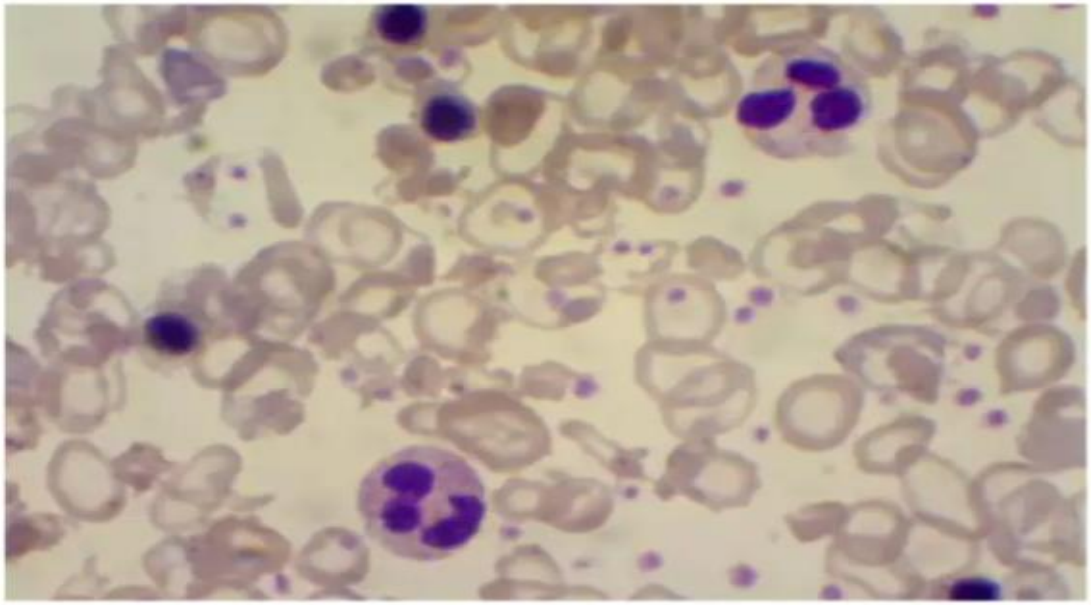
RBCs Histogram

Volume Histogram





Thalassemia major→ WBC / RBC / PLT

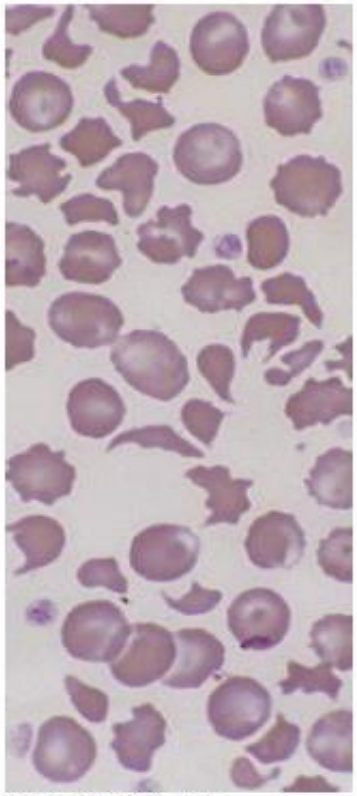


Abu Jad Caesar

RBCs Histogram

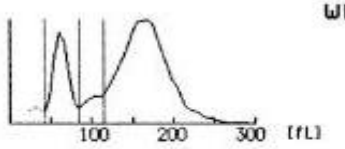
Volume Histogram

RL flag



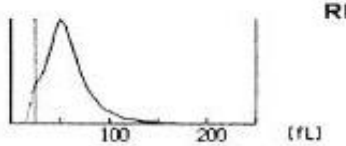
WBC		5.8×10³/μL
RBC	RL*	5.65×10⁶/μL
HGB	-	8.4g/dL
HCT	RL*	32.5%
MCV	RL*	57.5fL
MCH	RL*	14.9pg
MCHC	RL*	25.8g/dL
PLT	PU!	1884×10³/μL

WBC



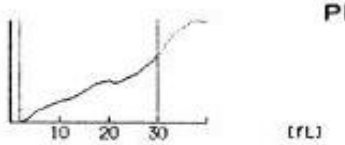
LYM%	21.0%
MXD%	7.2%
NEUT%	71.8%
LYM#	1.2×10³/μL
MXD#	0.4×10³/μL
NEUT#	4.2×10³/μL

RBC

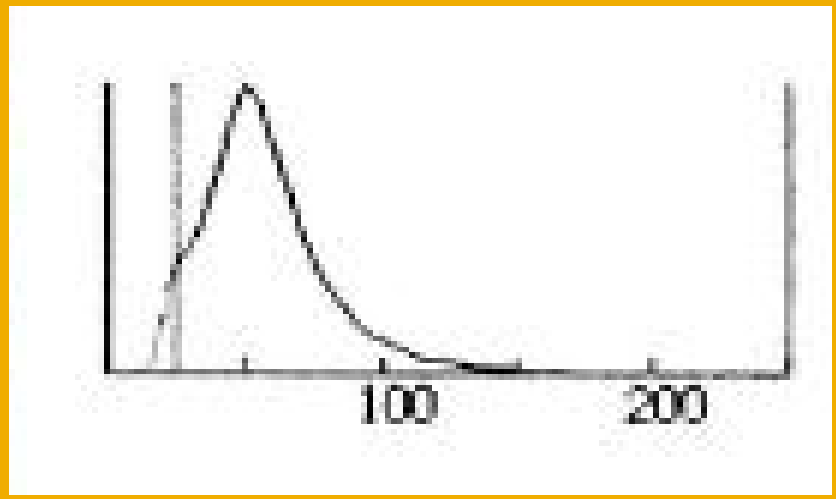


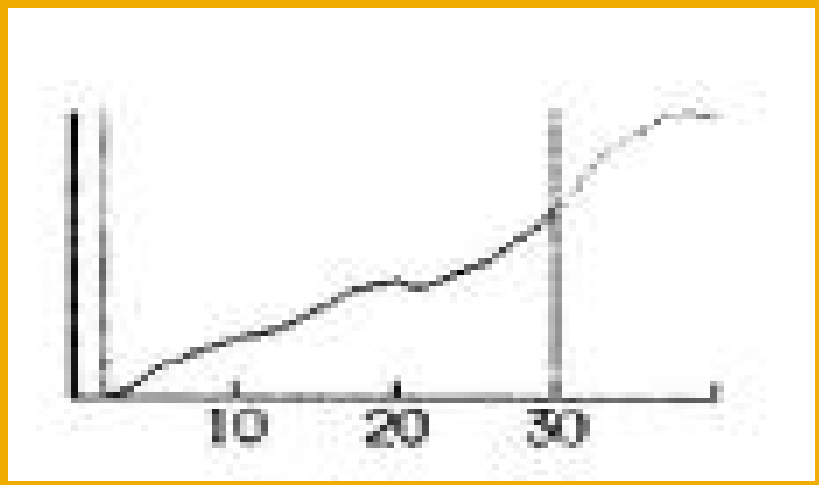
RDW RL* 32.3%

PLT



PDW	DW	---.-fL
MPV	PU	---.-fL
P-LCR	PU	---.-%





شکل ۱۱-۱۱: راست) CBC و گستره خون محیطی از اگریگاسیون پلاکتی (فلاگ PL ،MP ،WL) و چپ) CBC و گستره خون محیطی از شیستوسیتوز شدید (فلاگ RL، PU و DW)

RBCs Histogram

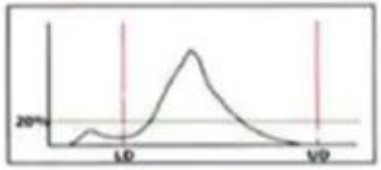
Volume Histogram

Schictocytes & extreme microcytes

RL flag

- RBC count, HCT, MCV, MCH and MCHC show RL flag

RBC Lower Discriminator Error



LD error e.g. Plt aggregation RBC fragments, noise

HCT	41.8 RL
MCV	117.1 RL
MCH	32.2 RL
MCHC	27.5 RL

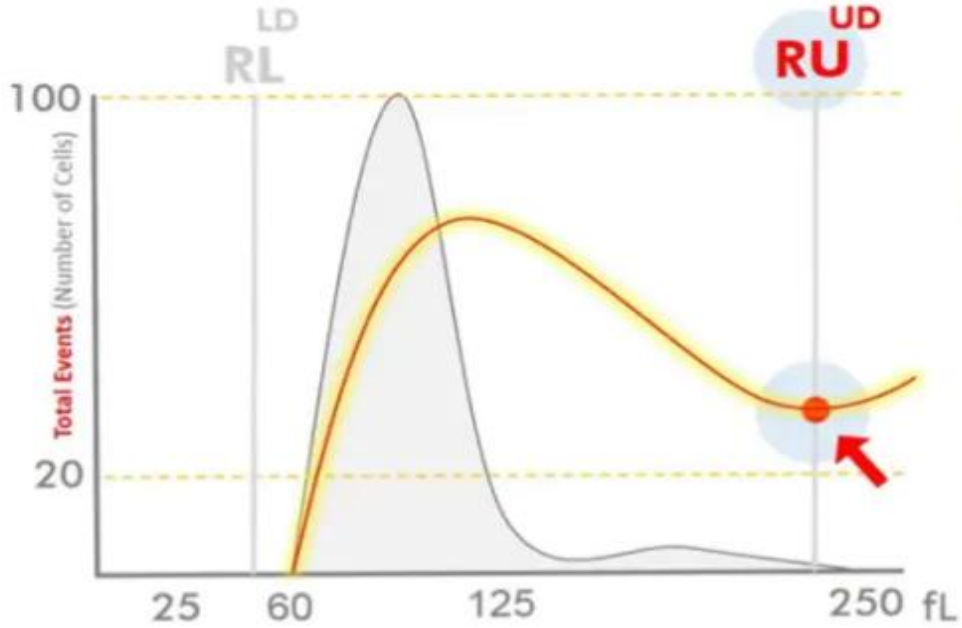
- In case of fragmented RBC and extreme microerythrocytosis ➡ there is no clear separation in volume between platelets and erythrocytes.
- Due to high numbers of RBC ➡ platelet result might be false high and should be checked with alternative methods.

RBCs Histogram

Volume Histogram

Flag 2 **RU Flag**

UD Flag



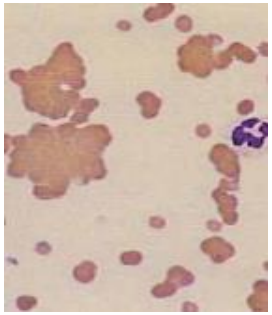
RBCs Histogram

Volume Histogram

- **Abnormal** Height at **UD**
- The UD exceeds the preset height by **> 5 %**

Possible Causes :

- **RBCs** Agglutination
- **Cold** Agglutinins
  Disappear when the samples are incubated at 37 °C
- Nucleated **RBCs**
- **CLL**
  when small lymphoid cells are present in a very high number



Case 9

RBCs Agglutination

RBCs Histogram
Volume Histogram

Parameters

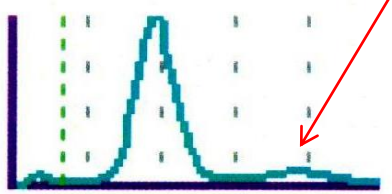
WBC	5.82		[10^3/uL]
RBC	3.05	*	[10^6/uL]
HGB	12.8	*	[g/dL]
HCT	30.9	*	[%]
MCV	101.3	*	[fL]
MCH	42.0	*	[pg]
MCHC	41.4	*	[g/dL]
RDW-SD	43.4		[fL]
RDW-CV	16.0	+	[%]

RU Flag
UD Flag

Anisocytosis

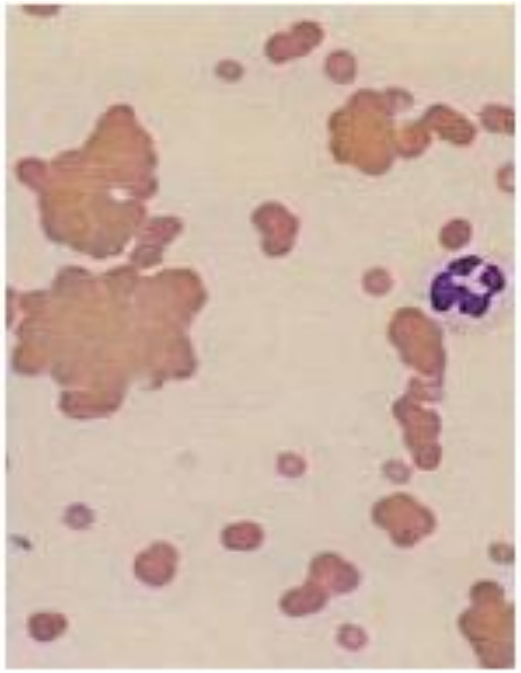
RBC Agglutination?
Turbidity/HGB
Interf?

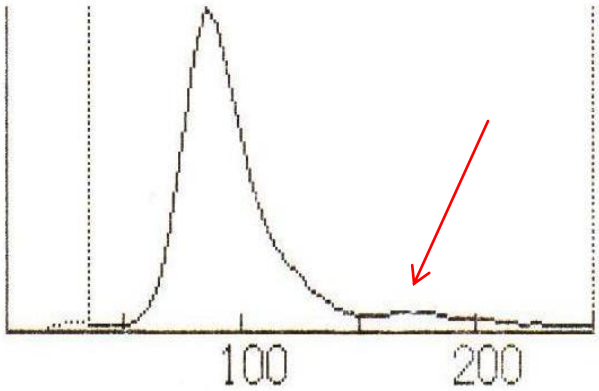
RBC



PLT

RBC





Cold Agglutination

Case 9

RBCs Agglutination

RBCs Histogram
Volume Histogram

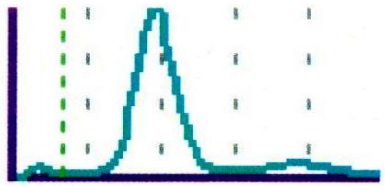
Parameters

WBC	5.82		[10^3/uL]
RBC	3.05	*	[10^6/uL]
HGB	12.8	*	[g/dL]
HCT	30.9	*	[%]
MCV	101.3	*	[fL]
MCH	42.0	*	[pg]
MCHC	41.4	*	[g/dL]
RDW-SD	43.4		[fL]
RDW-CV	16.0	+	[%]

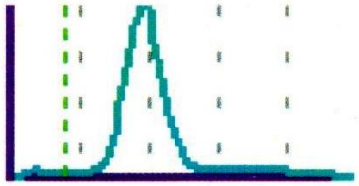
Before

RU Flag
UD Flag

RBC



RBC



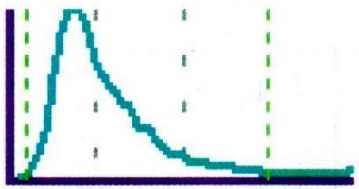
PLT

PLT

Parameters

WBC	6.21		[10^3/uL]
RBC	4.17		[10^6/uL]
HGB	12.6		[g/dL]
HCT	38.8		[%]
MCV	93.0	+	[fL]
MCH	30.2		[pg]
MCHC	32.5		[g/dL]
RDW-SD	43.8		[fL]
RDW-CV	13.2		[%]

After



Before

After

Cold Agglutination

Before & after 30-60 min incubation of blood in 37°C water bath

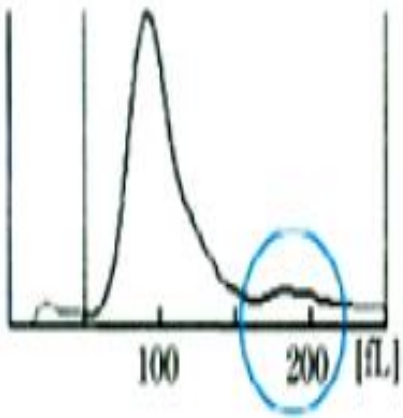
Case 9

RBCs Agglutination

RBCs Histogram

Volume Histogram

RBC-Histogram



Results

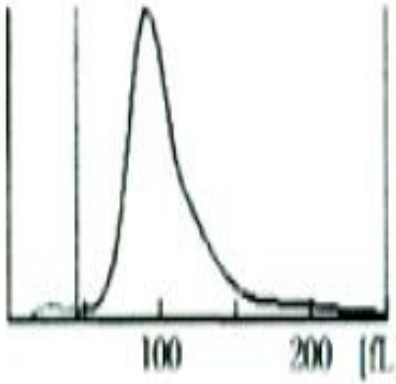
RBC	RU*	2.23x10¹²/L
HGB		14.4g/dl
HCT	RU*	24.9%
MCV	RU*	111.7fl
MCH	RU*	64.6pg
MCH(	RU*	57.8g/dl
RDW	*	25.4fl

RU Flag

UD Flag

Incubation 30 min

RBC-Histogram



Results

RBC	4.35x10¹²/L
HGB	14.5g/dl
HCT	43.5%
MCV	100.0fl
MCH	33.3pg
MCHC	33.3g/dl
RDW	14.7fl

MCH= Hb/RBC

MCHC= Hb/HCT

Flag 2

RU Flag

UD Flag

RBCs Histogram

Volume Histogram

Item	Data		Unit
WBC	489.53	@	10^3/uL
RBC	3.73	*	10^6/uL
HGB	9.2		g/dL
HCT	37.0	*	%
MCV	99.2	*	fL
MCH	24.7	*	pg
MCHC	24.9	*	g/dL
PLT	209		10^3/uL
RDW-SD	----		fL
RDW-CV	----		%
MPV	11.1		fL
RET%	2.69		%
RET#	10.03	*	10^4/uL
IRF	0.131		Ratio
NRBC#	0.00		10^3/uL
NRBC%	0.0		/100WBC

Flag(s)

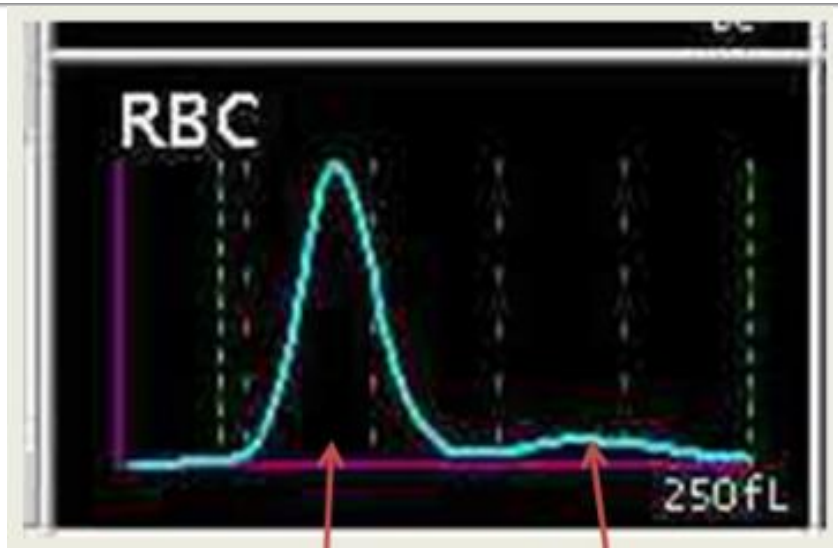
WBC

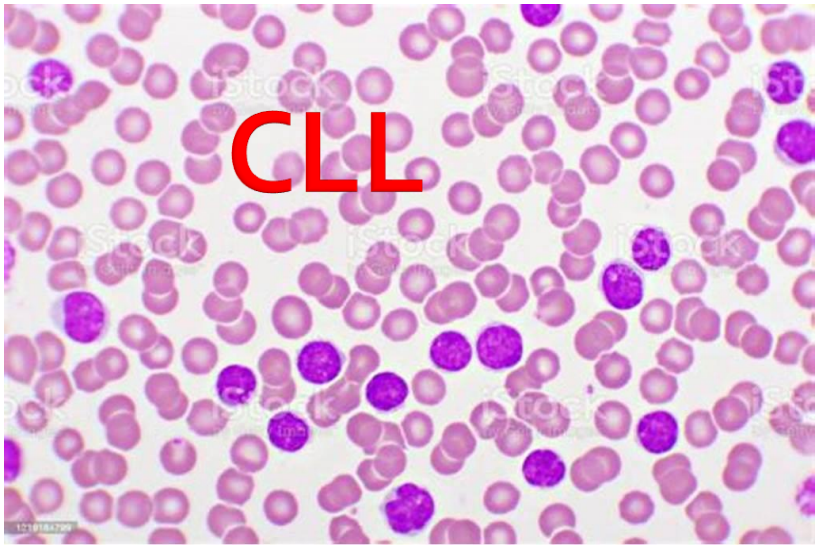
Imm Gran?
Abn Ly/L_Bl?
WBC Abn Scg

RBC/RET

RBC Abn Dst
Dimorph Pop

PLT





Flag 2

RU Flag
UD Flag

RBCs Histogram
Volume Histogram

VERY HIGH WBC – CLL

Graph | WBC/NRBC | RBC/PLT | Cumulative

Measurement Parameters

Item	Data		Unit
WBC	746.24	@	10^3/uL
RBC	1.37	*	10^6/uL
HGB	2.4		g/dL
HCT	21.4	*	%
MCV	156.2	*	fL
MCH	17.5	*	pg
MCHC	11.2	*	g/dL
PLT	95		10^3/uL
RDW-SD	----		fL
RDW-CV	----		%
MPV	10.2		fL
RET%	----		%
RET#	----		10^4/uL
IRF	----		Ratio
NRBC#	0.00		10^3/uL
NRBC%	0.0		/100WBC

Item	Data		Unit
RET-He	----		pg
IPF	----		%

Measure

Item
NEUT#
LYMPH#
MONO#
EO#
BASO#
NEUT%
LYMPH%
MONO%
EO%
BASO%

Item
IG#
IG%

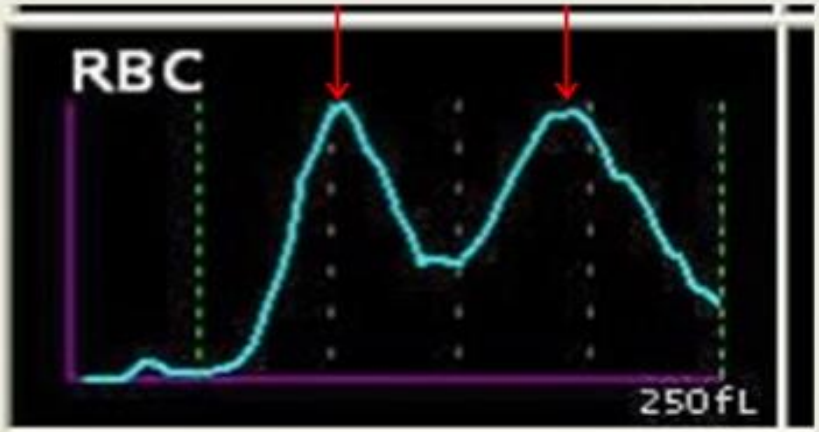
Item
HPC#

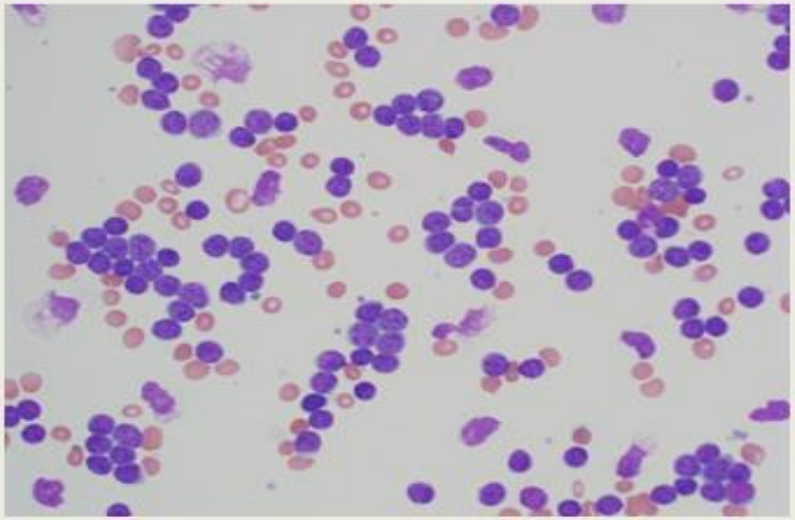
Flag(WBC)

- Imm Gran?
- Atypical Ly?
- Abn Ly/L_Bl?

Flag(RBC/RET)

- RBC Abn Dst
- Dimorph Pop
- Hypochromia

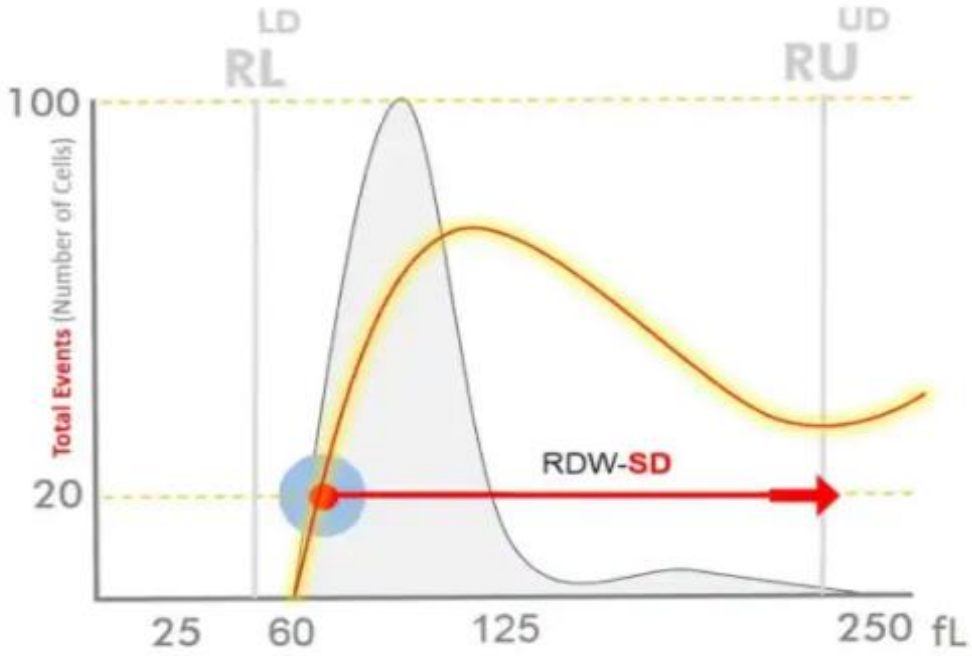




RBCs Histogram

Volume Histogram

Flag 3 RDW Flag



RBCs Histogram

Volume Histogram

- Abnormal RDW
- This flag is seen when the curve does not match the **20% line twice.**

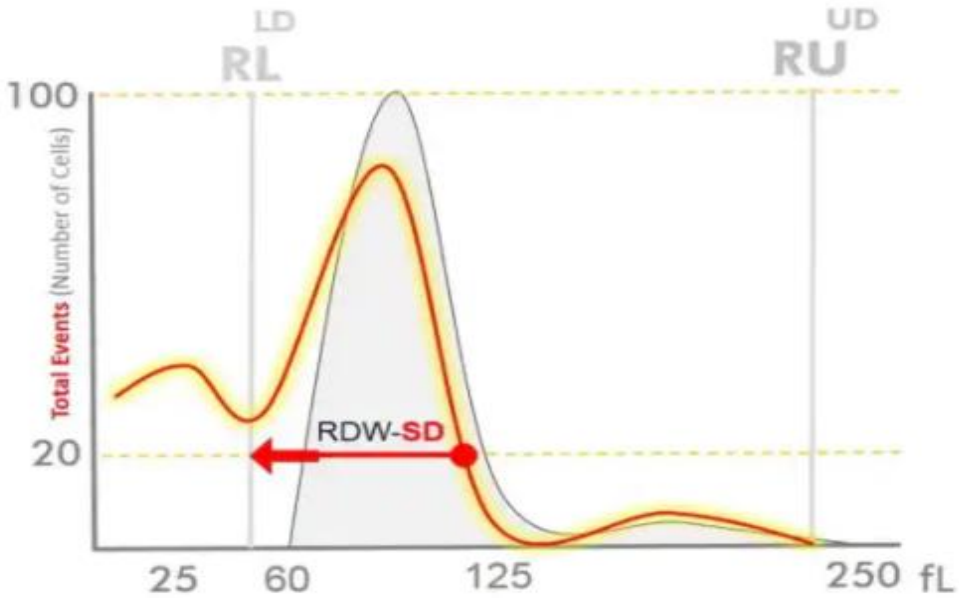
Possible Causes :

- The same as **RU** flag
  - **RBCs** Agglutination
  - **Cold** Agglutinins
    Disappear when the samples are incubated at 37 °C
  - Nucleated **RBCs**
  - **CLL**
    when small lymphoid cells are present in a very high number

RBCs Histogram

Volume Histogram

Flag 3 DW Flag



RBCs Histogram

Volume Histogram

- Abnormal RDW
- This flag is seen when the curve does not match the **20% line twice.**

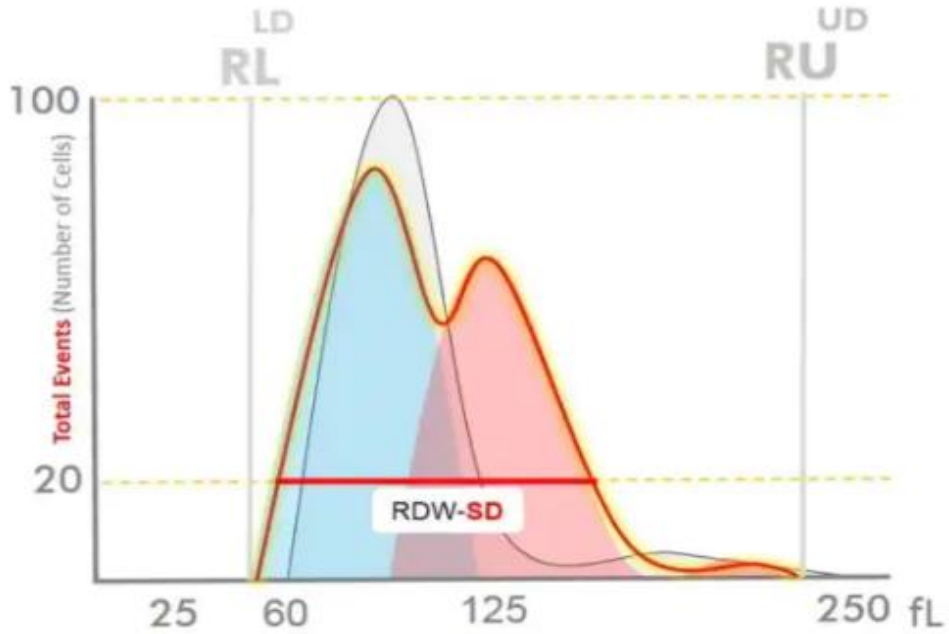
Possible Causes :

- The same as **RL** flag

RBCs Histogram

Volume Histogram

Flag 4 **MP Flag** Multiple Peaks



RBCs Histogram

Volume Histogram

- ↑ RDW (**Aniso**cyosis)
- **Possible causes**

1. Iron deficiency in recovery
2. After blood transfusion
3. Dual deficiency anemia
(**Iron** and Vit.B_{12}/Folic)

Clinical Cases

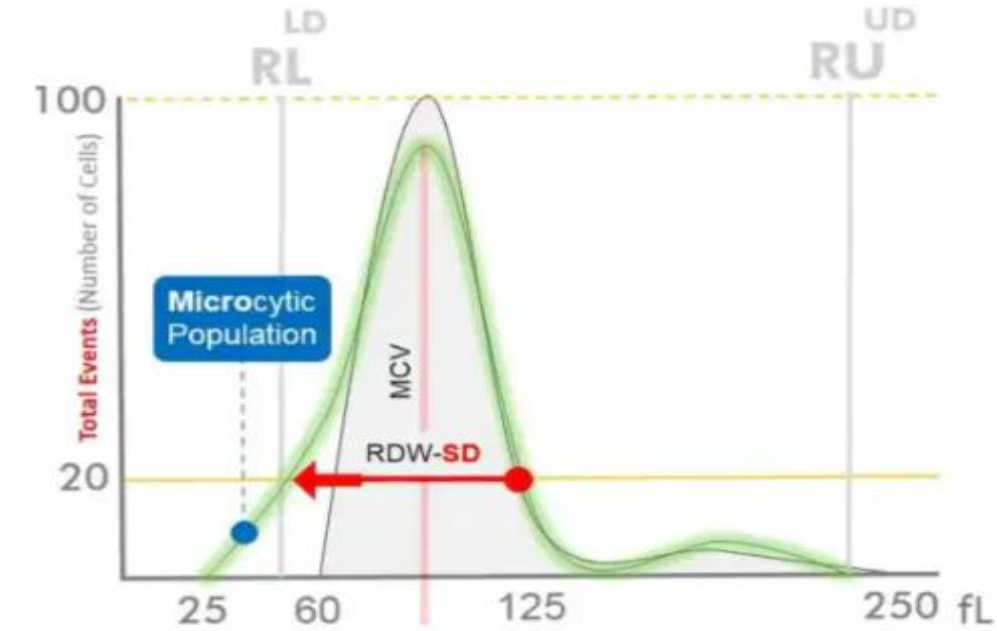
RBCs Histogram

Volume Histogram

RBCs Histogram

Volume Histogram

Case 1 — **Early** Iron Deficiency



RBCs Histogram

Volume Histogram

The **Base** of the curve :

- **Wider** = RDW is ↑

  (**Earliest** indicator)

- Extended toward **left** side ←

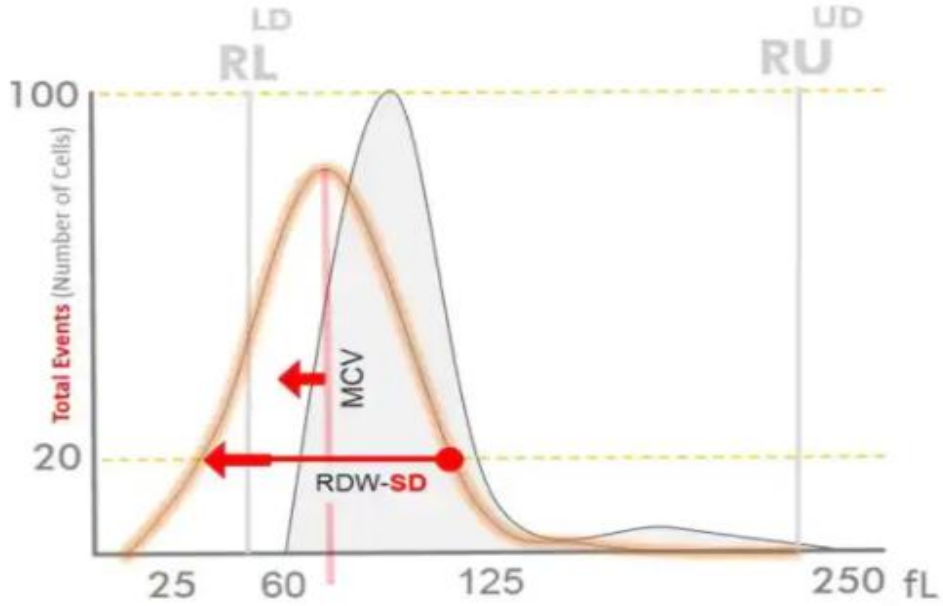
  (**Micro**cytic population)

MCV still normal

RBCs Histogram

Volume Histogram

Case 2 **Advanced** Iron Deficiency



RBCs Histogram

Volume Histogram

The **entire** curve :

- More **Wider** = RDW is ↑↑

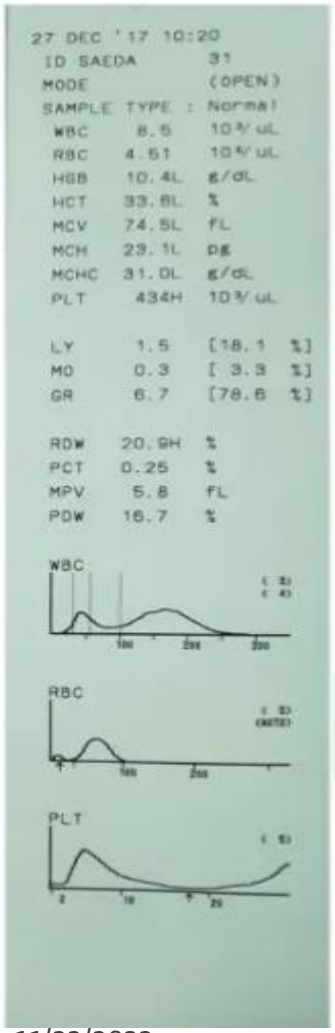
  RBCs **hetero**geneity

- Shifted to the **left** = MCV ↓

  (**Micro**cytic population)

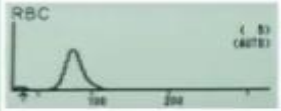
RBCs Histogram

Volume Histogram

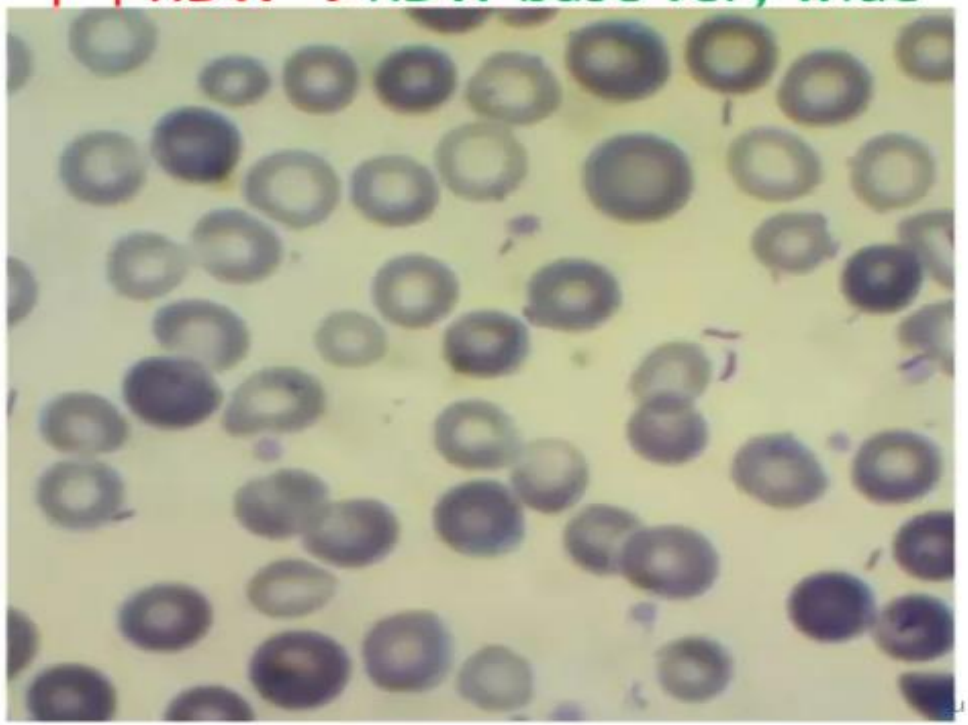


Advanced iron deficiency

↑↑RDW →RDW base very wide



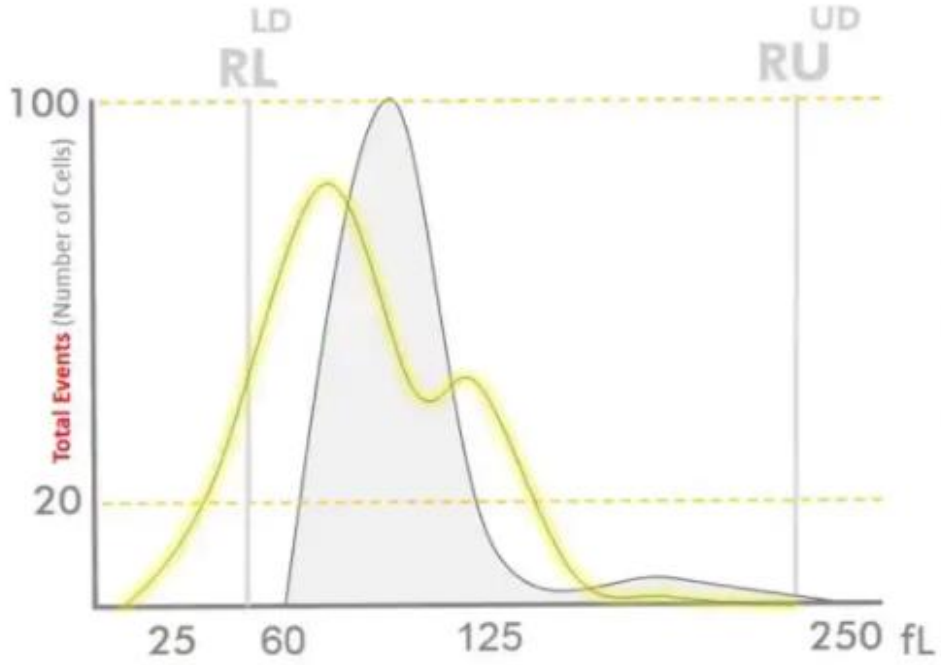
Normal curve



RBCs Histogram

Volume Histogram

Case 3 **Recovery** from Iron Deficiency



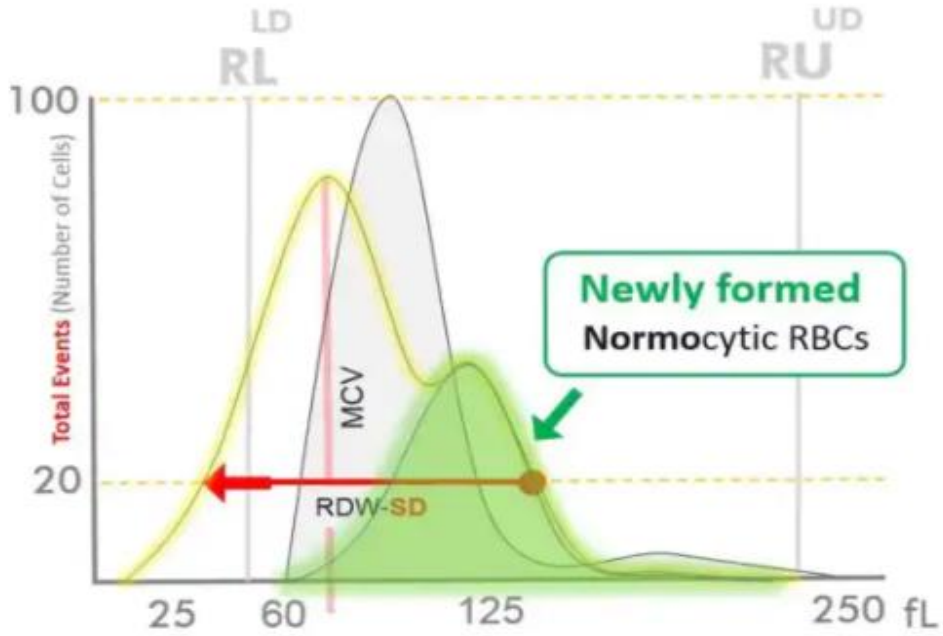
RBCs Histogram

Volume Histogram

- **RBCs count** is ↑↑
- **MCV** is not normal yet
- **2 Populations** could be easily distinguished :

RBCs Histogram
Volume Histogram

Case 3 Recovery from Iron Deficiency



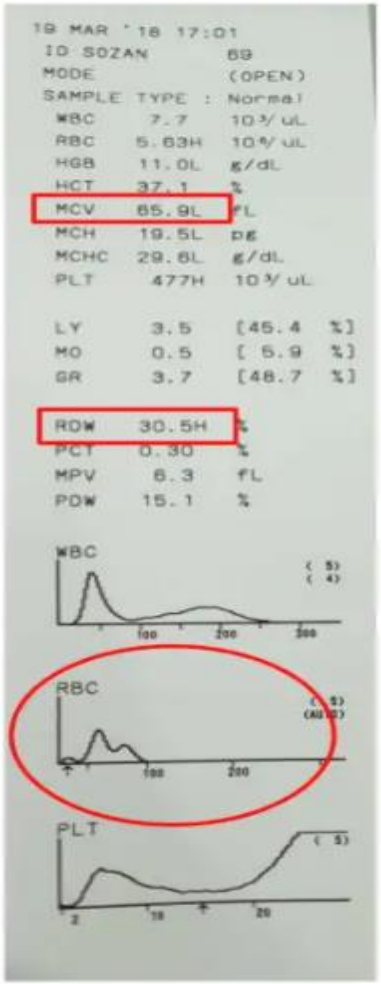
RBCs Histogram
Volume Histogram

- **RBCs count** is ↑↑
- **MCV** is not normal yet
- **2 Populations** could be easily distinguished :

The pre-existing **micro**cytic RBCs
The newly formed **normo**cytic RBCs

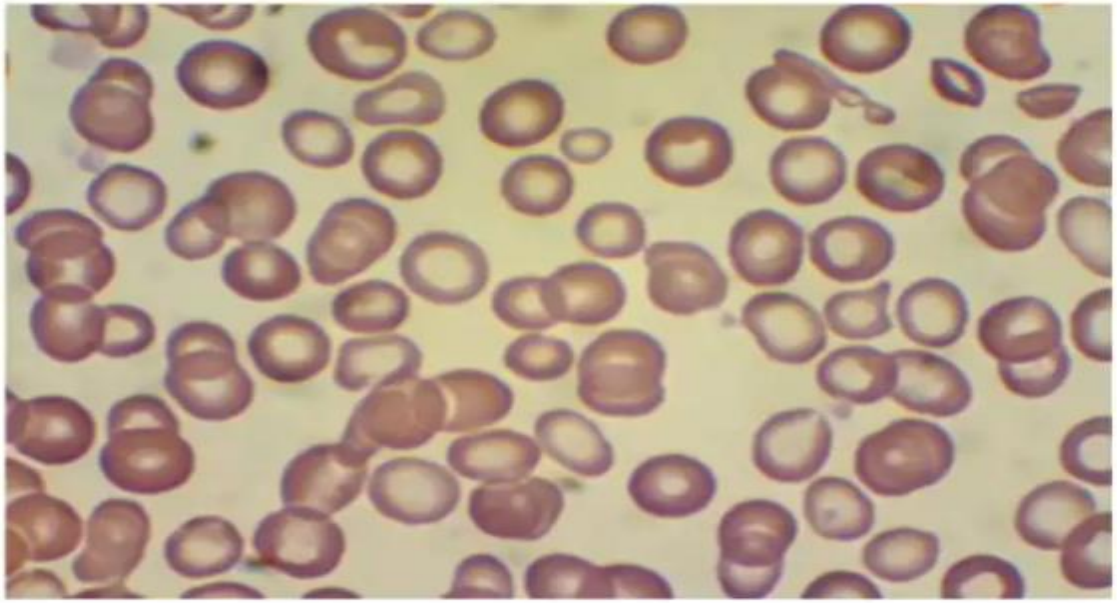
RBCs Histogram

Volume Histogram



After iron therapy-**Early** recovery

↑↑RDW →RDW base very wide (MP)



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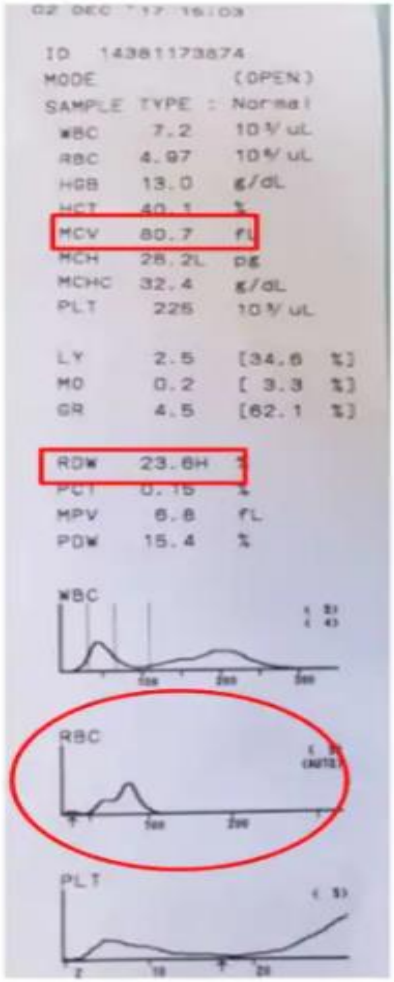
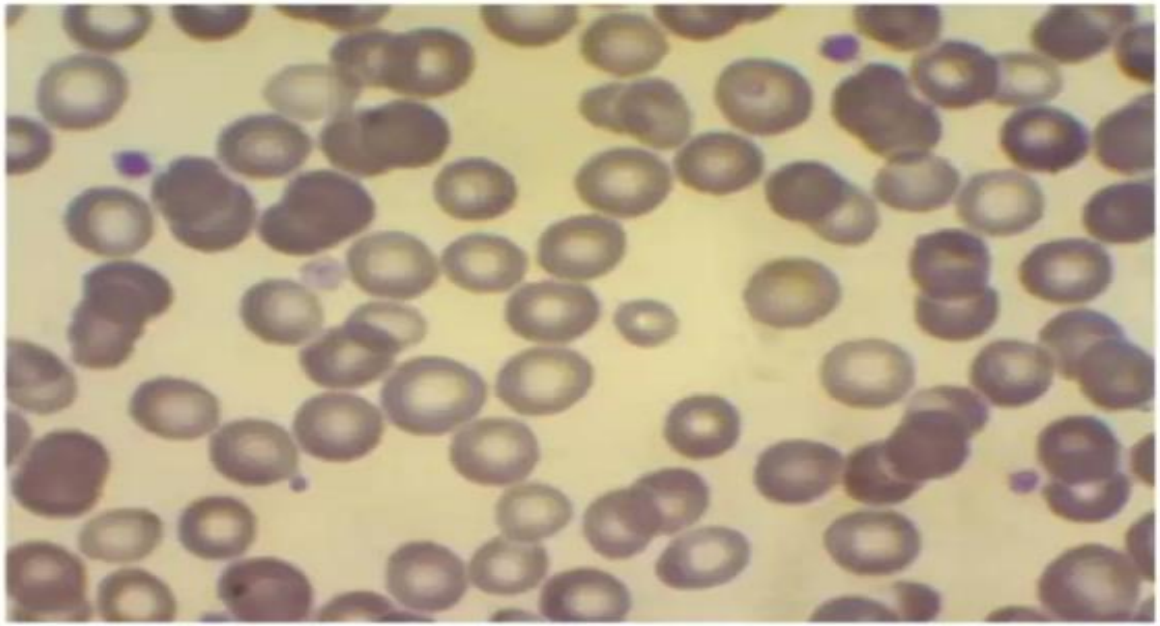
RBCs Histogram

Volume Histogram



After iron therapy-**Advanced** recovery

↑↑RDW → RDW base very wide (MP)



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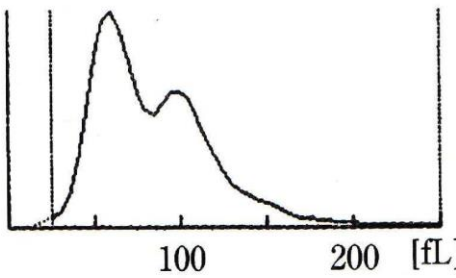
RBCs Histogram

Volume Histogram

Iron Deficiency Anemia being Treated

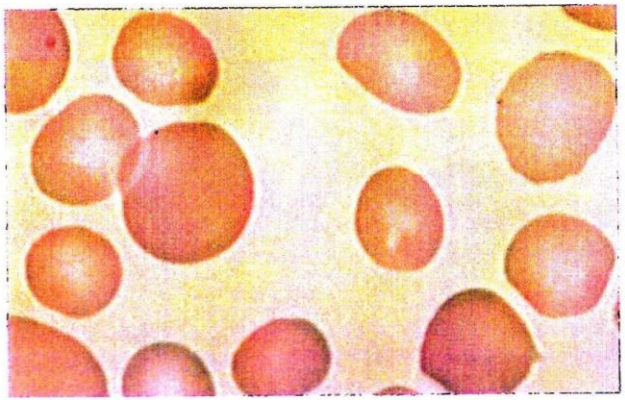
2nd Week of Treatment

<RBC Histogram>



<measurement data>

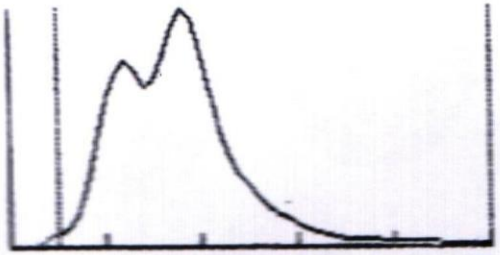
RBC		4.37×10^{12}/L
HGB		104g/L
HCT		0.353
MCV	—	80.8fL
MCH	—	23.8pg
MCHC	—	295g/L
RDW	MP*	0.357



(×1000)

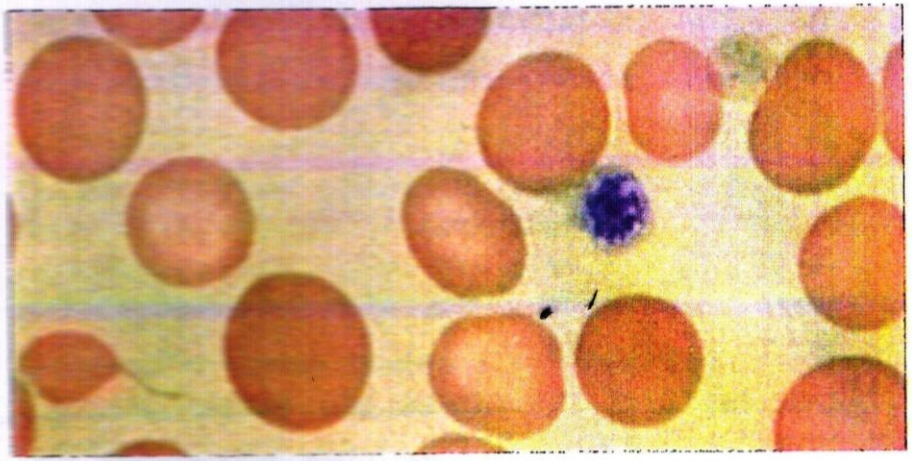
4th Week of Treatment

<RBC Histogram>



<measurement data>

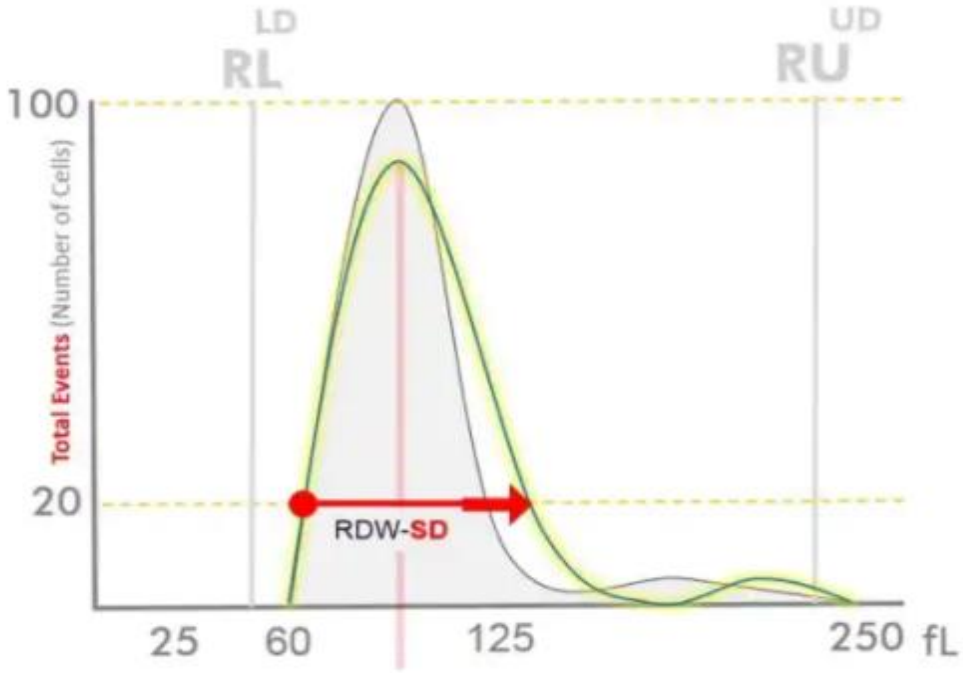
RBC		5.14×10^{12}/L
HGB		132g/L
HCT		0.425
MCV	—	82.7fL
MCH	—	25.7pg
MCHC		311g/L
RDW	MP*	0.319



RBCs Histogram

Volume Histogram

Case 4 — Early Megaloblastic Anemia



RBCs Histogram

Volume Histogram

- **MCV** is still **Normal**

but **RBCs** count and **Hgb** are slightly ↓

The **Base** of the curve :

- **Wider** = RDW is ↑

(**Earliest** indicator)

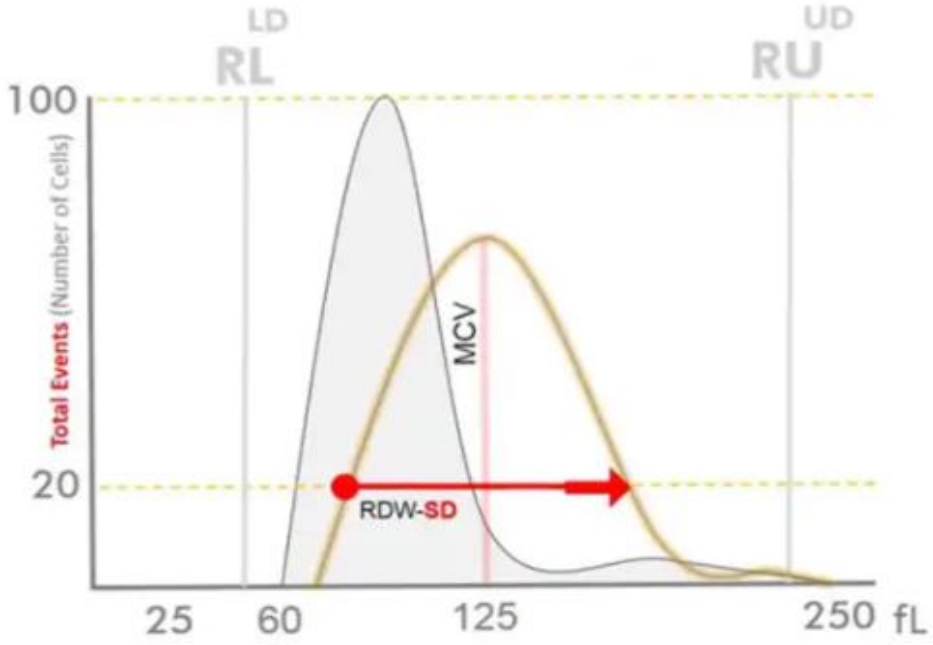
- Extended toward **Right** side

(**Macro**cytic population)

RBCs Histogram

Volume Histogram

Case 5 **Advanced** **Megalo**blastic Anemia



RBCs Histogram

Volume Histogram

- **RBCs count ↓**
- **Hb ↓**

The **entire** curve :

- More **Wider** = RDW is ↑↑

RBCs **hetero**geneity

→

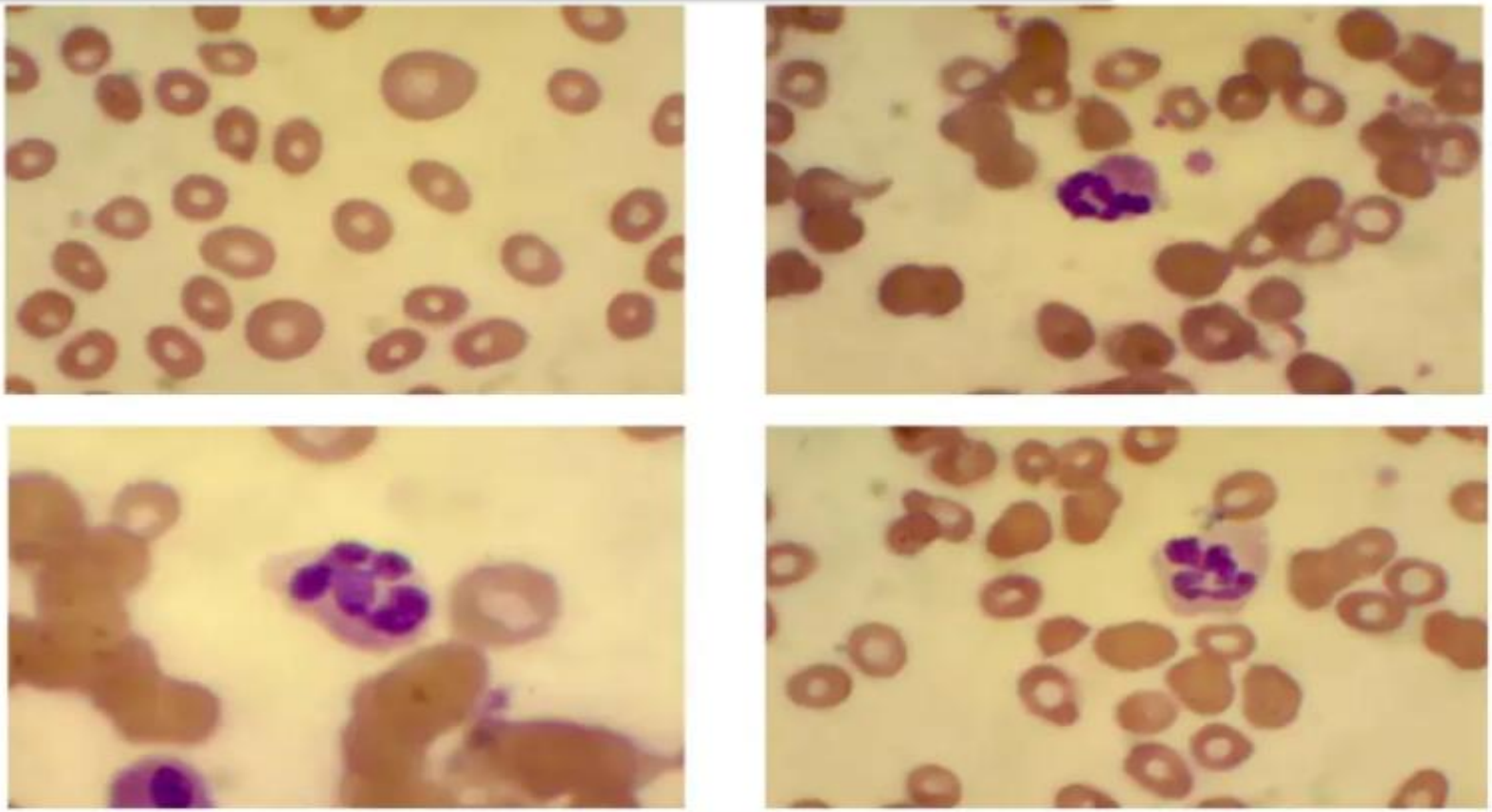
- Shifted to the **Right** = MCV ↑

Macrocytic population

RBCs Histogram

Volume Histogram

Macro-ovalocytes and neutrophil hypersegmentation

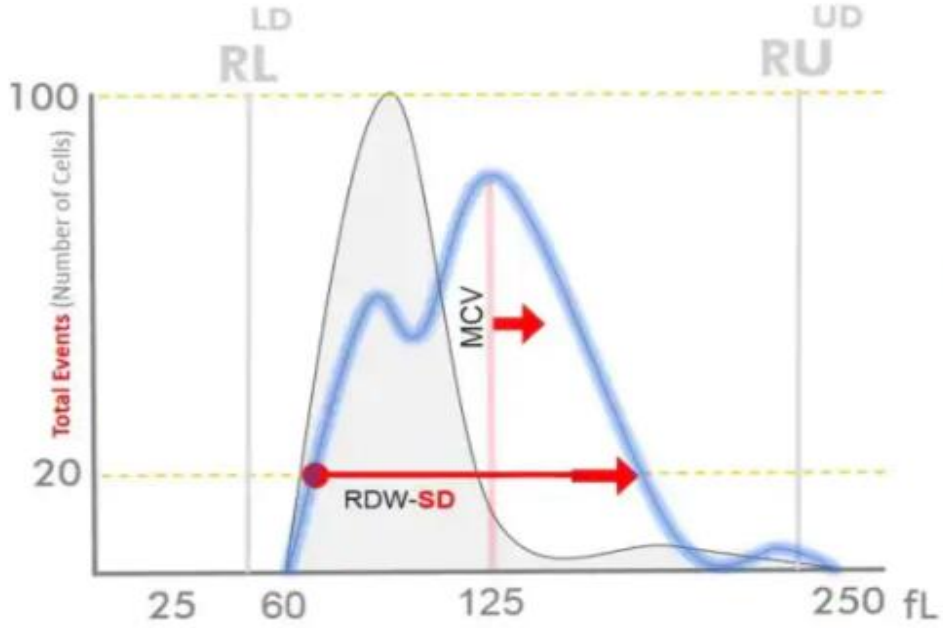


RBCs Histogram

Volume Histogram

Case 6

Recovery from **Megalo**blastic Anemia



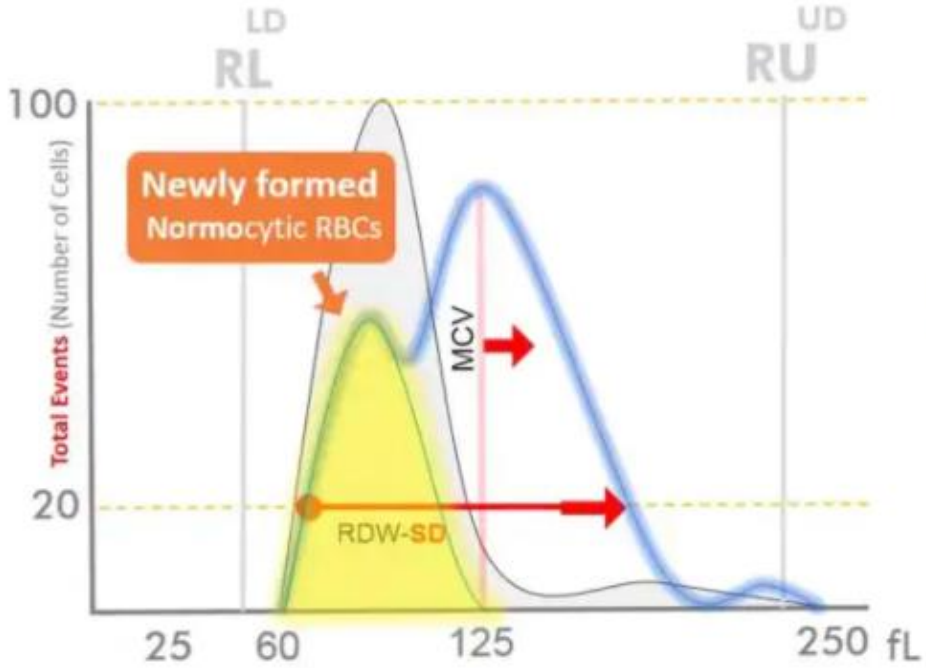
RBCs Histogram

Volume Histogram

- **RBCs count** is ↑↑
- **MCV** is not normal yet
- More ↑↑↑ **RDW** Higher than **Untreated** cases
- **2 Populations** could be easily distinguished :

RBCs Histogram
Volume Histogram

Case 6
Recovery from **Megalo**blastic Anemia



RBCs Histogram
Volume Histogram

- **RBCs count** is ↑↑
- **MCV** is not normal yet
- More ↑↑↑ **RDW** Higher than **Untreated** cases
- **2 Populations** could be easily distinguished :

The **pre-existing** **macro**cytic RBCs
The **newly formed** **normo**cytic RBCs

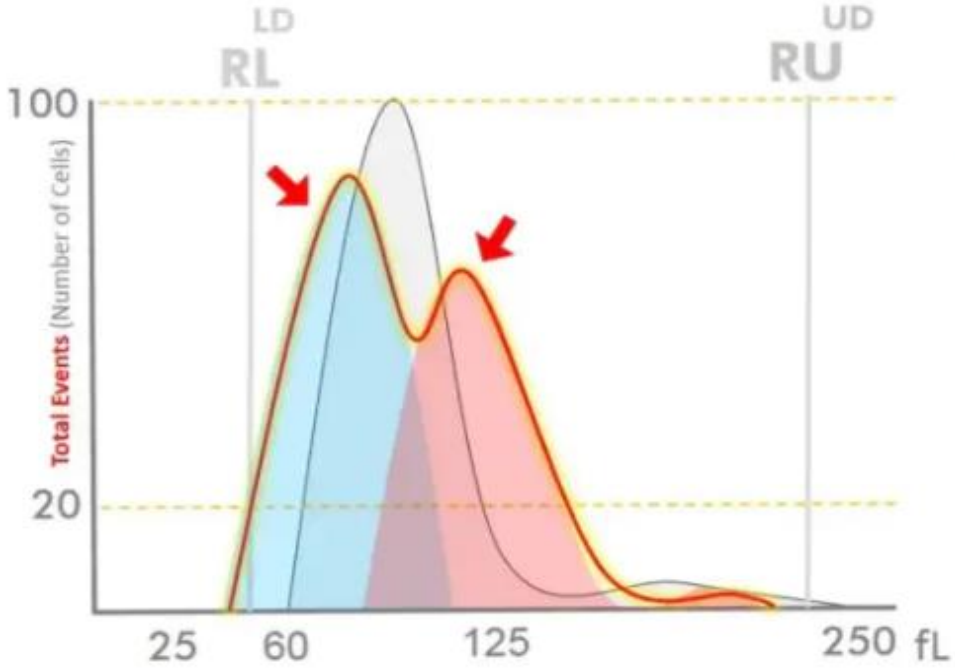
RBCs Histogram

Volume Histogram

Case 7

Bimodal or **MP** Curve

Multiple Peaks



RBCs Histogram

Volume Histogram

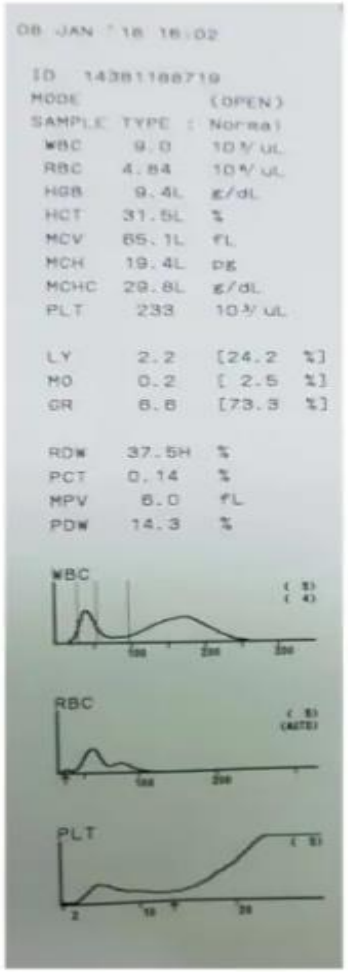
- **Dimorphic RBCs population**
- **Possible causes**

1. Patients on Hematinic treatment
2. Following blood transfusion
3. Dual deficiency anemia

(**Iron** and Vit.B_{12}/Folic)

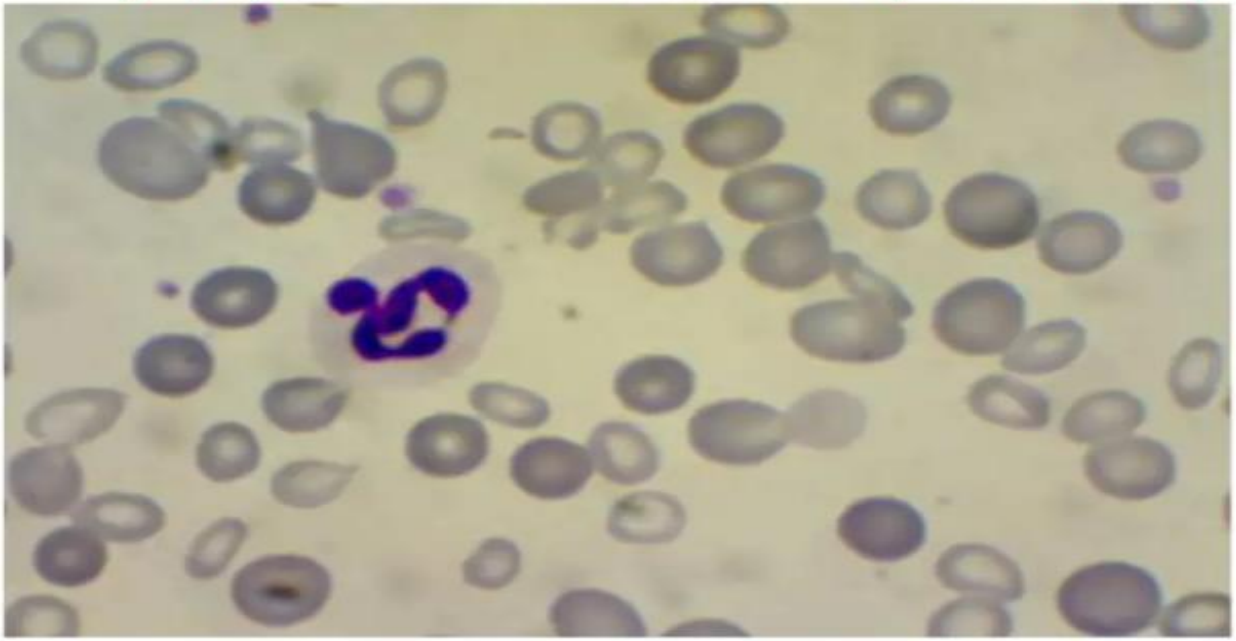
RBCs Histogram

Volume Histogram



After blood transfusion-Dimorphic

↑↑↑RDW → RDW base very wide (MP)



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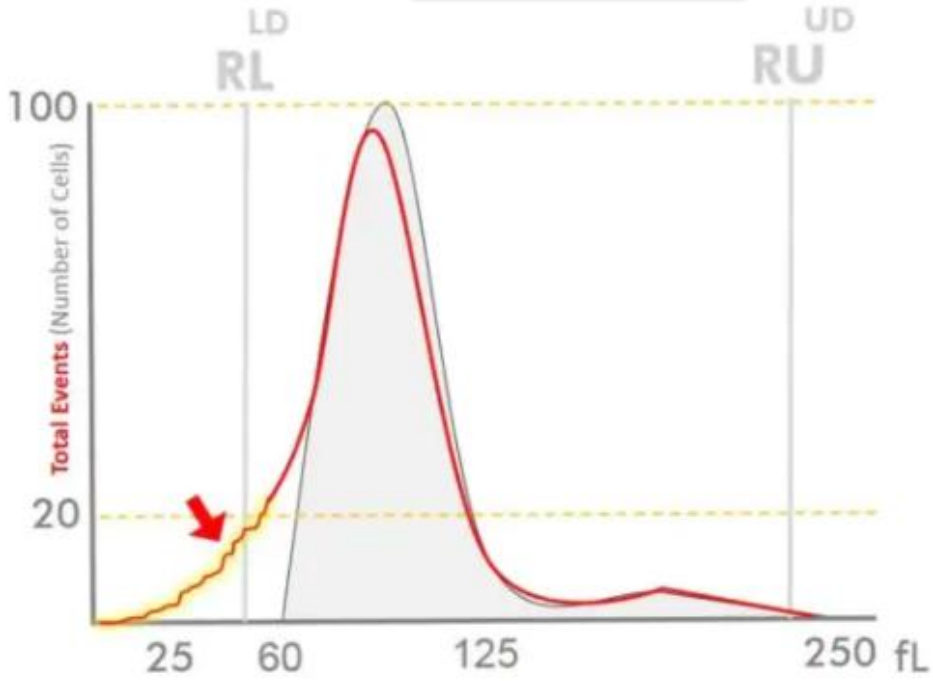
RBCs Histogram

Volume Histogram

Case 8

RBCs **Fragmentation**

Schistocytes



RBCs Histogram

Volume Histogram

- **MCV** is normal
- **RDW** is ↑↑
- A plateau to the **left** of the curve peak

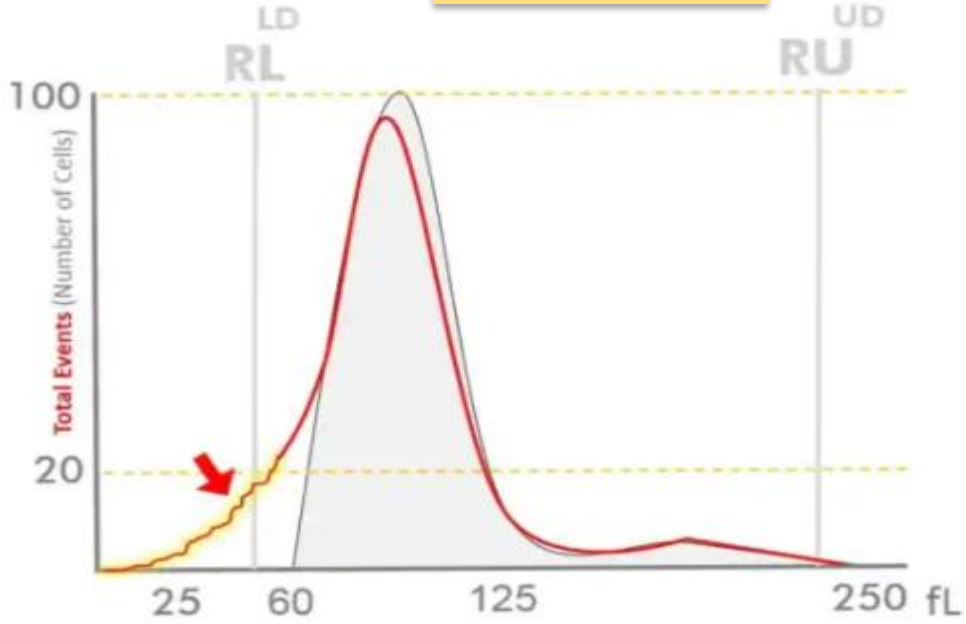
RBCs Histogram

Volume Histogram

Case 8

RBCs Fragmentation

Schistocytes



RBCs Histogram

Volume Histogram

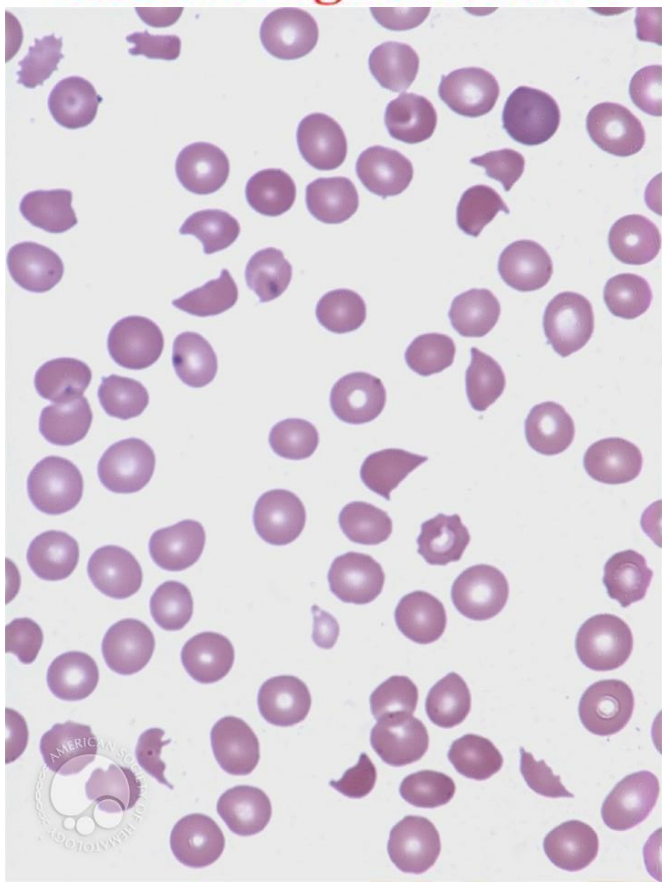
Possible Causes :

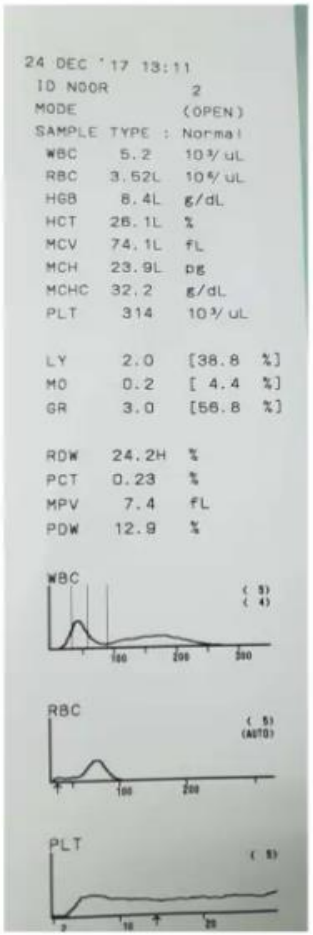
- **DIC**
- **TTP**
- **HUS**
- **Burns**
- Cardiac prosthetic valves
- Metastatic tumors
- **Sickle** cell anemia
- **Megalo**blastic anemia
- Cyto**toxic** chemotherapy
- HELLP

RBCs Histogram

Volume Histogram

RBCs fragmentation





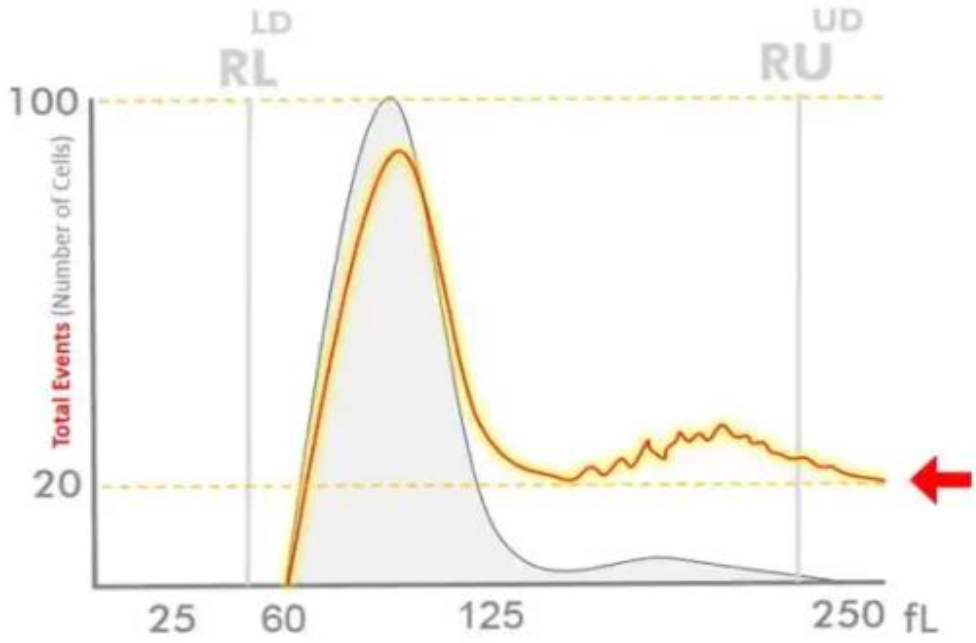
RBCs Histogram

Volume Histogram

Case 9 RBCs **Agglutination**

RBCs Histogram

Volume Histogram



Extension on the **Right** side of the histogram curve.

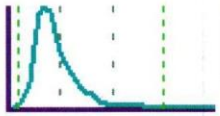
Normal RBC & PLT Histogram

Parameters				Normal Ranges
WBC	5.14	[10^3/uL]		(4.40 - 11.30)
RBC	4.57	[10^6/uL]		(4.50 - 5.90)
HGB	13.7 -	[g/dL]		(14.0 - 17.4)
HCT	42.2	[%]		(41.5 - 50.4)
MCV	92.3	[fL]		(80.0 - 96.0)
MCH	30.0	[pg]		(27.5 - 32.5)
MCHC	32.5 -	[g/dL]		(33.4 - 35.0)
RDW-SD	43.4	[fL]		(37.0 - 54.0)
RDW-CV	13.2	[%]		(11.0 - 14.5)
PLT	213	[10^3/uL]		(150 - 450)
PDW	10.7	[fL]		(9.0 - 14.0)
MPV	9.2	[fL]		(9.0 - 12.0)
P-LCR	19.4	[%]		(13.0 - 43.0)
PCT	0.20	[%]		(0.17 - 0.35)
NEUT	2.50	[10^3/uL]	48.7 - [%]	(54.0 - 62.0)
LYMPH	2.15	[10^3/uL]	41.8 + [%]	(25.0 - 35.0)
MONO	0.38	[10^3/uL]	7.4 [%]	(2.0 - 8.0)
EO	0.10	[10^3/uL]	1.9 [%]	(0.0 - 1.0)
BASO	0.01	[10^3/uL]	0.2 [%]	(0.5 - 3.0)

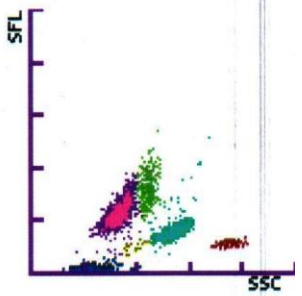
WBC IP Message(s) RBC IP Message(s) PLT IP Message(s)

RBC

PLT



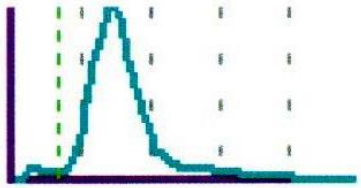
DIFF



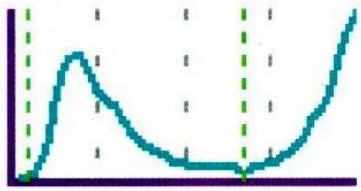
IDA

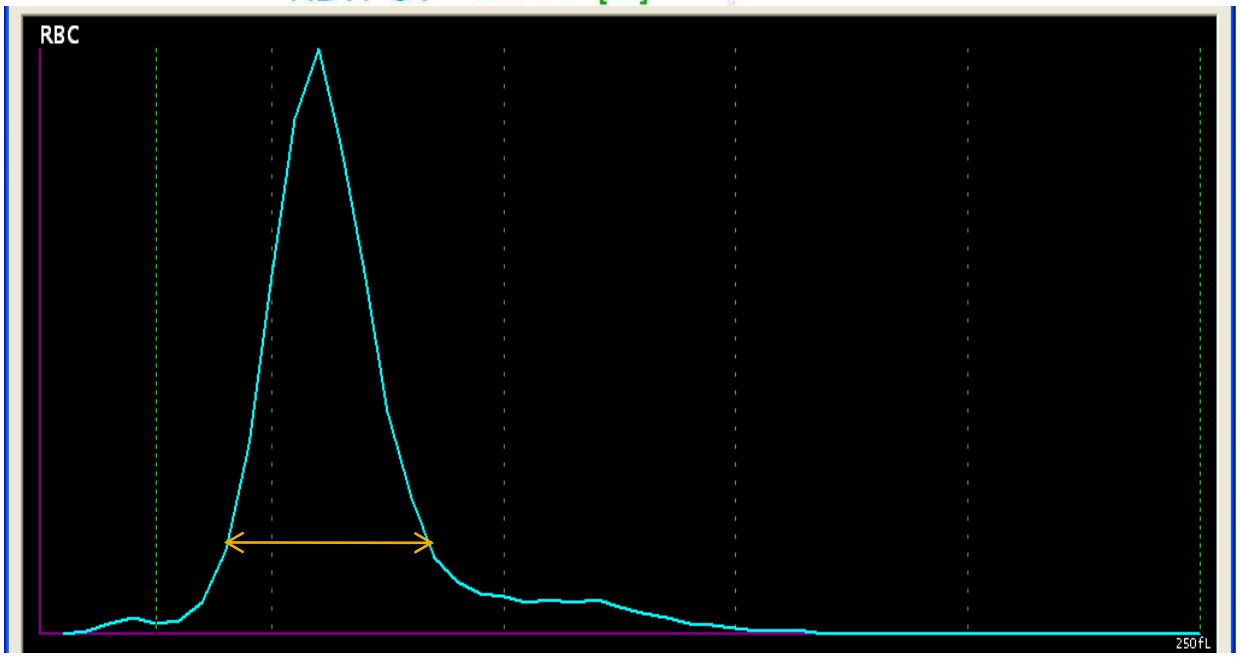
Parameters			
WBC	4.74		[10^3/uL]
RBC	4.08	-	[10^6/uL]
HGB	9.5	-	[g/dL]
HCT	29.9	-	[%]
MCV	73.3	-	[fL]
MCH	23.3	-	[pg]
MCHC	31.8		[g/dL]
RDW-SD	51.0		[fL]
RDW-CV	21.4	+	[%]

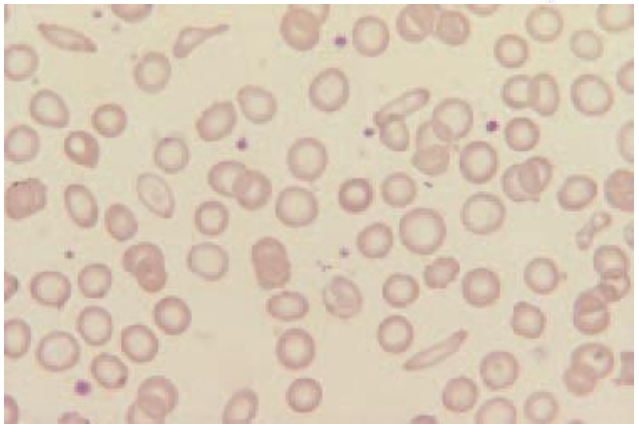
RBC



PLT





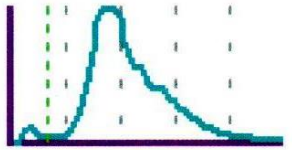


Megalobalstic anemia

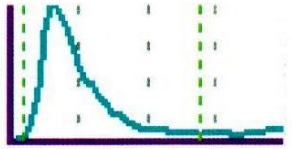
Parameters

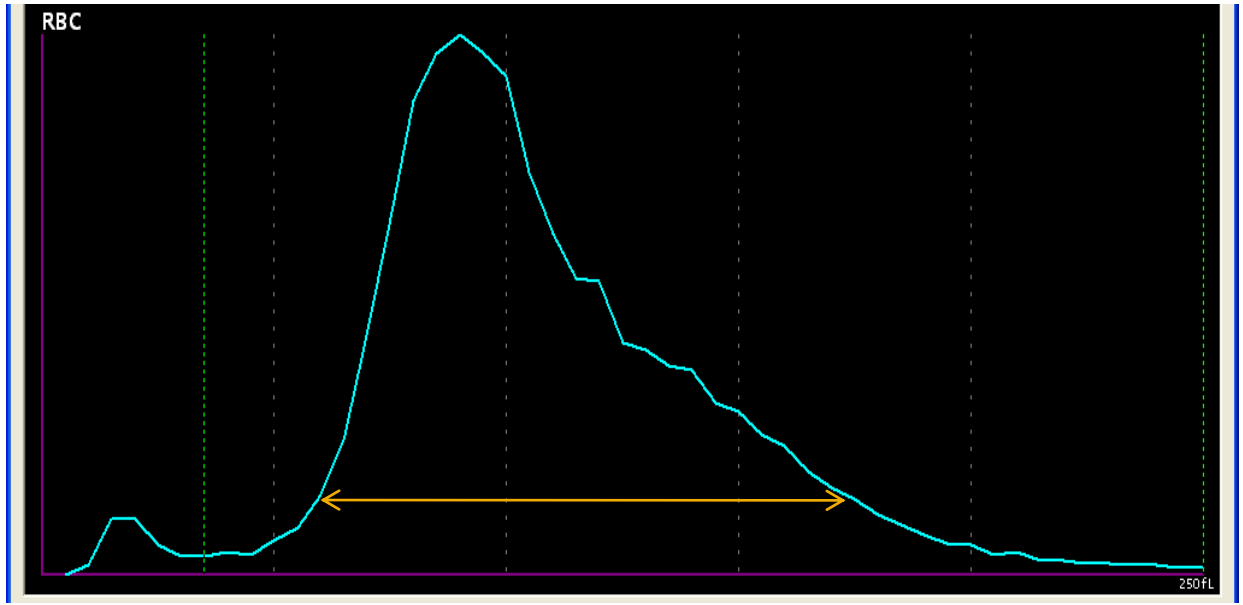
WBC	3.70	-	[10^3/uL]
RBC	2.86	-	[10^6/uL]
HGB	9.4	-	[g/dL]
HCT	29.5	-	[%]
MCV	103.1	+	[fL]
MCH	32.9		[pg]
MCHC	31.9		[g/dL]
RDW-SD	92.7	+	[fL]
RDW-CV	27.7	+	[%]

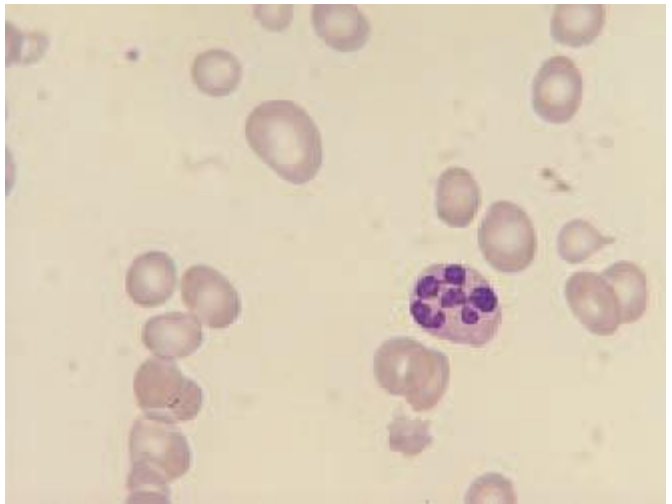
RBC



PLT



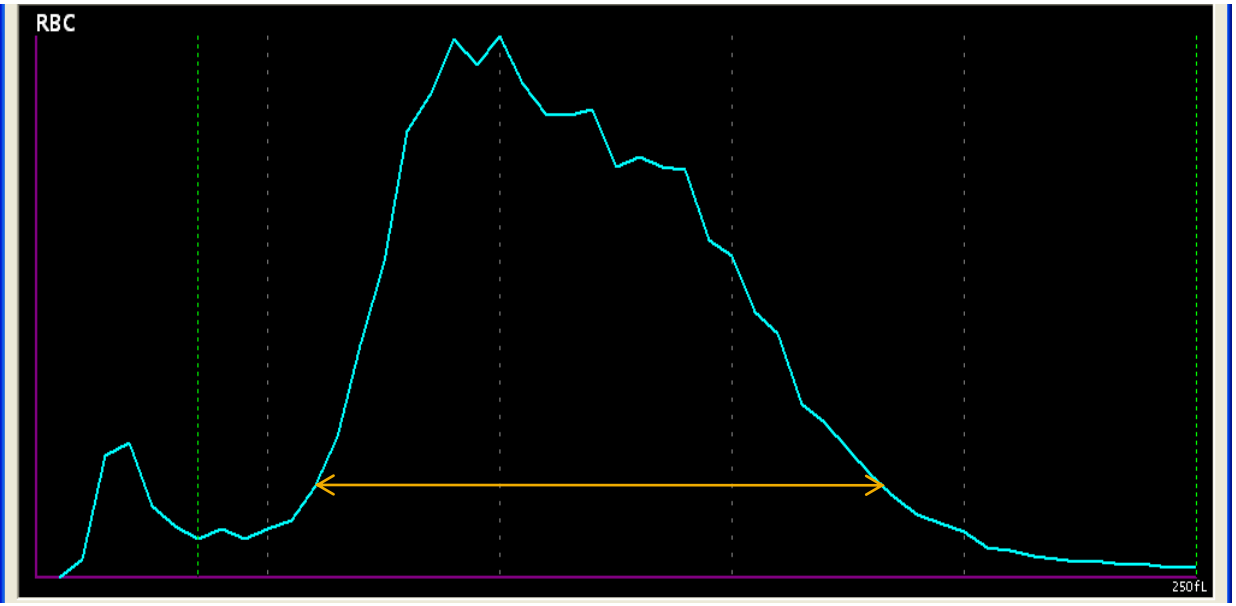




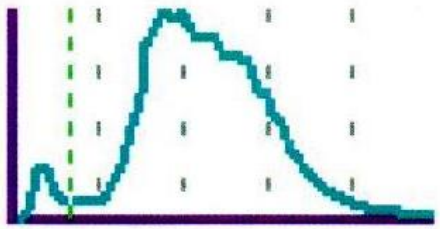
Megaloblastic Anemia

Parameters

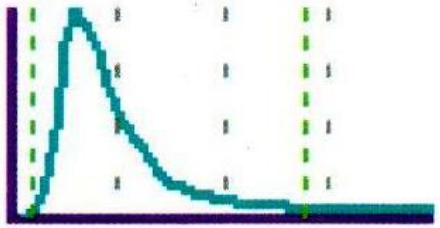
WBC	4.29	-	[10^3/uL]
RBC	1.85	-	[10^6/uL]
HGB	6.6	-	[g/dL]
HCT	20.8	-	[%]
MCV	112.4	+	[fL]
MCH	35.7	+	[pg]
MCHC	31.7	-	[g/dL]
RDW-SD	106.9	+	[fL]
RDW-CV	29.2	+	[%]



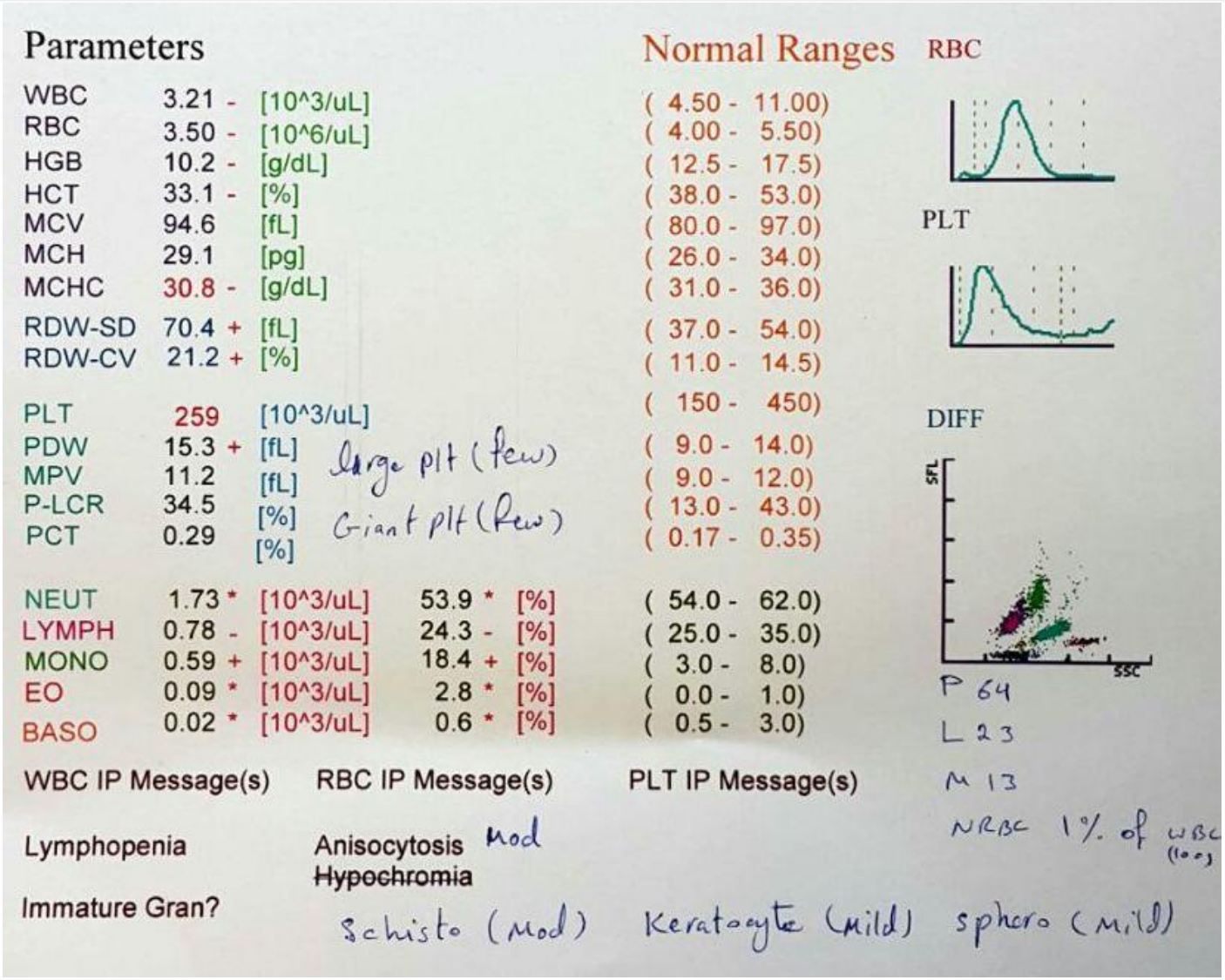
RBC



PLT



Hemolytic Anemia



Parameters			Normal Ranges
WBC	3.21 -	[10^3/uL]	(4.50 - 11.00)
RBC	3.50 -	[10^6/uL]	(4.00 - 5.50)
HGB	10.2 -	[g/dL]	(12.5 - 17.5)
HCT	33.1 -	[%]	(38.0 - 53.0)
MCV	94.6	[fL]	(80.0 - 97.0)
MCH	29.1	[pg]	(26.0 - 34.0)
MCHC	30.8 -	[g/dL]	(31.0 - 36.0)
RDW-SD	70.4 +	[fL]	(37.0 - 54.0)
RDW-CV	21.2 +	[%]	(11.0 - 14.5)
PLT	259	[10^3/uL]	(150 - 450)
PDW	15.3 +	[fL]	(9.0 - 14.0)
MPV	11.2	[fL]	(9.0 - 12.0)
P-LCR	34.5	[%]	(13.0 - 43.0)
PCT	0.29	[%]	(0.17 - 0.35)
NEUT	1.73 *	[10^3/uL] 53.9 * [%]	(54.0 - 62.0)
LYMPH	0.78 -	[10^3/uL] 24.3 - [%]	(25.0 - 35.0)
MONO	0.59 +	[10^3/uL] 18.4 + [%]	(3.0 - 8.0)
EO	0.09 *	[10^3/uL] 2.8 * [%]	(0.0 - 1.0)
BASO	0.02 *	[10^3/uL] 0.6 * [%]	(0.5 - 3.0)

large plt (few)

Giant plt (few)

RBC

PLT

DIFF

SFL

SSC

P 64

L 23

M 13

NRBC 1% of WBC (10.0)

WBC IP Message(s)

Lymphopenia

Immature Gran?

RBC IP Message(s)

Anisocytosis Mod

~~Hypochromia~~

Schisto (Mod) Keratocyte (Mild) Sphero (Mild)

PLT IP Message(s)

Hemolytic Anemia

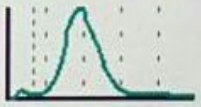
Parameters			Normal Ranges
WBC	3.21 -	[10^3/uL]	(4.50 - 11.00)
RBC	3.50 -	[10^6/uL]	(4.00 - 5.50)
HGB	10.2 -	[g/dL]	(12.5 - 17.5)
HCT	33.1 -	[%]	(38.0 - 53.0)
MCV	94.6	[fL]	(80.0 - 97.0)
MCH	29.1	[pg]	(26.0 - 34.0)
MCHC	30.8 -	[g/dL]	(31.0 - 36.0)
RDW-SD	70.4 +	[fL]	(37.0 - 54.0)
RDW-CV	21.2 +	[%]	(11.0 - 14.5)
PLT	259	[10^3/uL]	(150 - 450)
PDW	15.3 +	[fL]	(9.0 - 14.0)
MPV	11.2	[fL]	(9.0 - 12.0)
P-LCR	34.5	[%]	(13.0 - 43.0)
PCT	0.29	[%]	(0.17 - 0.35)

large plt (few)

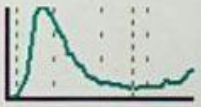
Giant plt (few)

NEUT	1.73 *	[10^3/uL]	53.9 *	[%]	(54.0 - 62.0)
LYMPH	0.78 -	[10^3/uL]	24.3 -	[%]	(25.0 - 35.0)
MONO	0.59 +	[10^3/uL]	18.4 +	[%]	(3.0 - 8.0)
EO	0.09 *	[10^3/uL]	2.8 *	[%]	(0.0 - 1.0)
BASO	0.02 *	[10^3/uL]	0.6 *	[%]	(0.5 - 3.0)

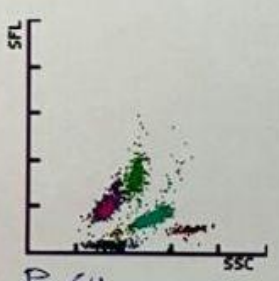
RBC



PLT



DIFF



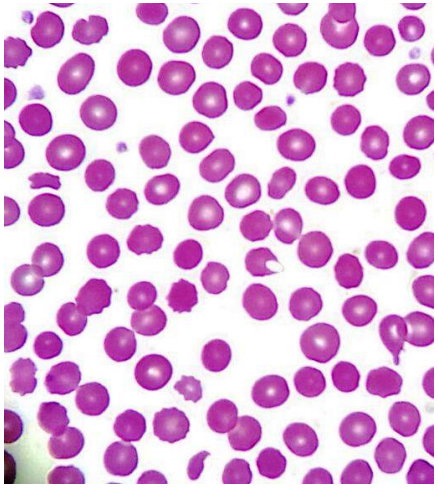
P 64

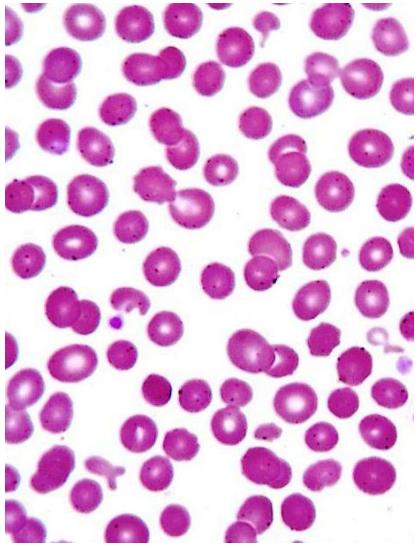
L 23

M 13

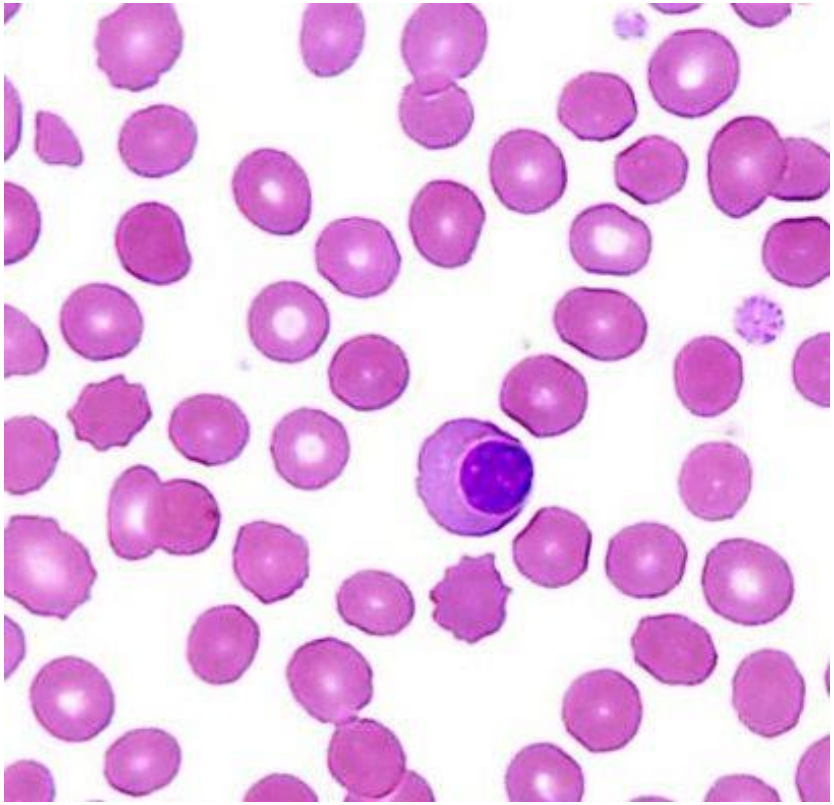
NRBC 1% of WBC (10.4)

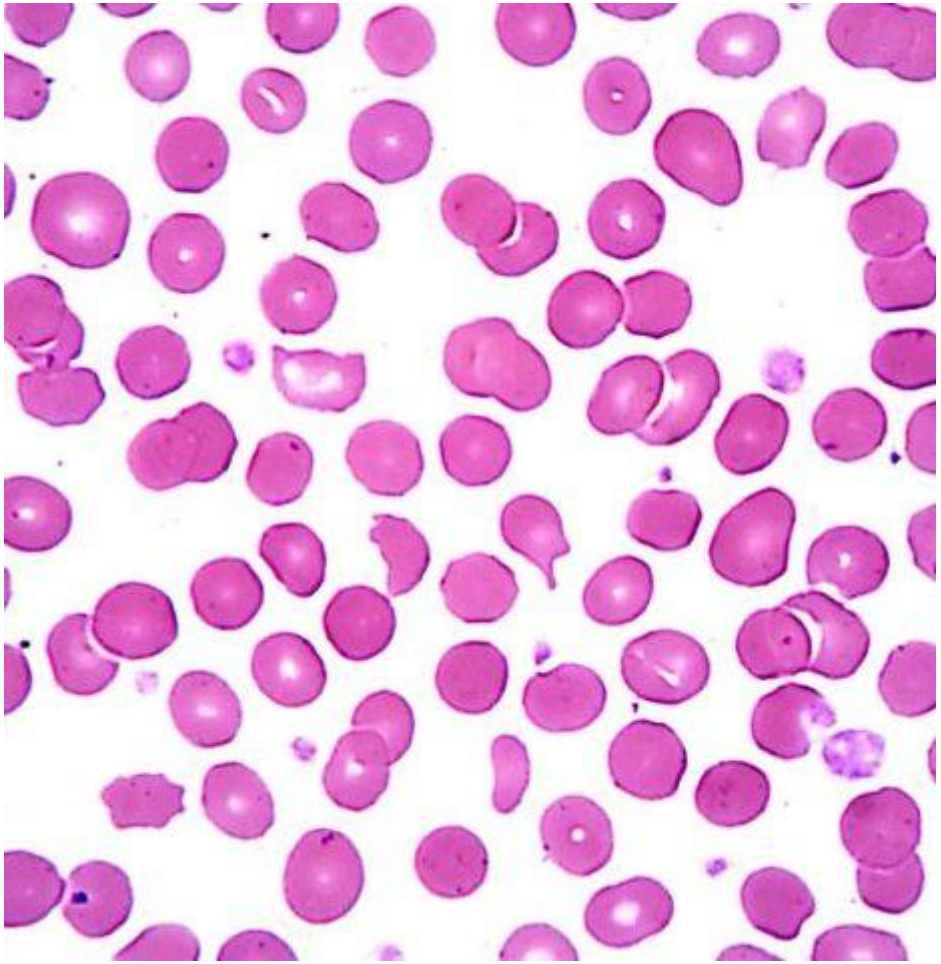
WBC IP Message(s)	RBC IP Message(s)	PLT IP Message(s)
Lymphopenia	Anisocytosis Mod	
Immature Gran?	~~Hypochromia~~	
	Schisto (Mod) Keratocyte (Mild) sphero (Mild)	





Hemolytic Anemia





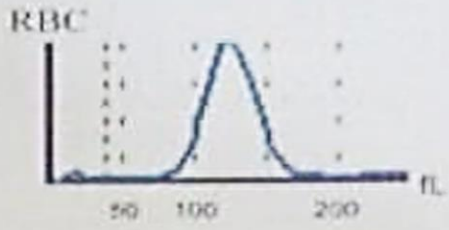
Severe Macrocytic Anemia

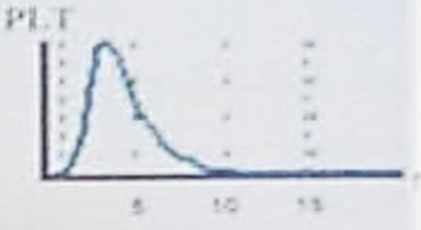
RDW-SD or CV?

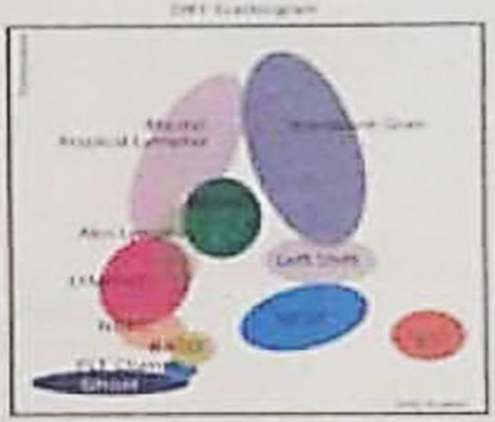
Parameters		Unit	Reference Value
WBC	7.31	[10^3/uL]	(4.00 - 11.00)
RBC	3.46 -	[10^6/uL]	(4.20 - 5.40)
HGB	14.1	[g/dL]	(12.5 - 16.0)
HCT	41.5	[%]	(37.0 - 47.0)
MCV	119.9 +	[fL]	(78.0 - 100.0)
MCH	40.8 +	[pg]	(27.0 - 31.0)
MCHC	34.0	[g/dL]	(32.0 - 37.0)
PLT	443	[10^3/uL]	(140 - 450)
RDW-SD	56.6 +	[fL]	(37.0 - 54.0)
RDW-CV	13.0	[%]	(11.5 - 14.0)
PDW	9.9	[fL]	(9.0 - 17.0)
MPV	8.7 -	[fL]	(9.0 - 13.0)
P-LCR	15.5 -	[%]	(17.0 - 47.0)
PCT	0.38 +	[%]	(0.17 - 0.35)

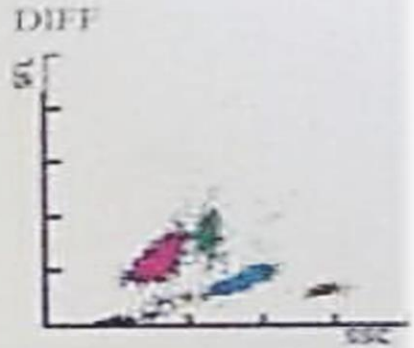
References values has been adjusted by sex and age !

NEUT	3.16	[10^3/uL]	43.2	[%]
LYMPH	3.38	[10^3/uL]	46.0	[%]
MONO	0.65	[10^3/uL]	8.9	[%]
EO	0.11	[10^3/uL]	1.5	[%]
BASO	0.03	[10^3/uL]	0.4	[%]









WBC IP Message(s)

RBC IP Message(s)
Macrocytosis

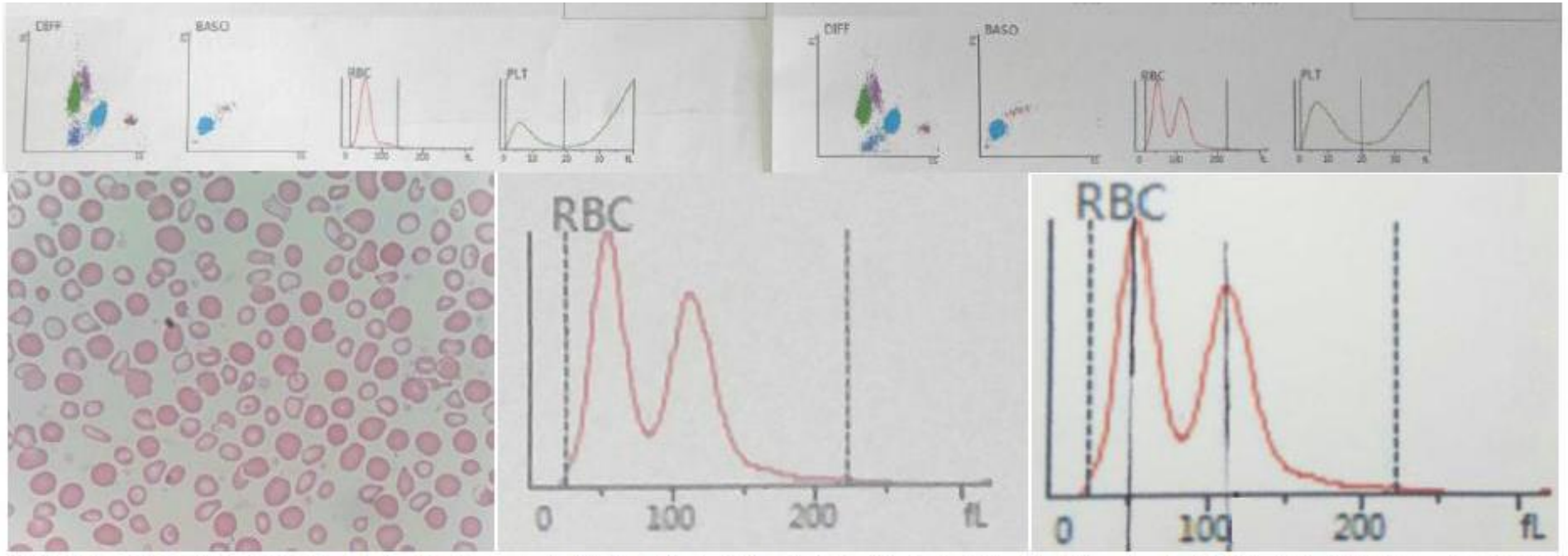
PLT IP Message(s)

ماکروسیتیک شدید منجر به کاهش کاذب RDW-CV شده است. البته RBC نسبتا پایین باعث افزایش MCH شده ولی روی MCHC تاثیر نداشته است

فقدان دم راست در هیستوگرام RBC احتمال Cold Agg را رد می کند.

Treatment of severe IDA & Megaloblastic crisis

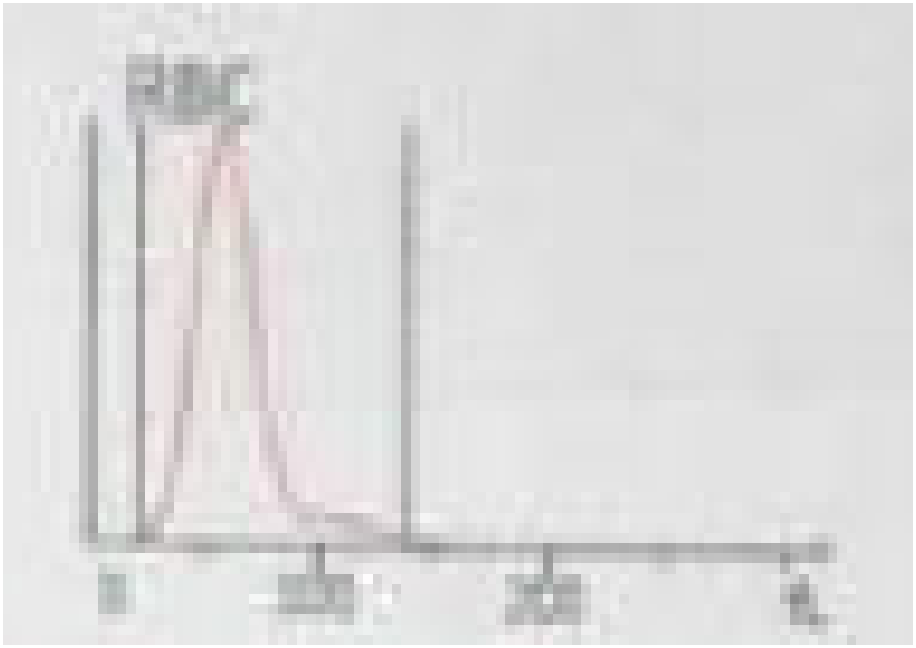
MP Flag Multiple Peaks

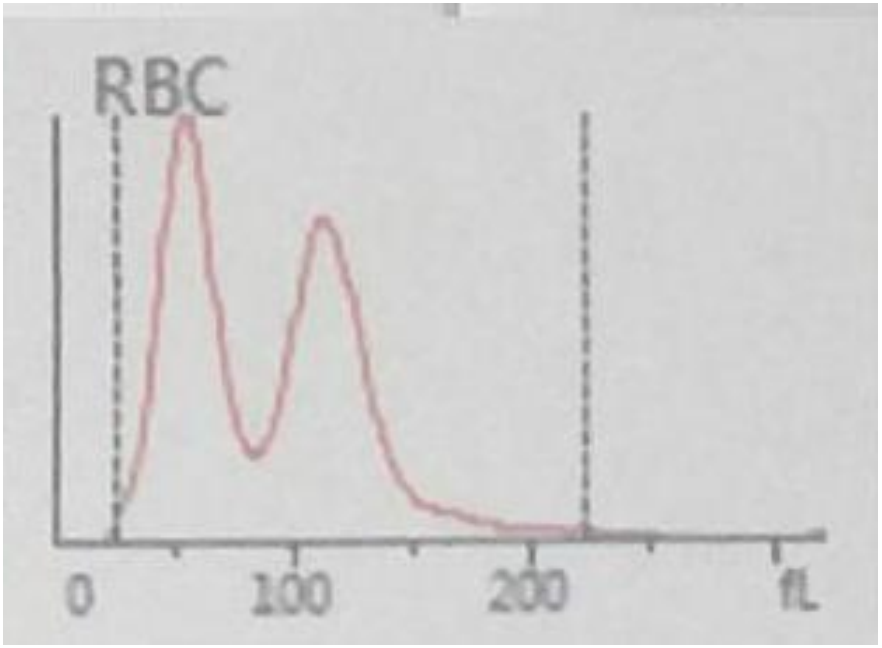


شکل ۶۲-۱۰: بیمار خانم ۳۶ ساله هست که ۳ سال پیش بعد از سزارین و خونریزی شدید با فریتین 2.0 و هموگلوبین 7.5g/dl مراجعه کرده ولی طی این مدت هرگز به آهن خوراکی پاسخ نمیداده تا اینکه مرداد ماه سال ۹۶ پزشک ۴ واحد آهن تزریقی به بیمار تجویز میکند که نتیجه آن فوق العاده موثر بوده و جمعیت جدیدی از اریتروسیت‌ها شکل گرفته و فریتین بیمار اکنون ۲۹۹ و TIBC 336 و آهن سرم ۸۳ می‌باشد. ولی یک سوال مهم هنوز باقی مانده که چرا با فقدان پلی کرومازیا و رتیکولوسیتوز (رتیک ۴/۱٪)، جمعیت جدید ماکروسیتوز بوده و پیک قدیمی روی 54fl و جمعیت جدید روی 112fl و کاملاً ماکروسیتیک می‌باشد که میانگین دو جمعیت 79fl و مقدار RDW حدود ۴۸٪ شده است. در حل این مسئله وضعیت ماکروسیتوز، اووالوسیتوز و نوتروفیل هیپرسگمانته چک شد که هرسه در مقادیر ۱+ مشهود بودند. لذا می‌توان نتیجه گرفت که همزمانی فقر فولات یا کوبالامین نیز شاید سوار بر فقر آهن شده و این رخداد باعث ماکروسیتوز جدید و کاهش رتیک (کریز مگالوبلاستیک) شده است. برای بیمار بررسی بیشتر، سطح فولات و کوبالامین (B9 و B12) درخواست گردید و در عین حال از عدم دریافت فراورده خونی طی مدت مذکور نیز اطمینان حاصل گردید. سوال دوم شمارش RBC بیمار هست که حتی در روزگار شدید آنمی که Hb زیر ۸ بود، کماکان RBC بالای ۵ میلیون بوده و هنوز هم هست و لذا یک تابلوی مینور هم مورد شک هست که متعاقب از بین رفتن پیک دوم و پایداری شرایط می‌بایست بررسی شود. سوال سوم پلاکت بالای ۹۰۰ هزار هست که البته در اریتروپوئز شدید و تحریک BM و طحال می‌تواند به صورت موقتی رخ بدهد.

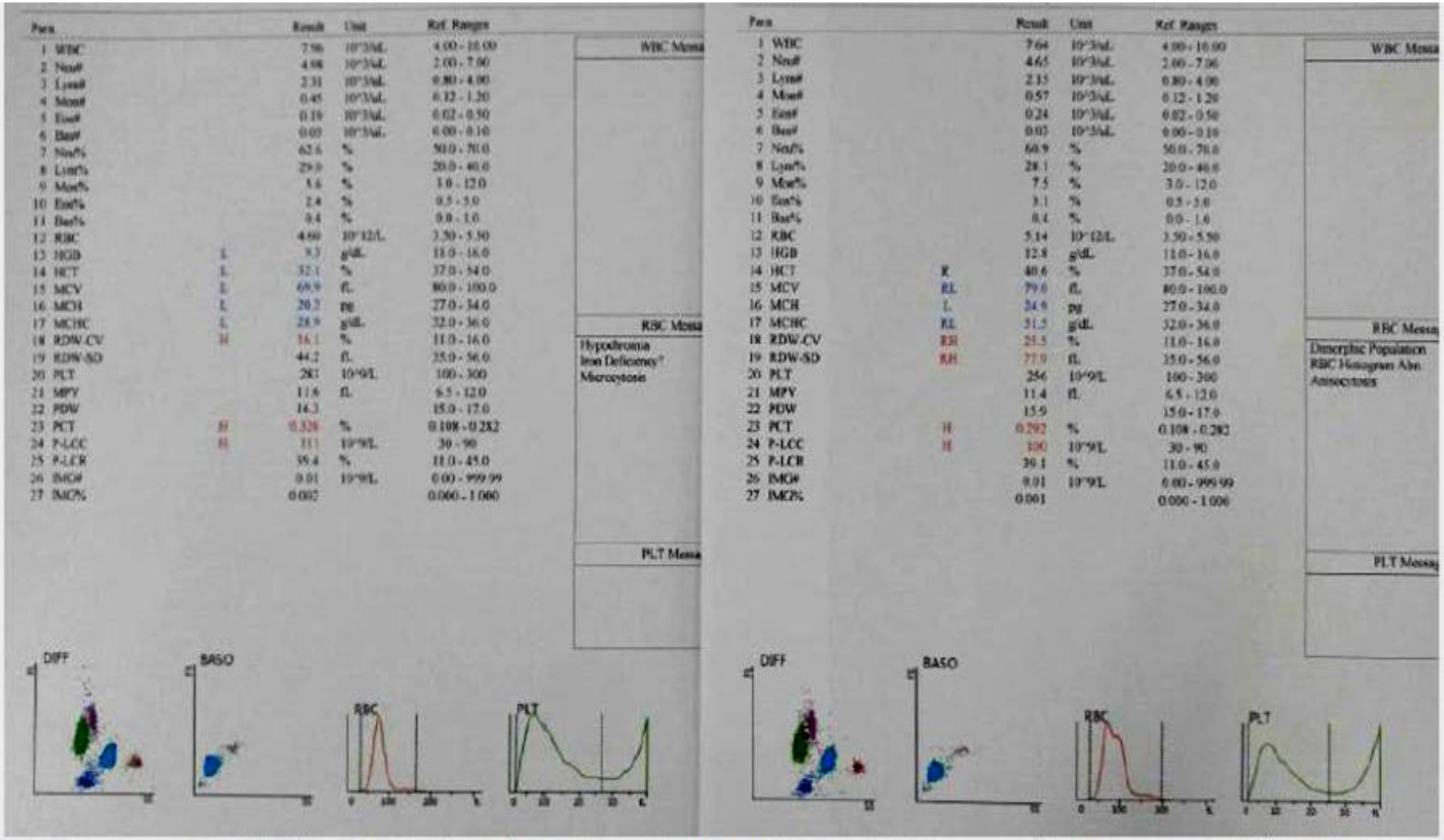
Treatment of severe IDA & Megaloblastic crisis

MP Flag Multiple Peaks





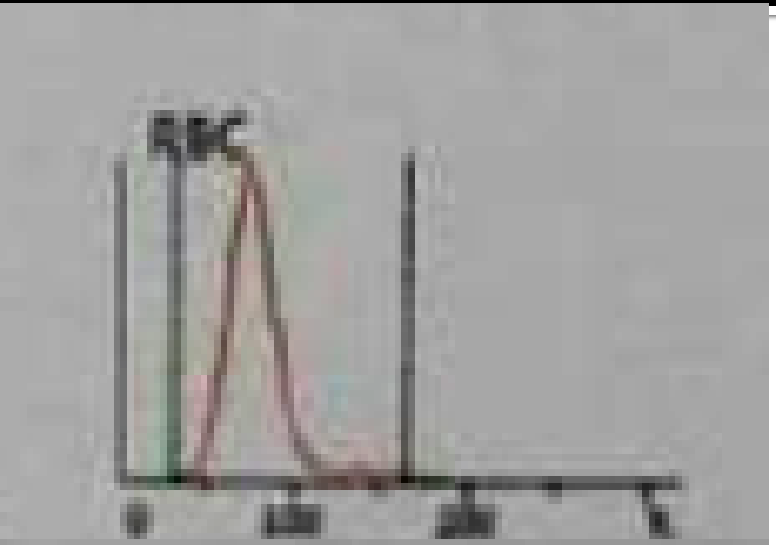
RBC Histogram after treatment of severe IDA

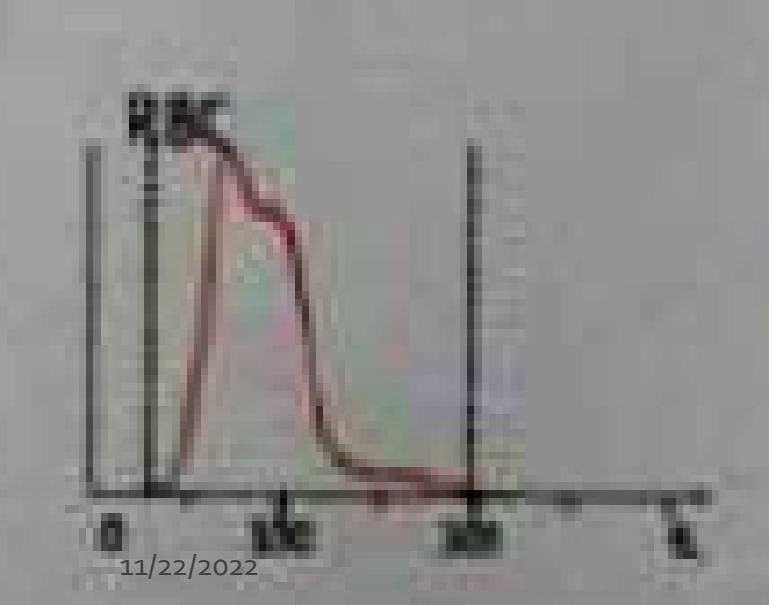


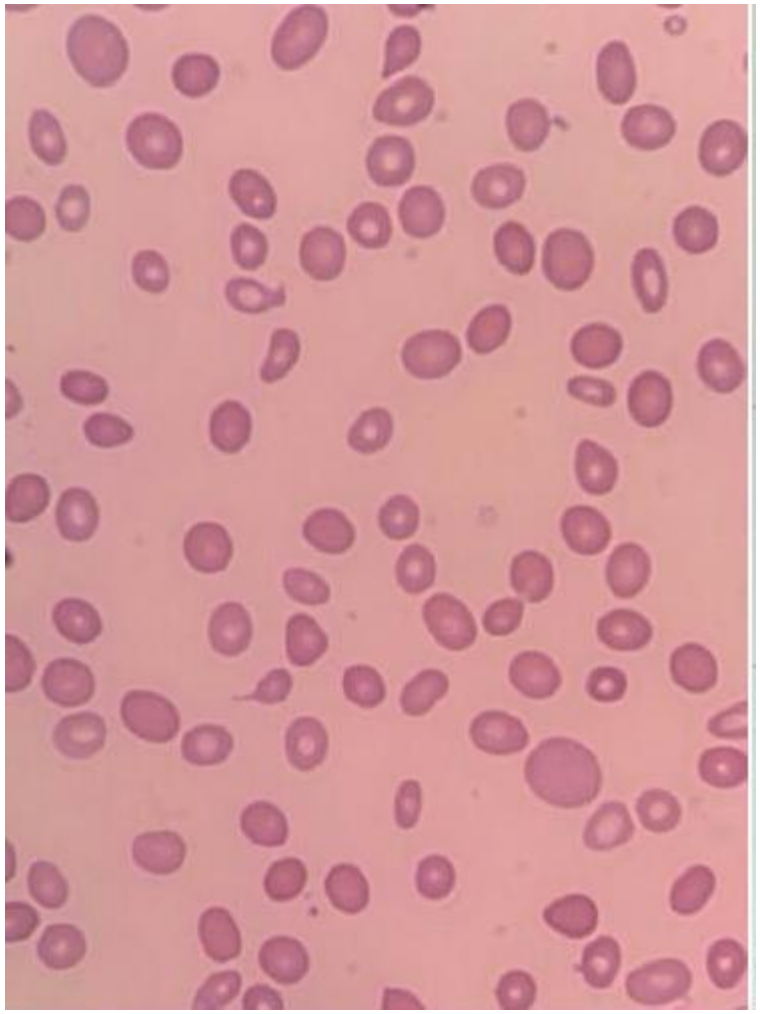
شکل ۶۳-۱۰: بیمار احتمالاً تالاسمیک مینور توام با فقر آهن شدید هست که طی درمان یک ماهه با آهن، فریتین از ۳ به ۱۶ افزایش یافته ولی کماکان TIBC بالای ۴۲۰ هست و هیستوگرام دوقله ای شده است. مقدار RBC، MCV، MCH، MCHC و RDW همگی افزایش محسوس داشته و هیستوگرام RBC دو قله‌ای شده است.

RBC Histogram after treatment of severe IDA

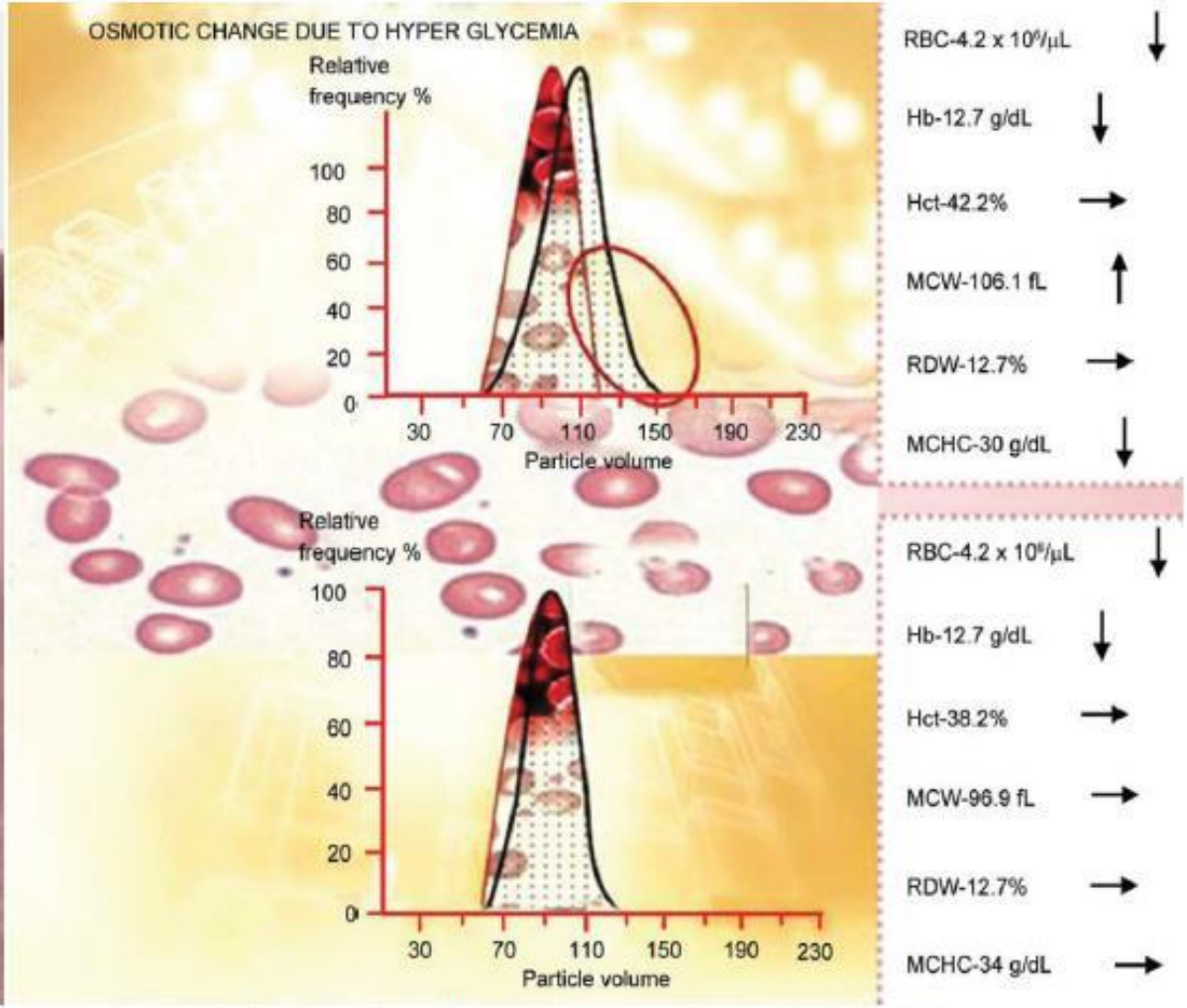
Dimorphic Picture







Hyperglycemia & Acute swelling phenomenon



شکل ۱۳۹-۱۰: سندرم تورم حاد ناشی از هیپرگلایسمی که بعد از انکوباسیون در ایزوتون به سایز اصلی خود بازگشته است.

High Serum Glucose

Acute swelling phenomenon

Items

Item	Data		Unit
WBC	7.29	*	10^3/uL
RBC	2.57		10^6/uL
HGB	7.5		g/dL
HCT	31.1		%
MCV	121.0	+	fL
MCH	29.2		pg
MCHC	24.1	-	g/dL
PLT	96	*	10^3/uL
RDW-SD	100.2		fL
RDW-CV	22.7		%
MPV	14.0	*	fL
RET%	0.77		%
RET#	1.98		10^4/uL
IRF	0.130		Ratio
NRBC#	0.00	*	10^3/uL
NRBC%	0.0	*	/100WBC

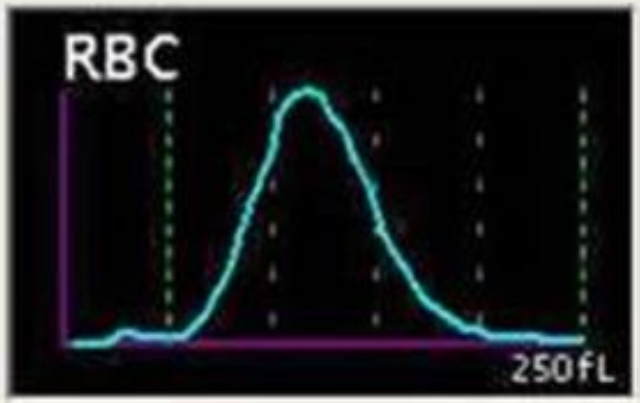
WBC Differential

Item	Data		Unit
NEUT#	5.04	*	10^3/uL
LYMPH#	1.23	*	10^3/uL
MONO#	0.96	*	10^3/uL
EO#	0.05	*	10^3/uL
BASO#	0.01	*	10^3/uL
NEUT%	69.1	*	%
LYMPH%	16.9	*	%
MONO%	13.2	*	%
EO%	0.7	*	%
BASO%	0.1	*	%

Extended Differential

WBC

Item	Data		Unit
IG#	0.06	*	10^3/uL
IG%	0.8	*	%



VERY HIGH…… 1494 mg/dL

High Serum Sodium(Na=176)

Acute swelling phenomenon

Items

Item	Data		Unit
WBC	2.41		10^3/uL
RBC	2.89		10^6/uL
HGB	9.4		g/dL
HCT	34.2		%
MCV	118.3		fL
MCH	32.5		pg
MCHC	27.5	-	g/dL
PLT	124		10^3/uL
RDW-SD	70.9		fL
RDW-CV	16.5		%
MPV	11.8		fL
RET%			%
RET#			10^4/uL
IRF			Ratio
NRBC#			10^3/uL
NRBC%			/100WBC

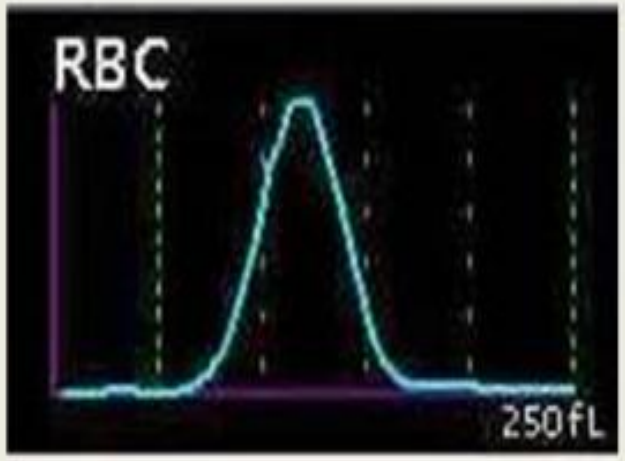
WBC Differential

Item	Data		Unit
NEUT#	1.44		10^3/uL
LYMPH#	0.58		10^3/uL
MONO#	0.30		10^3/uL
EO#	0.08		10^3/uL
BASO#	0.01		10^3/uL
NEUT%	59.8		%
LYMPH%	24.1		%
MONO%	12.4		%
EO%	3.3		%
BASO%	0.4		%

Extended Differential

WBC

Item	Data		Unit
IG#	0.00		10^3/uL
IG%	0.0		%



Dehydration can cause a high MCHC

Main | Graph | WBC | RBC | Cumulative | Q-Flags | Service | HPC

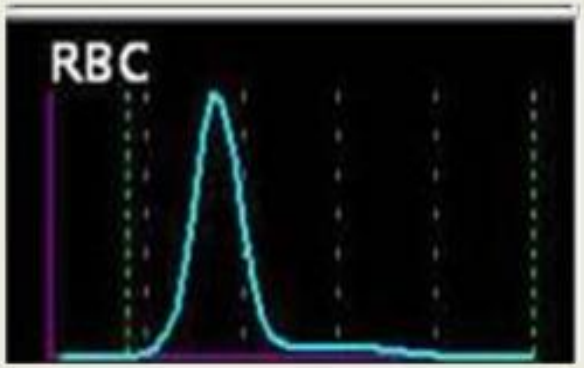
Items

Item	Data		Unit
WBC	11.87		10^3/uL
RBC	5.52	+	10^6/uL
HGB	17.2	+	g/dL
HCT	47.4		%
MCV	85.9		fL
MCH	31.2		pg
MCHC	36.3		g/dL
PLT	176		10^3/uL
RDW-SD	41.6		fL
RDW-CV	13.4		%
MPV	10.1		fL
RET%			%
RET#			10^4/uL
IRF			Ratio

Item	Data		Unit
NEUT#	6.28		10^3/uL
LYMPH#	4.16	+	10^3/uL
MONO#	1.19	+	10^3/uL
EO#	0.21		10^3/uL
BASO#	0.03		10^3/uL

Item	Data		Unit
NEUT%	52.9		%
LYMPH%	35.0		%
MONO%	10.0		%
EO%	1.8		%
BASO%	0.3		%

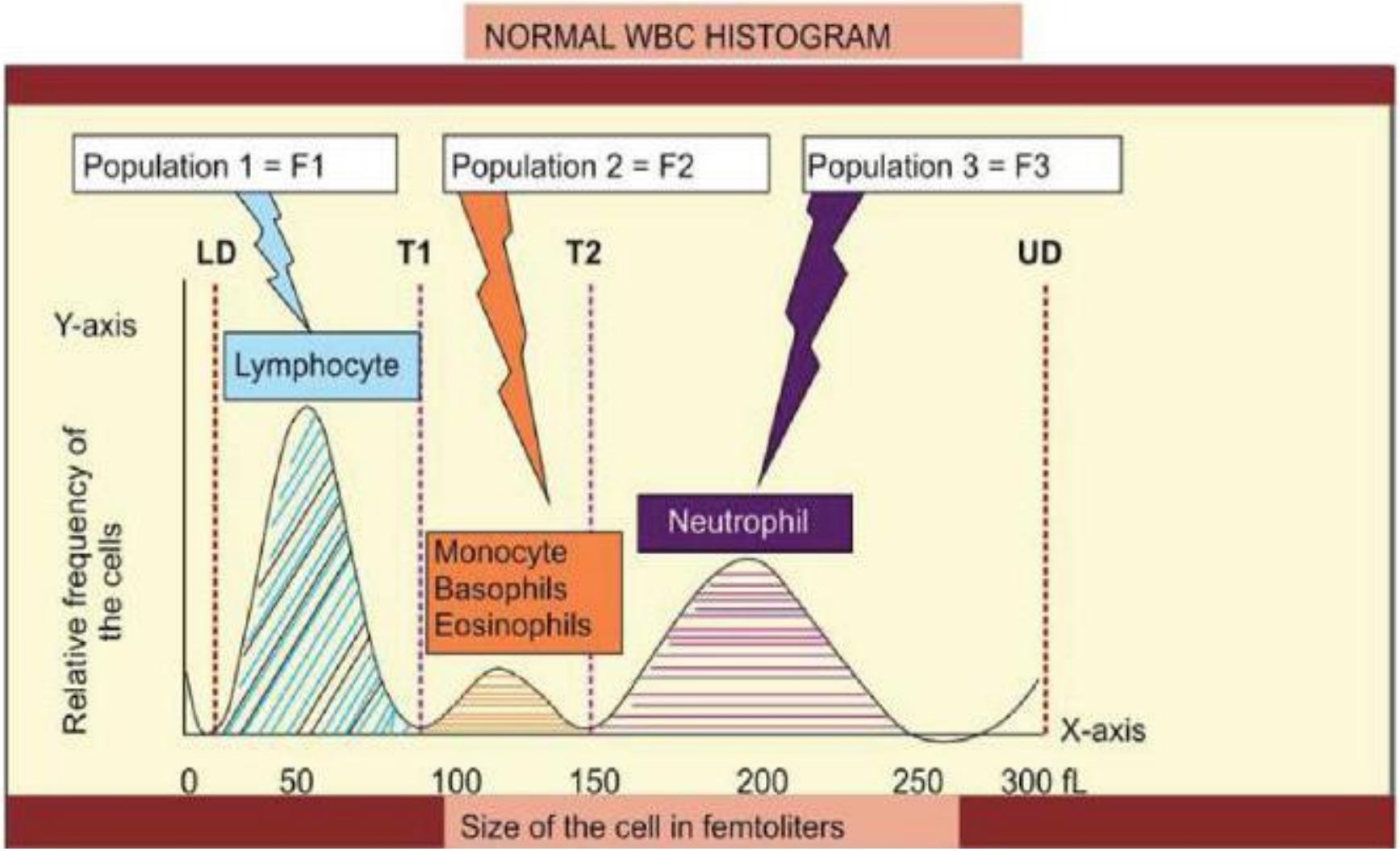
Flag(s)



IF THE PATIENT IS DEHYDRATED SO ARE THE RED CELLS

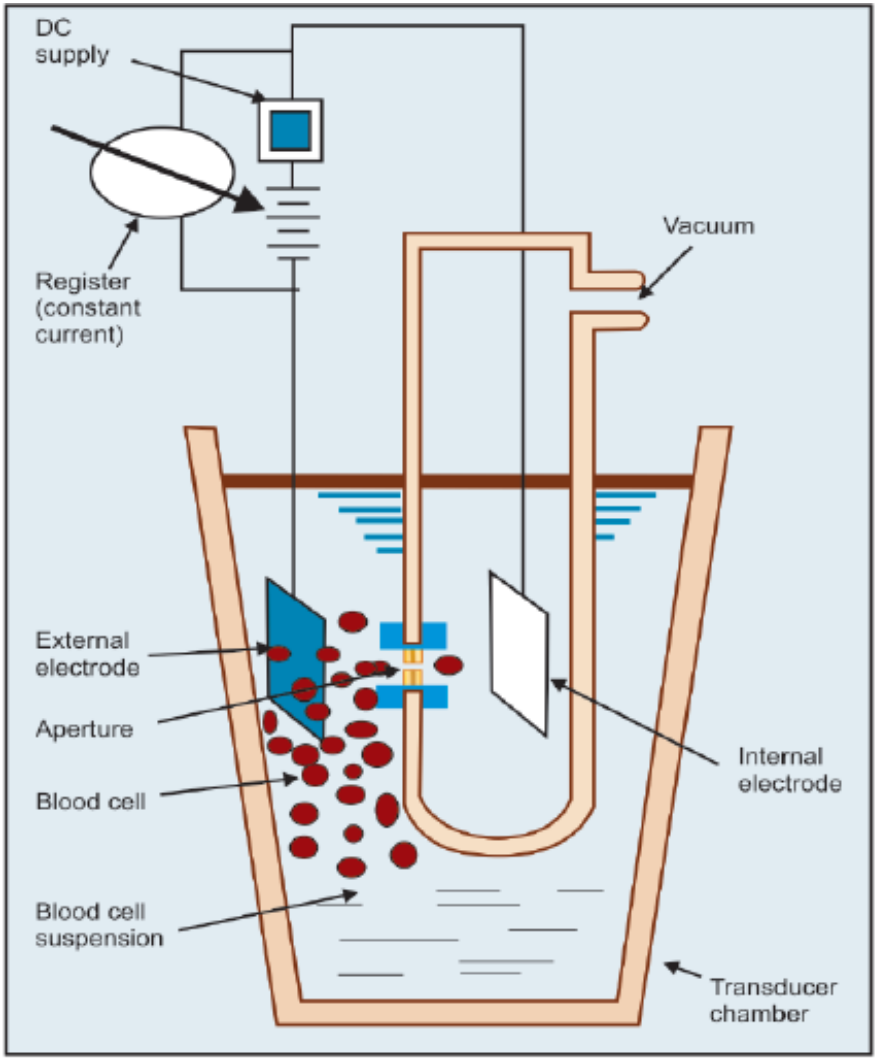
WBCs Histogram

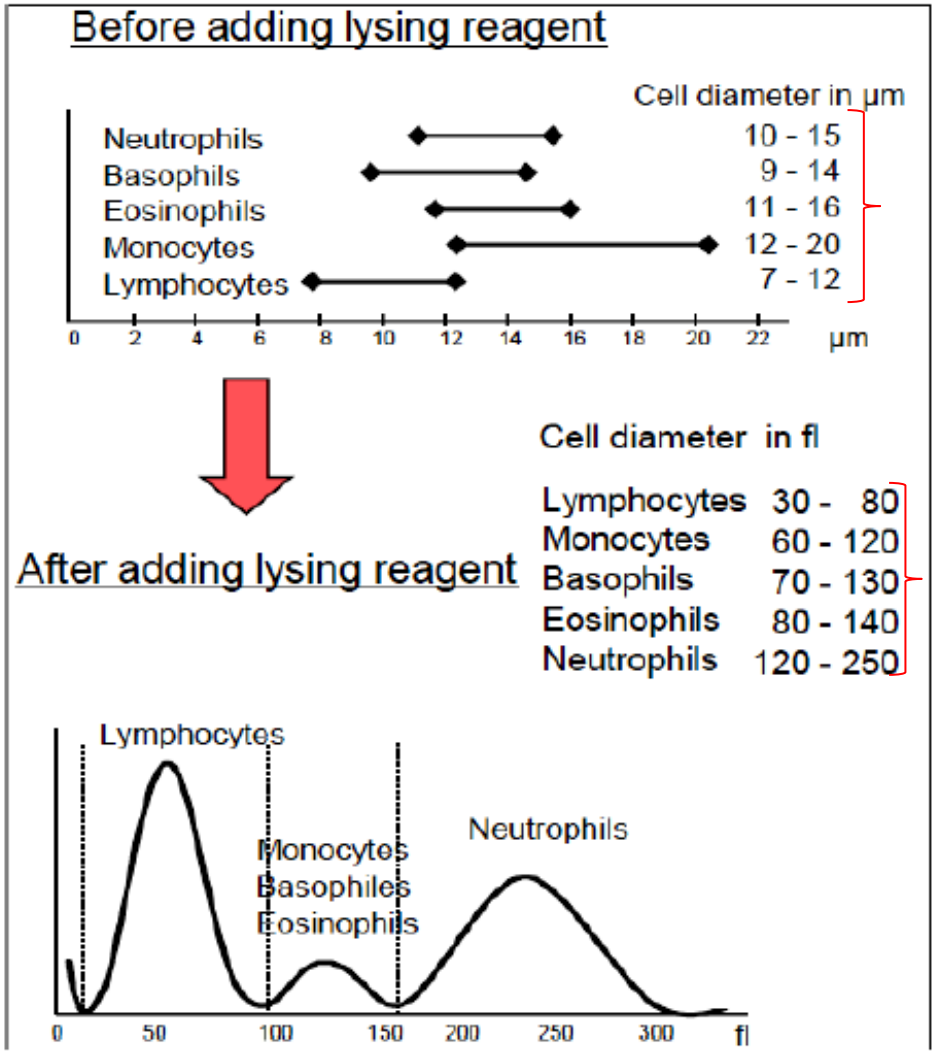
3-Part Differentiation



- WBC detection is between 30 and 300 fL.

WBC Histograms





شکل ۱۲-۱۰: اختلاف سایز لکوسیت‌ها قبل و بعد از لیز نسبی در سل کانتر

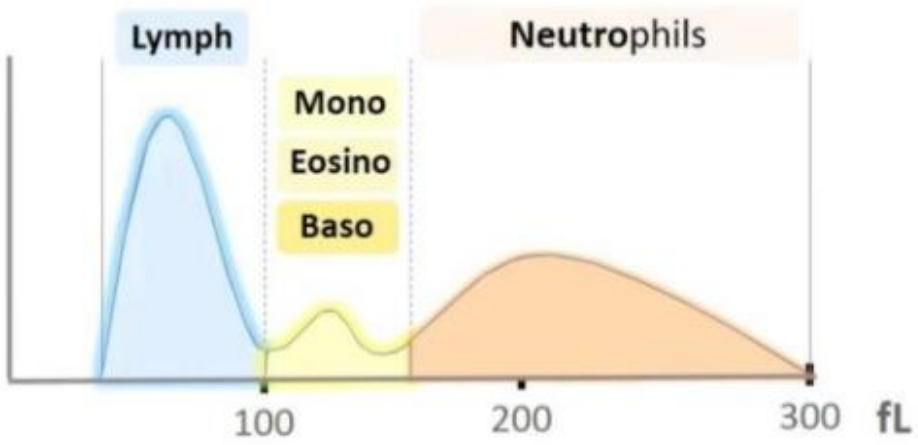
WBCs Histogram
3-Part Differentiation

LYSE Reagent effect on WBCs

After adding Lyse Reagent

WBCs Histogram
3-Part Differentiation

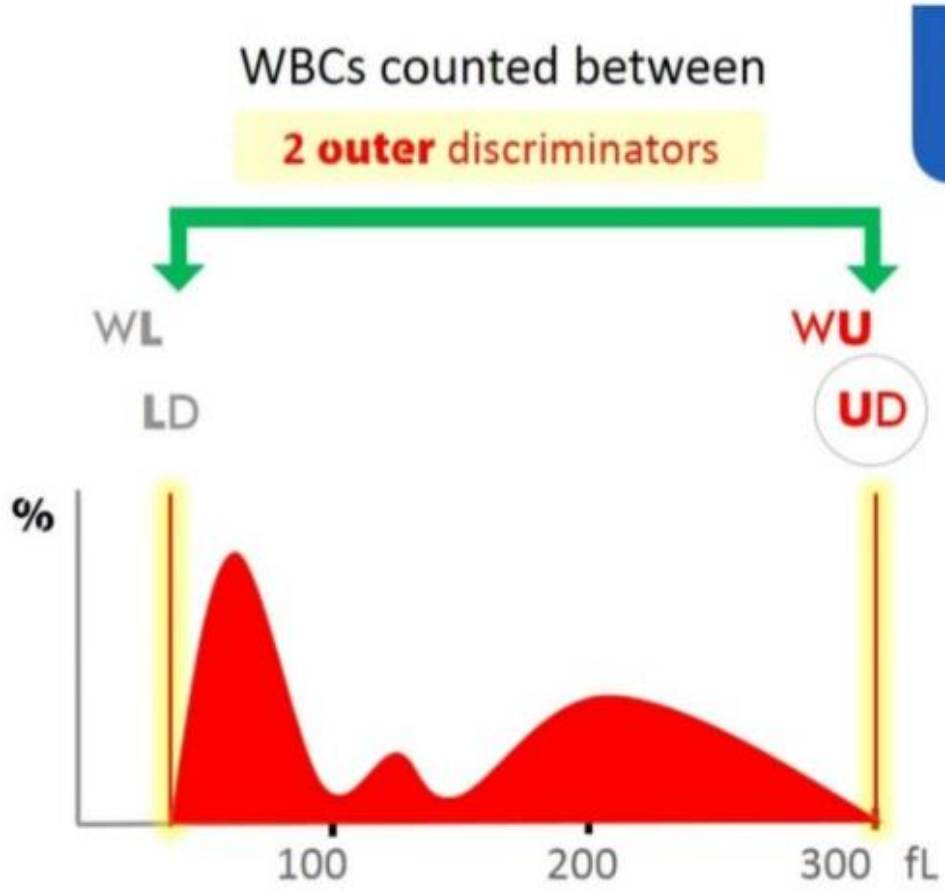
- Cells will be shown in a histogram according to their size.



Lymphocytes	30 – 80	fL
Monocytes	60 – 120	fL
Basophils	70 – 130	fL
Eosinophils	80 – 140	fL
Neutrophils	120 – 250	fL

- WBC detection is between 30 and 300 fL.

WBCs Histogram
3-Part Differentiation



WBCs Histogram
3-Part Differentiation

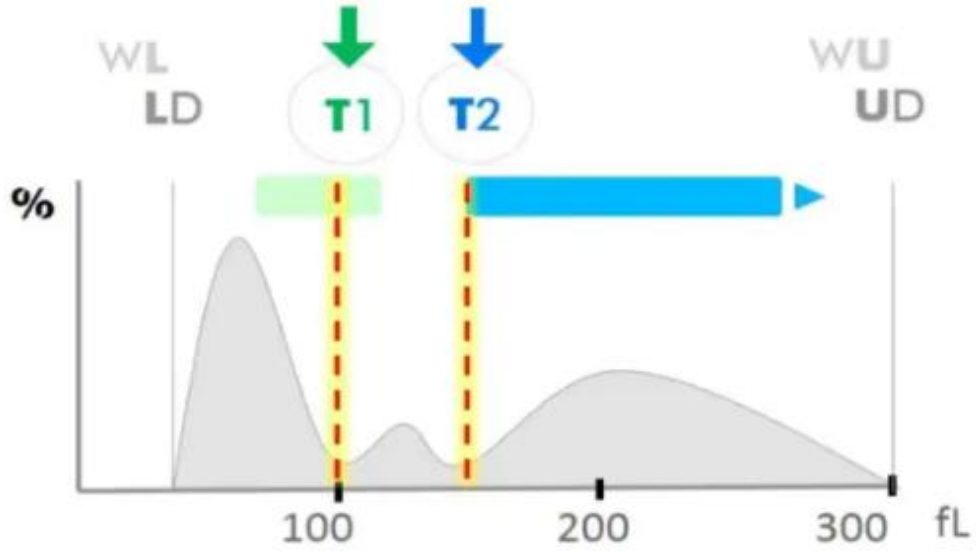
WL **W**BCs **L**ower discriminator
= **LD** **L**ower **D**iscriminator
[**Flexible**] fluctuates between 30 – 60 fL

WU **W**BCs **U**pper discriminator
= **UD** **U**pper **D**iscriminator
[**Fixed**] at **300** fL

WBCs Histogram
3-Part Differentiation

WBCs histogram consists of **2 Troughs**
[Valleys]

[Detected by **2 inner** discriminators]



WBCs Histogram
3-Part Differentiation

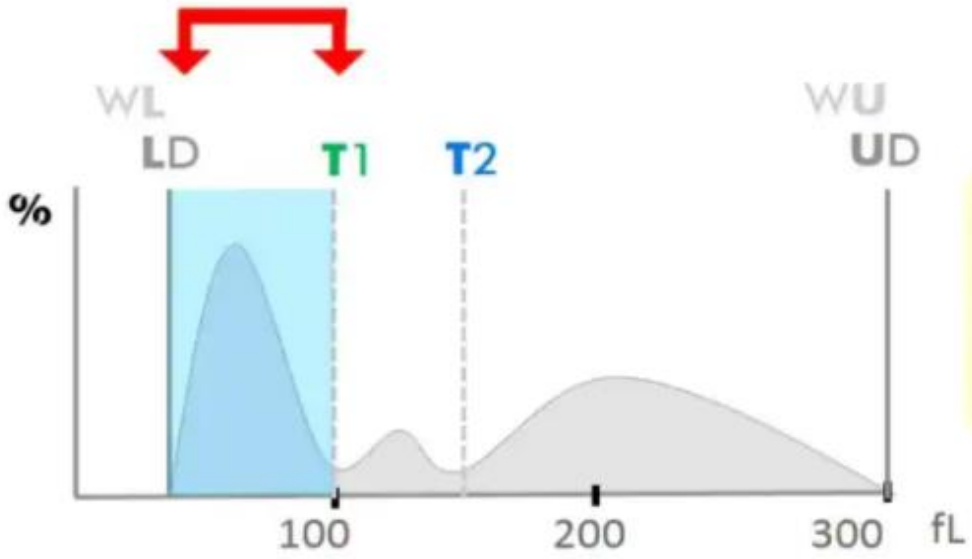
T1 : **78 – 114** fL

T2 : **> 150** fL

WBCs Histogram
3-Part Differentiation

WBCs histogram consists of **2 Troughs**
[Valleys]

[Detected by **2 inner** discriminators]



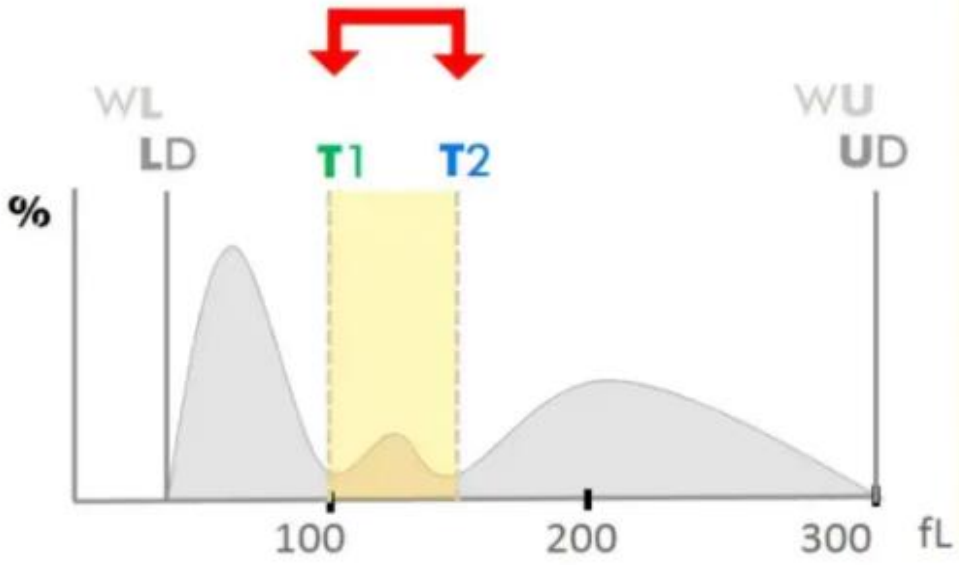
WBCs Histogram
3-Part Differentiation

Peak between **LD** and **T1** represents small cells
i.e. **Lymphocytes**

WBCs Histogram
3-Part Differentiation

WBCs histogram consists of **2 Troughs**
[Valleys]

[Detected by **2 inner** discriminators]



WBCs Histogram
3-Part Differentiation

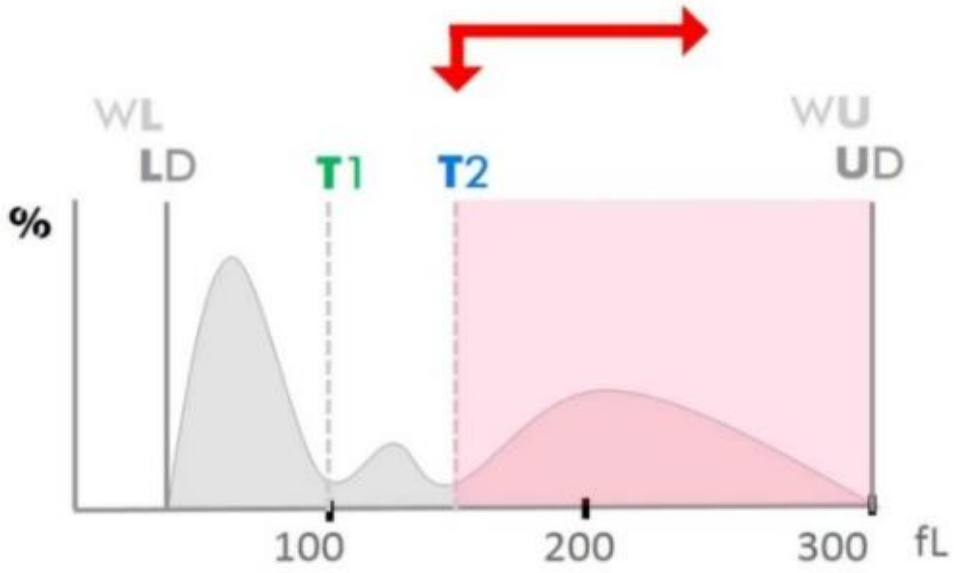
Peak between **T1** and **T2** includes:

- **Eosino**phils
- **Mono**cytes
- **Baso**phils
- **Blast** cells
- **Promyelo**cytes
- **Myelo**cytes
- **Metamyelo**cytes

WBCs Histogram
3-Part Differentiation

WBCs histogram consists of **2 Troughs**
[Valleys]

[Detected by **2 inner** discriminators]

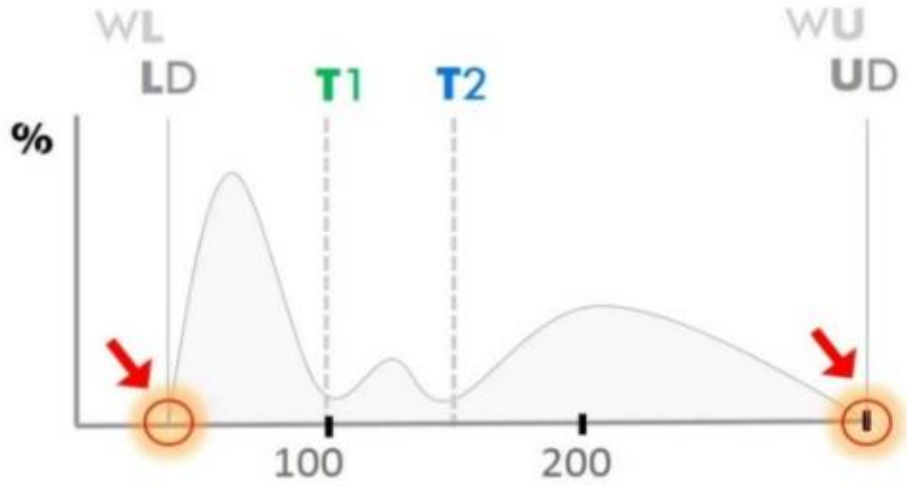


WBCs Histogram
3-Part Differentiation

Peak after **T2** represents :
Neutrophils **Band cell**

WBCs Histogram
3-Part Differentiation

Important Notes



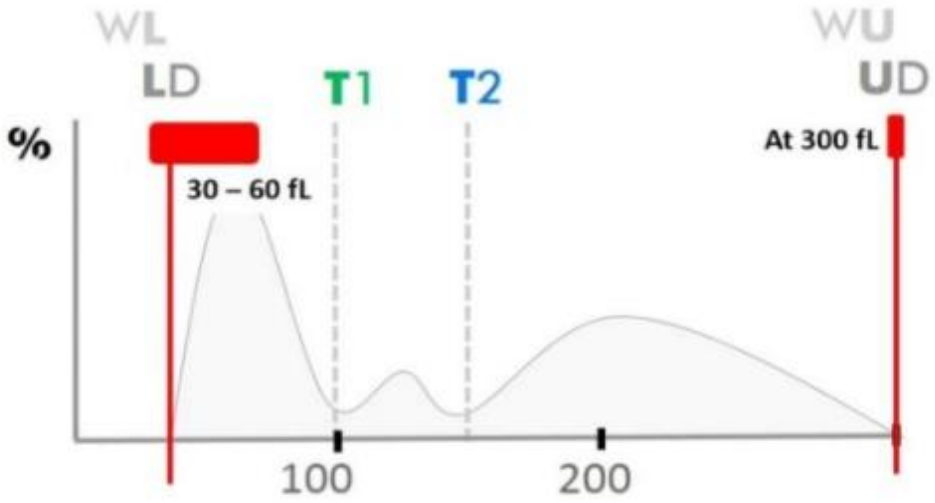
WBCs Histogram
3-Part Differentiation

The distribution curve should be within the discriminators, starts and ends at the base line.

Less than 20%

WBCs Histogram
3-Part Differentiation

Important Notes



WBCs Histogram
3-Part Differentiation

The distribution curve should be within the discriminators, **starts** and **ends** at the **base line**.

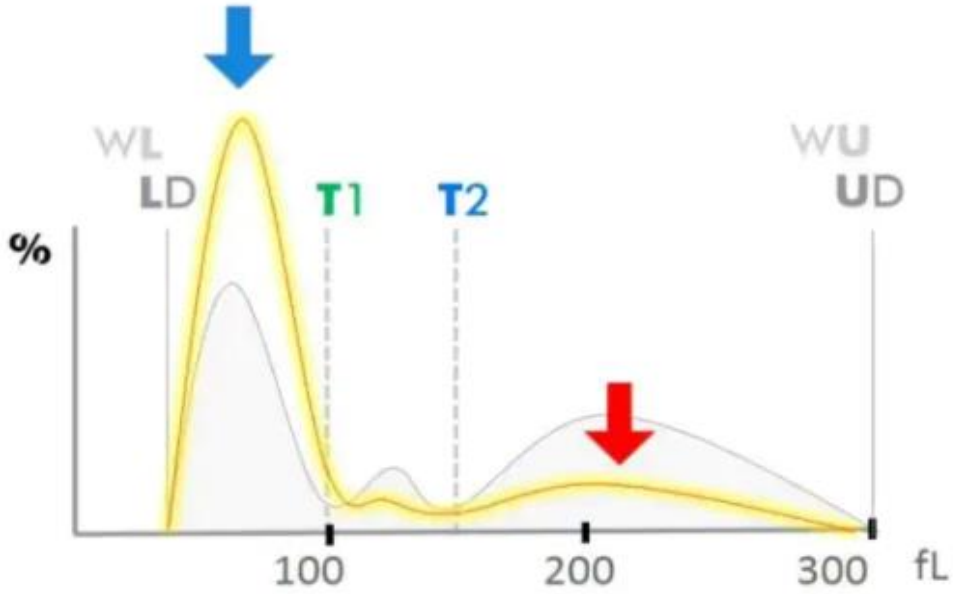
The **LD** is **flexible** while **UD** is **fixed**.

The WBC-channel shows **only WBCs** and **platelets** (**RBCs are lysed**)

The volume of the platelet is usually between 8 - 12 fl, therefore the LD at the WBC Histogram **seperates** the WBCs from the platelets.
(**Platelets were not counted**).

WBCs Histogram
3-Part Differentiation

Prominent peak with broad distribution between **WL/LD** and **T1**



WBCs Histogram
3-Part Differentiation

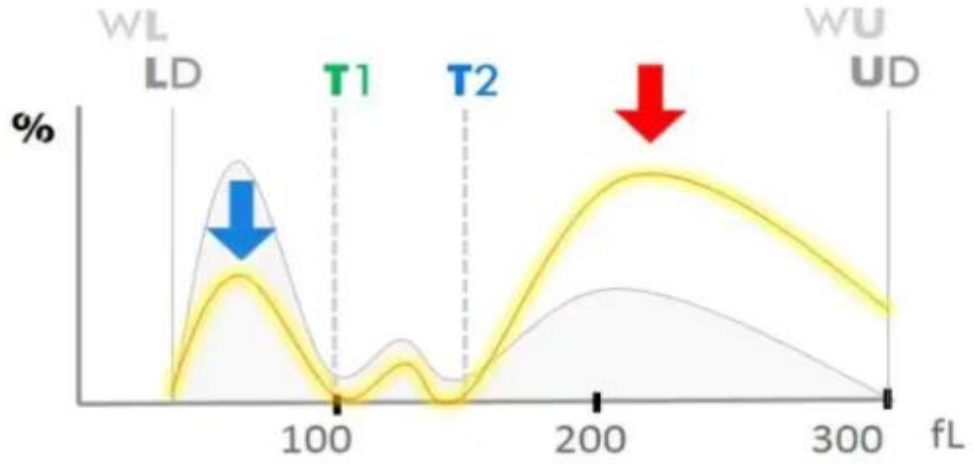
In cases of :

- **Lymphocytosis**
- **Neutropenia**

WBCs Histogram
3-Part Differentiation

Prominent peak with broad distribution between **T2** and **WU/UD**

WBCs Histogram
3-Part Differentiation

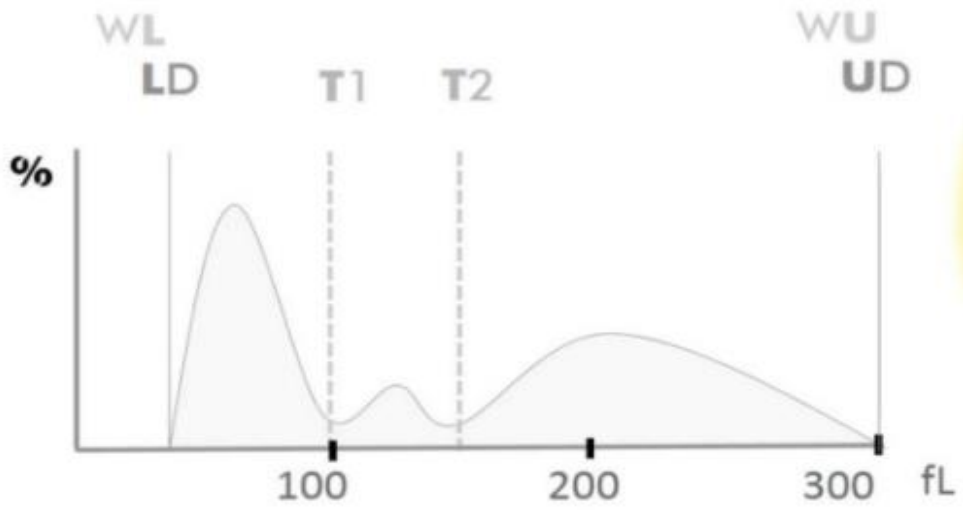


In cases of :

- **Neutrophilia**
- **Lymphopenia**

WBCs Histogram
3-Part Differentiation

WBCs Histogram
3-Part Differentiation



WBCs Histogram
3-Part Differentiation

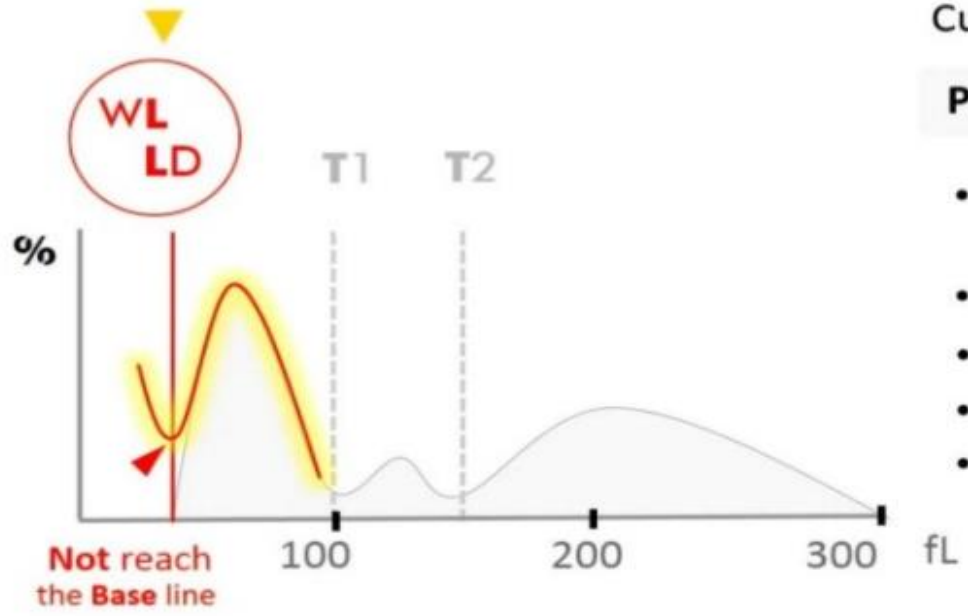
List of WBC error flags in order of priority	
WL	Relative frequency for LOWER discriminator (LD) exceeds the range. May be caused by the inclusion of platelet clumps, large platelets, fibrin, etc.
T1	Lower TROUGH Discriminator, that distinguishes lymphocytes and mixed cells, cannot be determined.
T2	Higher TROUGH Discriminator, that distinguishes mixed cells and neutrophils, cannot be determined.
F1	Small cell histogram error. Relative frequency for T1 exceeds the range.
F2	Middle cell histogram error. Relative frequency for T1 or T2 exceeds the range.
F3	Large cell histogram error. Relative frequency for T2 exceeds the range.
WU	Relative frequency for UPPER discriminator (UD) exceeds the range. May be caused by lyse-resistant red blood cells, or when numerous abnormal blood cells are present.

AG: The particle count equal to or less than the LD exceeds a prescribed range. Probable cause is platelet agglutination, which does not alter WBC count but may result in decreased platelet count. Therefore, this flag is added to the PLT parameter.

WBCs Histogram
3-Part Differentiation

- Action
  - All results marked with 'WL' should be controlled.
  - WBC count might be incorrect.

1 LD Flag (WL Flag)



WBCs Histogram
3-Part Differentiation

Curve **does not start** at base line

Possible Causes :

- PLT **Clumps** — Clotted sample / EDTA-Incompatibility [Re-collect on citrate]
- **Giant** Platelets
- **Nucleated** RBCs
- **Lyse-resistant** RBCs
- Cryoglobulins → artifacts → pseudoleukocytosis & pseudothrombocytosis

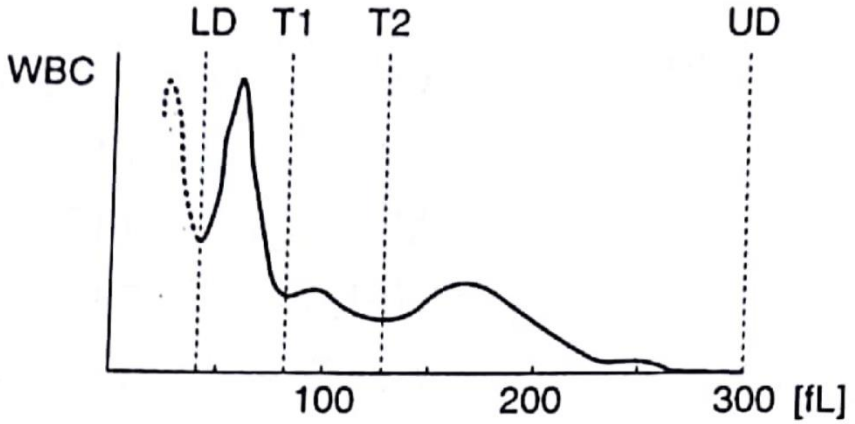
فلگ WL زمانی درج می شود که هیستوگرام ممیز LD را در ارتفاع بالاتر از ۴۰٪ قطع کند و این خطا در کنار هر سه پارت دیف درج می شود.

علل لیز نشدن RBC : بالا بودن HbF ، در neonates، بیماریهای کبدی و اورمی و nRBC

WBCs Histogram

3-Part Differentiation

- WBC Histogram Error-WL (1A)



WBC	WL 8.5 [$\times 10^3/\mu L$]
LYM%	WL 39.3 [%]
MXD%	WL 17.6 [%]
NEUT%	WL 43.1 [%]
LYM#	WL 3.4 [$\times 10^3/\mu L$]
MXD#	WL 1.5 [$\times 10^3/\mu L$]
NEUT#	WL 3.6 [$\times 10^3/\mu L$]

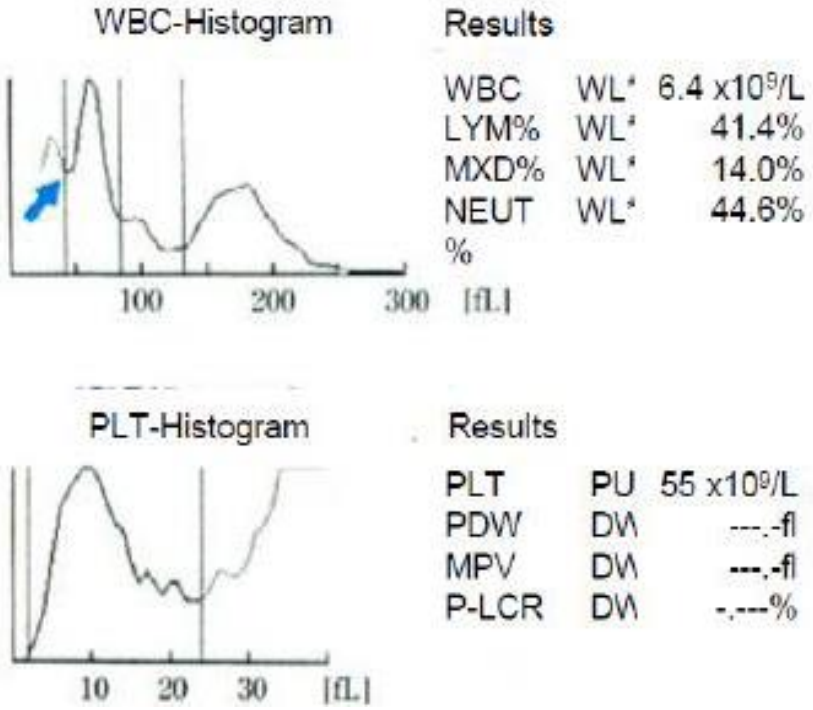
Possible causes :

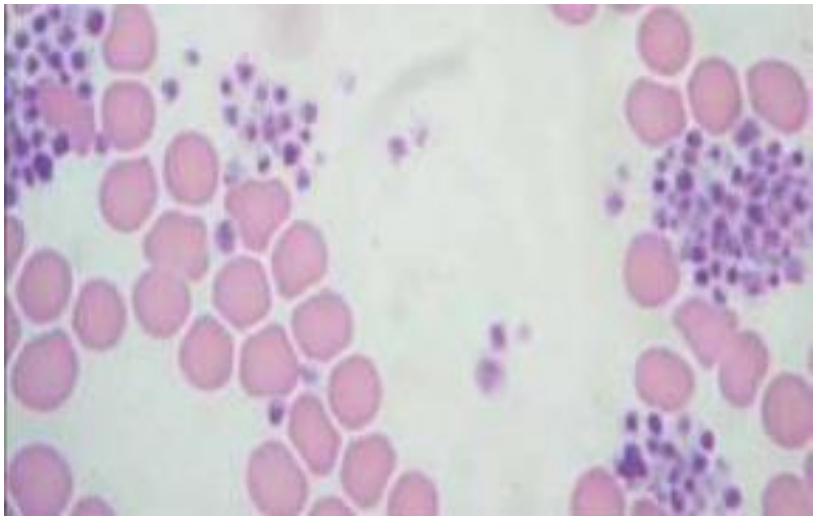
- Nucleated RBC
- Unlysed RBC
- Platelet clumps as in EDTA incompatibility and coagulated sample
- Cold agglutinins
- Impedance noise

WBCs Histogram
3-Part Differentiation

1 LD Flag (WL Flag)

WBCs Histogram
3-Part Differentiation



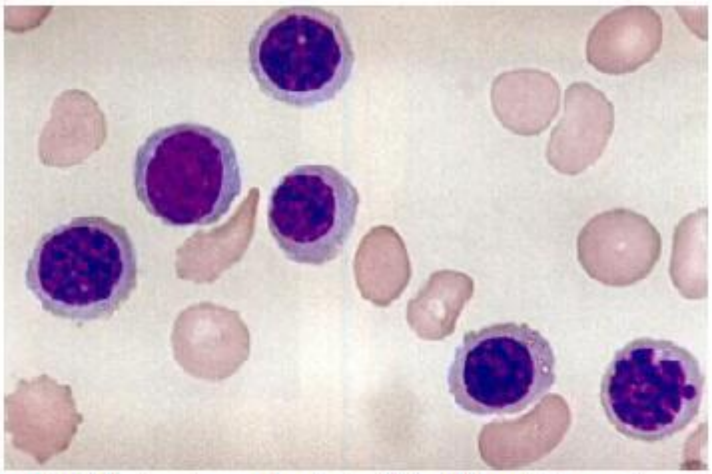


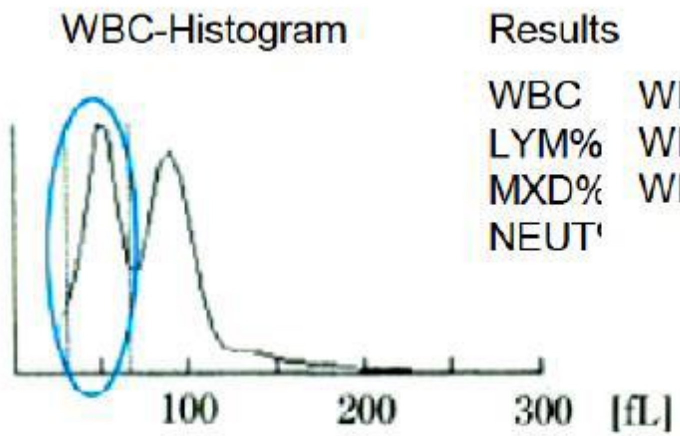
WBCs Histogram

3-Part Differentiation

1 LD Flag (WL Flag)

WL & Erythroblastosis





Results

WBC	WL*	56.1 x 10^9/L
LYM%	WL*	42.7%
MXD%	WL	-.---
NEUT'		-.---

شکل ۲۹-۱۰: اریتروبلاستوز شدید (1352/100WBC)که با تلاقی نورموبلاست‌ها و لنفوسیت‌ها. فراکسیون لکوسیت‌ها بهم خورده و خطای WL و T2 ایجاد شده است. در این شرایط امکان دیف ناحیه MXD و NEUT مقدور نبوده و نقطه چین میخورد. مرز بین RBCهای شبه لیز شده و لنفوسیت اختلال داشته و درصد لنفوسیت نیز افزایش محسوس و کاذب دارد.

WL & T2 flags

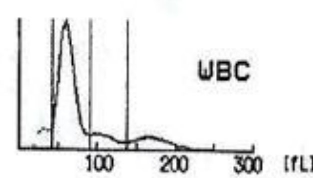
WBCs Histogram
3-Part Differentiation

1 LD Flag (WL Flag)

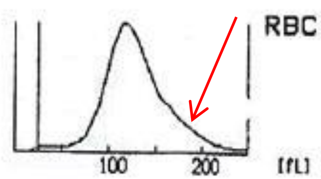
WL & Erythroblastosis

No. 25
Date 83/03/01 15:30
Mode WB

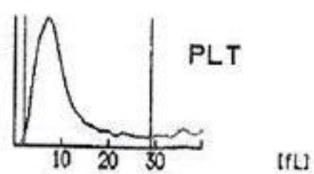
WBC	+	28.5×10³/μL
RBC	-	3.70×10⁶/μL
HGB		14.3g/dL
HCT		45.1%
MCV	+	121.9fL
MCH	+	38.6pg
MCHC		31.7g/dL
PLT	AG	186×10³/μL



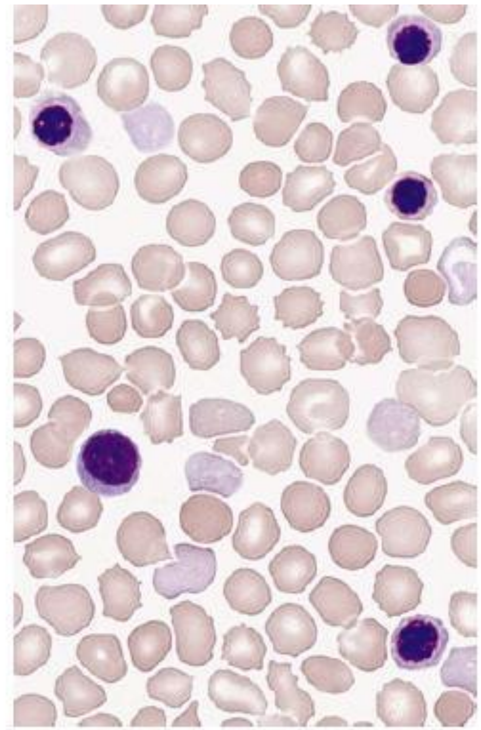
LYM%	+	70.6%
MXD%		12.8%
NEUT%	-	16.6%
LYM#		20.1×10³/μL
MXD#		3.6×10³/μL
NEUT#		4.8×10³/μL



RDW + 19.2%



PDW	12.0fL
MPV	10.2fL
P-LCR	26.1%

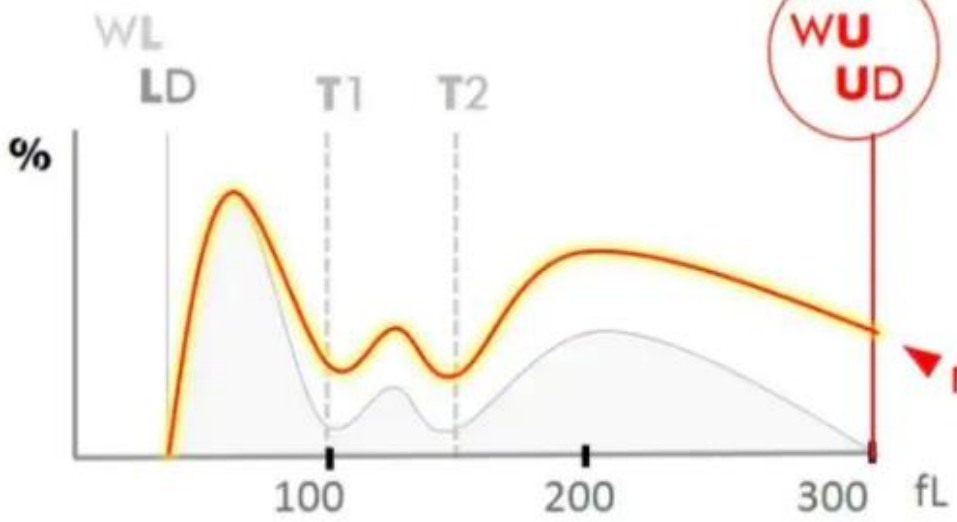


شکل ۱۲۴-۱۰: گزارش CBC دستگاه Sysmex-K21 در اریتروبلاستوز جنینی در نوزاد نارس (۲۸ هفته و ۱۱۰۰ گرم وزن) که باعث افزایش WBC، MCV، MCH و لنفوسیت و کاهش تعداد RBC می‌شود. نسبت N-RBC نوزاد به WBC حدود ۱۲۵:۱۰۰ و درصد دستی لنفوسیت ۴۷٪ است که با اصلاح آن از طریق فرمول True WBC=(WBC×100)/(100+NRBC)، شمارش واقعی لکوسیت به ۱۲۶۰۰ می‌رسد.

وجود nRBC باعث می شود WBC و لنفوسیت و MCV بصورت کاذب افزایش پیدا کند

WBCs Histogram
3-Part Differentiation

2 UD Flag (WU Flag)



WBCs Histogram
3-Part Differentiation

Curve **does not end** at base line

Possible Causes :

- **Sever** neutrophilia
  (Linearity exceeds the limit)

Pre-dilution [e.g. **1:5**] of the sample might help to obtain **correct** results.

Not reach the **Base** line

- **WBC aggregation**
- **Satellite phenomenon**
- **Hypersegmentation**

WBCs Histogram

3-Part Differentiation

2 UD Flag (WU Flag)

PLT satellitism vs Neutrophil aggregation

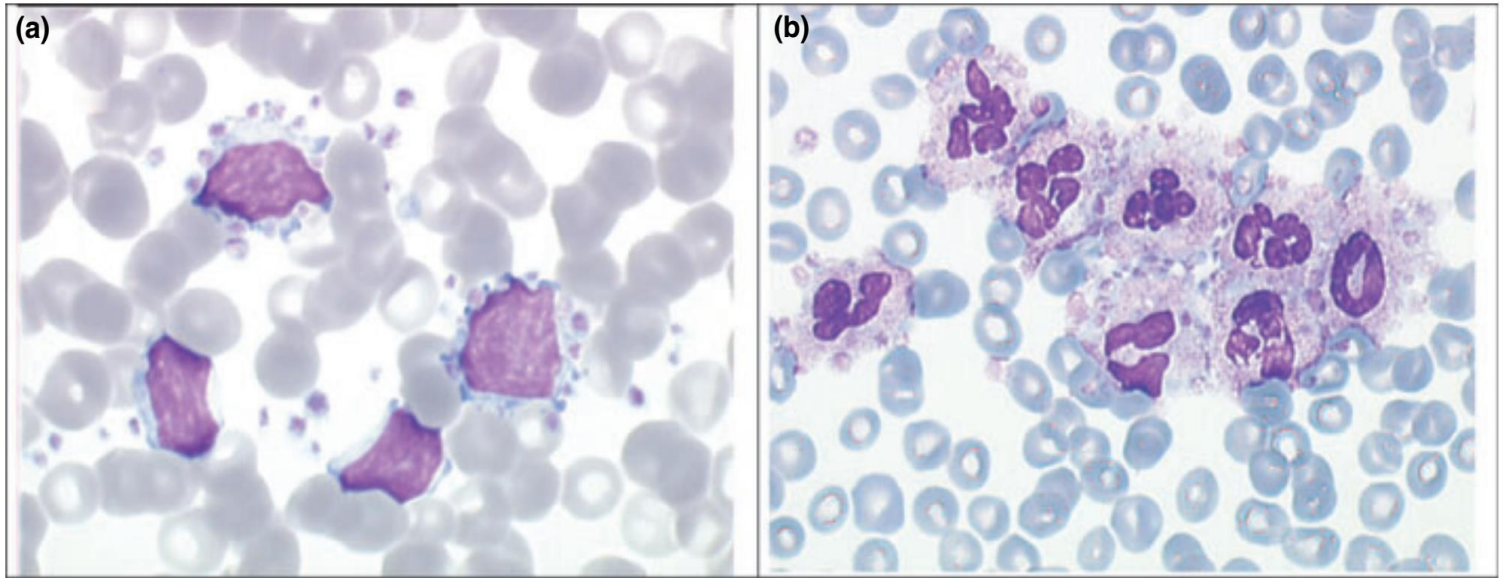


Figure 3. (a) Platelets surrounding lymphocytes in a patient known for chronic lymphocytic leukaemia. (b) Neutrophil–Platelet aggregates; that latter situation is related to PLT satellitism around polymorphs: PLT are 'bridges' between PLT-neutrophil rosettes, generating peculiar clumps, differing from neutrophil aggregates, as no PLT is observed within the latter (peripheral blood smears; MGG staining).

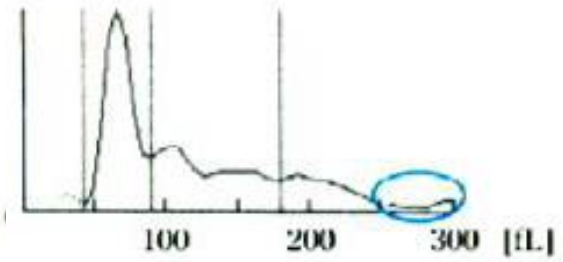
WBCs Histogram

3-Part Differentiation

2 UD Flag (WU Flag)

Neutrophil aggregation

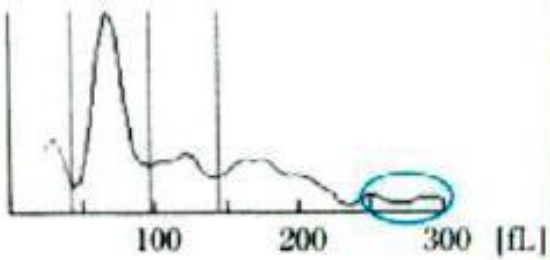
WBC-Histogram



Results

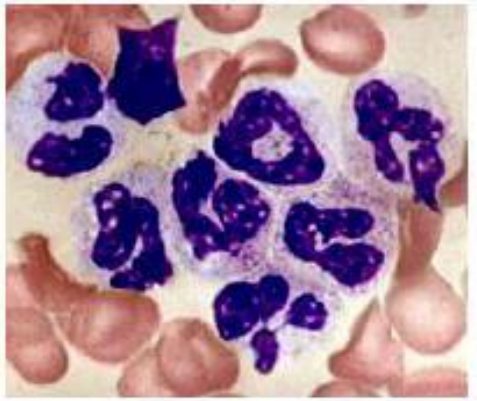
WBC – 2.3 x 10^9/L
LYM% 39.7%
MXD% + 32.2%
NEUT%- 28.1%

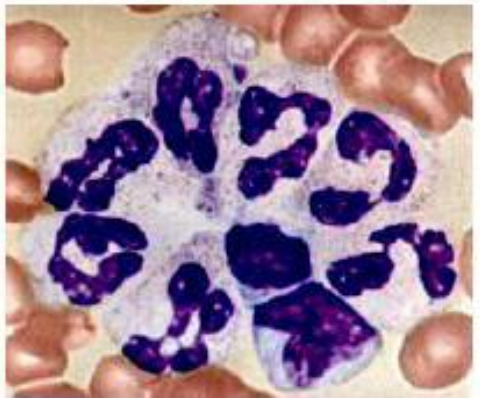
WBC-Histogram



Results

WBC – 2.1 x 10^9/L
LYM% 41.9%
MXD% 17.5%
NEUT%- 40.6%

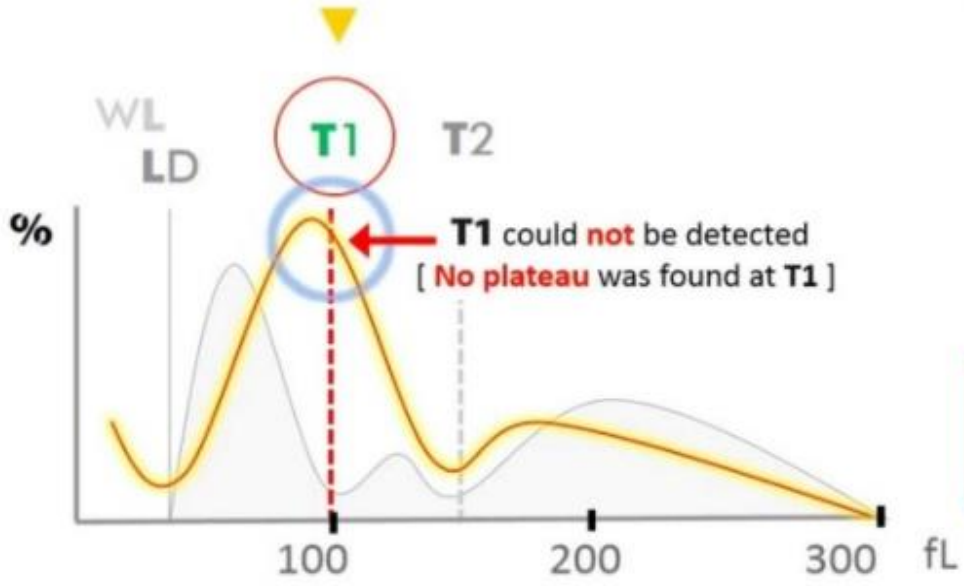




WBCs Histogram
3-Part Differentiation

3 T1 Flag

No differentiation between lymphocytes and mixed cells



T1: 78-114 fl

WBCs Histogram
3-Part Differentiation

Causes :

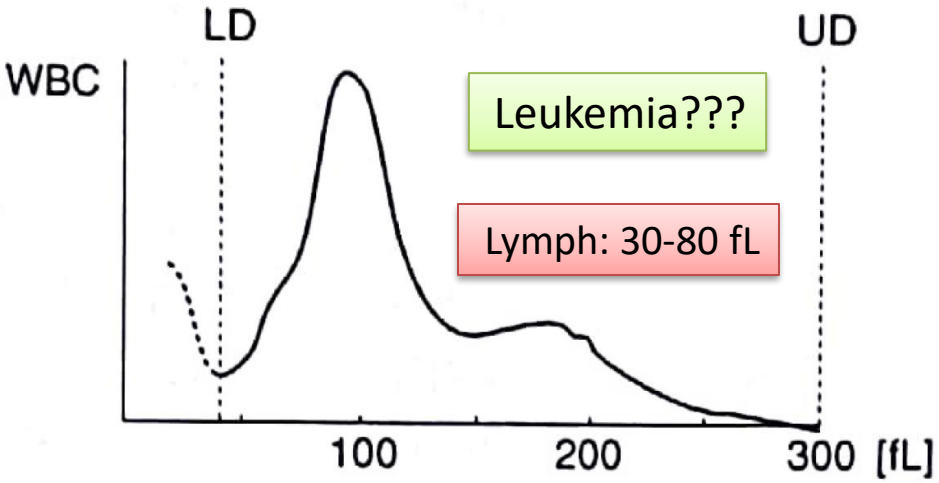
- Blast cells
- Eosinophilia
- Basophilia
- Plasma cells
- Abnormal/variant lymphs

Blood Smear is Recommended

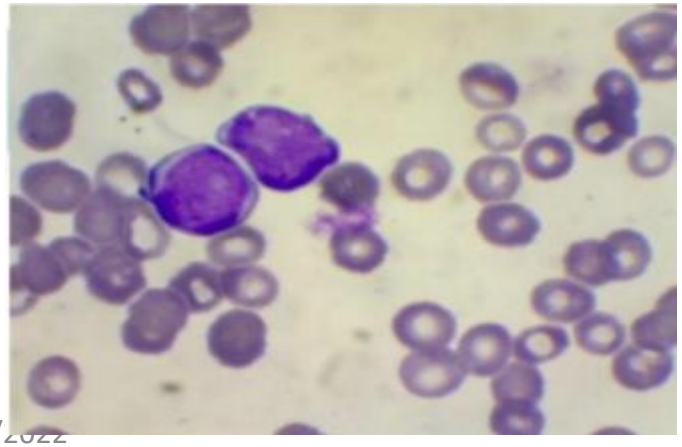
WBCs Histogram
3-Part Differentiation

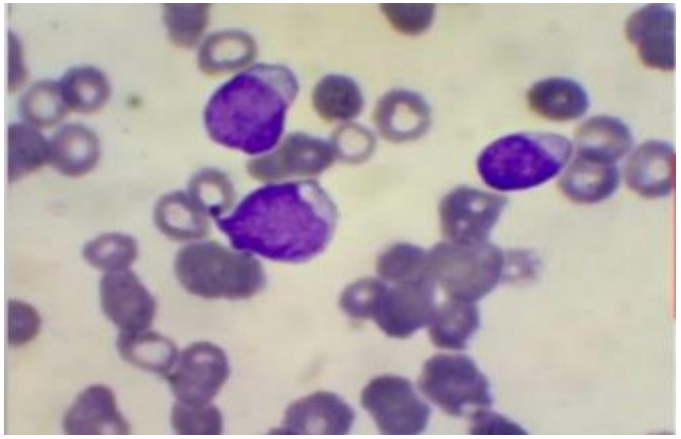
T1: 78-114 fL

WBC Histogram Error-T1 (2A)



WBC		+15.4 [×10³/μL]
LYM%	T1	---.- [%]
MXD%	T1	---.- [%]
NEUT%	T1	---.- [%]
LYM#	T1	---.- [×10³/μL]
MXD#	T1	---.- [×10³/μL]
NEUT#	T1	---.- [×10³/μL]

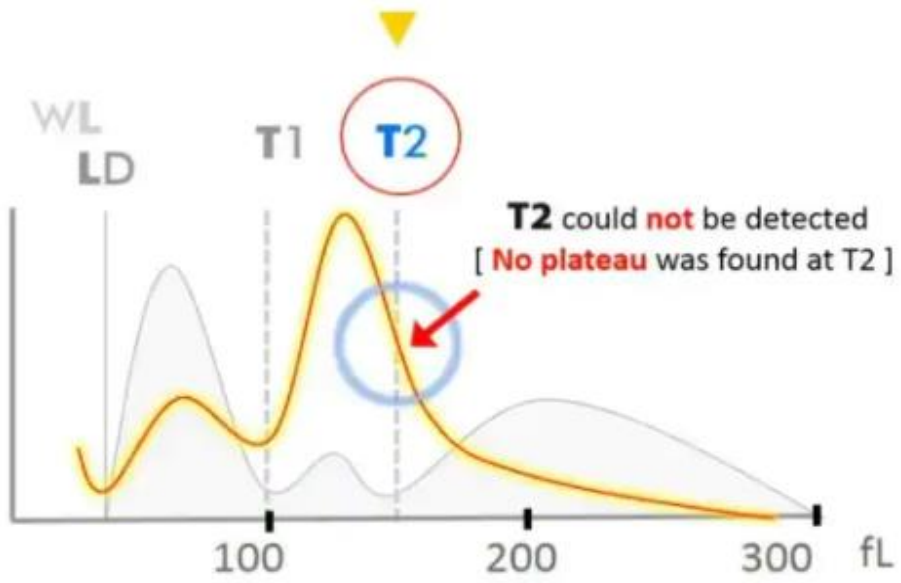




WBCs Histogram
3-Part Differentiation

4 T2 Flag

No differentiation between mixed cells and neutrophils



T2: > 150 fL

WBCs Histogram
3-Part Differentiation

Causes :

- Eosinophilia
- Immature granulocytes
- Abnormal cell populations

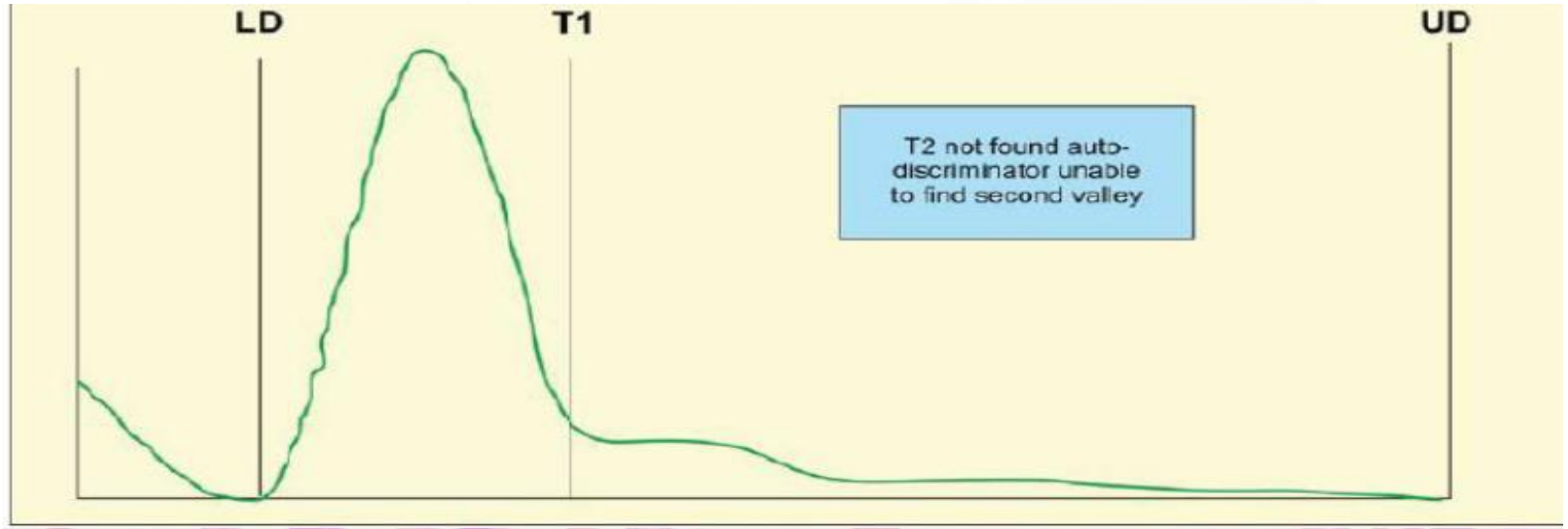
Blood Smear is Recommended

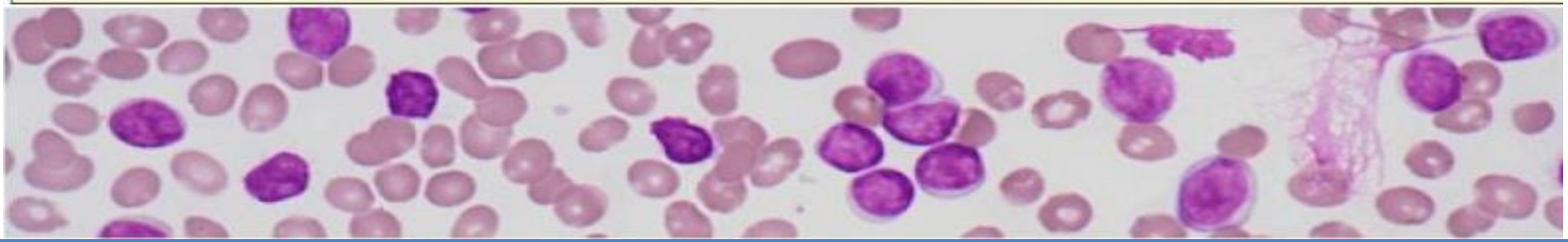
WBCs Histogram
3-Part Differentiation

4 T2 Flag

No differentiation between mixed cells and neutrophils

WBCs Histogram
3-Part Differentiation





بیمار مبتلا به **CLL** و ۹۷٪ لنفوسیت آبنرمال و فقدان سایر انواع لکوسیت است.
سل کانتر نمی تواند دره **T2** را شناسایی کند و نتیجه دیف را نمی دهد و **Flag** های **T2**، **F2** و **F3** می دهد.

WBCs Histogram

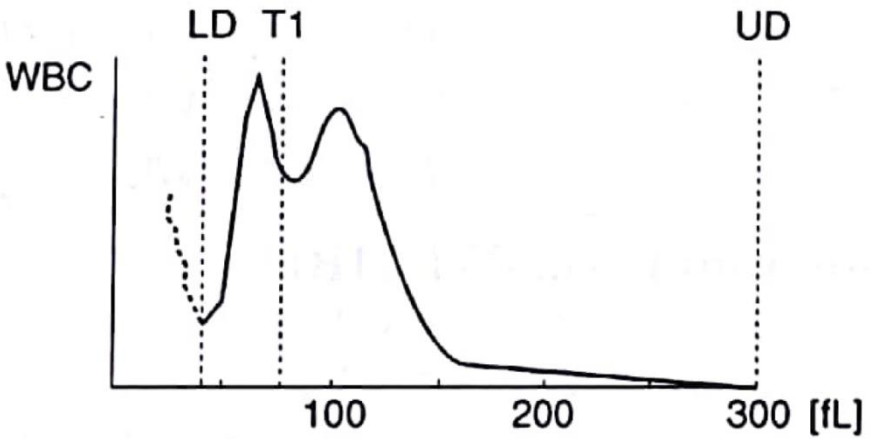
3-Part Differentiation

4 **T2 Flag**

No differentiation between mixed cells and neutrophils

Severe left shift or Eosinophila

- WBC Histogram Error-T2 (3A)



WBC		5.2 [×10³/μL]
LYM%	F1	29.7 [%]
MXD%	T2	---.- [%]
NEUT%	T2	---.- [%]
LYM#	F1	1.5 [×10³/μL]
MXD#	T2	---.- [×10³/μL]
NEUT#	T2	---.- [×10³/μL]

WBCs Histogram

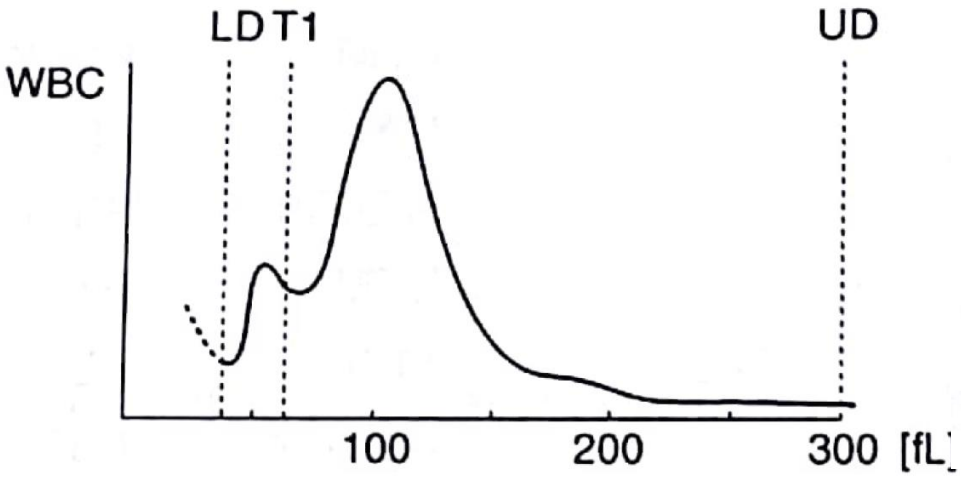
3-Part Differentiation

4 **T2 Flag**

No differentiation between mixed cells and neutrophils

Severe left shift or Eosinophila or …

- WBC Histogram Error-T2 (3C)

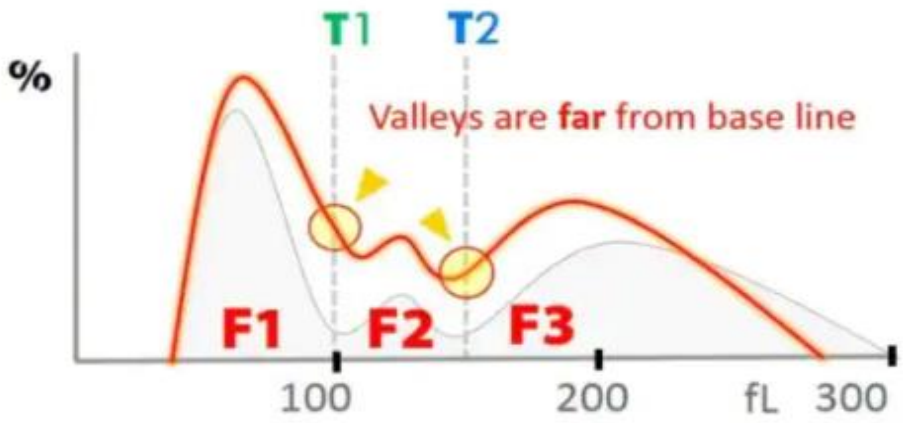


WBC		+15.2 [×10³/μL]
LYM%		12.9 [%]
MXD%	T2	---.- [%]
NEUT%	T2	---.- [%]
LYM#		1.6 [×10³/μL]
MXD#	T2	---.- [×10³/μL]
NEUT#	T2	---.- [×10³/μL]

WBCs Histogram
3-Part Differentiation

5 F1, F2, F3 Flags

F = Fraction



WBCs Histogram
3-Part Differentiation

F1 (small cells) Flag

Height of **T1** exceeds limit of **40%**

F2 (medium cells) Flag

Height of **T1** and **T2** exceeds limit of **40%** and **50%** Respectively

F3 (Large cells) Flag

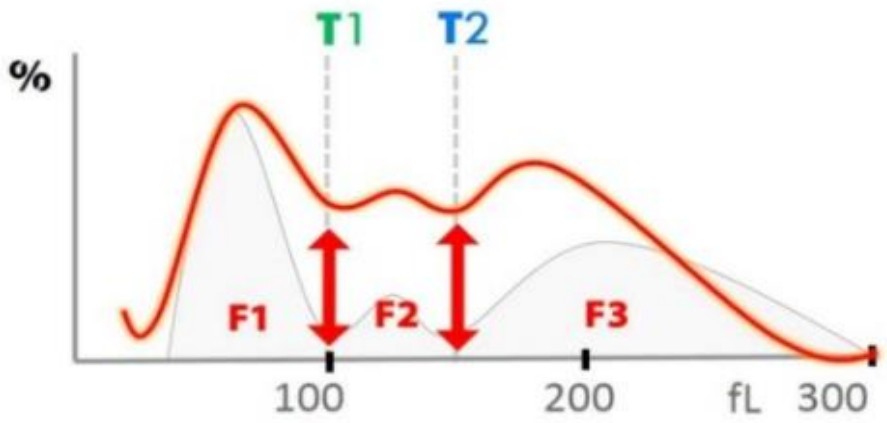
Height of **T2** exceeds limit of **50%**

WBCs Histogram
3-Part Differentiation

5 F1, F2, F3 Flags

F = Fraction

T1 or T2 discriminators are set but there is **no clear separation** between the different populations.



WBCs Histogram
3-Part Differentiation

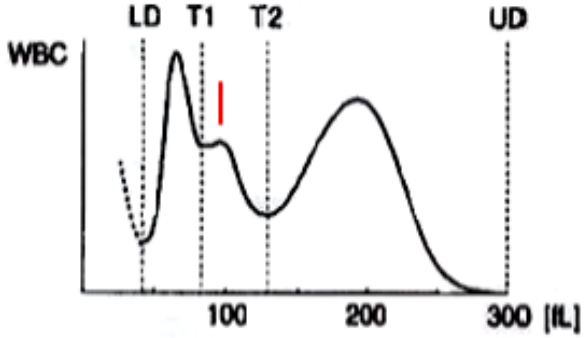
- WBC total count is **correct** (provided that no other flags)
- **T1** and **T2** were detected.
- The troughs are **away** from the basis line.
- It is possible that the fractions are **mixed**; i.e. **F1** and **F2**, or **F2** and **F3** **merge** into each other over large areas.

Manual Differentiation is necessary

WBCs Histogram
3-Part Differentiation

5 F1, F2, F3 Flags

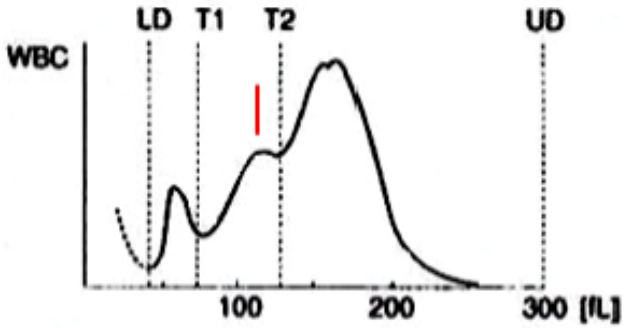
WBC Histogram Error - F1



WBC		6.7 [×10³/μL]
LYM%	F1	28.3 [%]
MXD%	F2	17.4 [%]
NEUT%		54.3 [%]
LYM#	F1	1.9 [×10³/μL]
MXD#	F2	1.2 [×10³/μL]
NEUT#		3.6 [×10³/μL]

WBCs Histogram
3-Part Differentiation

WBC Histogram Error - F2



WBC		+18.5 [×10³/μL]
LYM%		9.5 [%]
MXD%	F2	+23.7 [%]
NEUT%	F3	66.8 [%]
LYM#		1.1 [×10³/μL]
MXD#	F2	2.7 [×10³/μL]
NEUT#	F3	7.7 [×10³/μL]

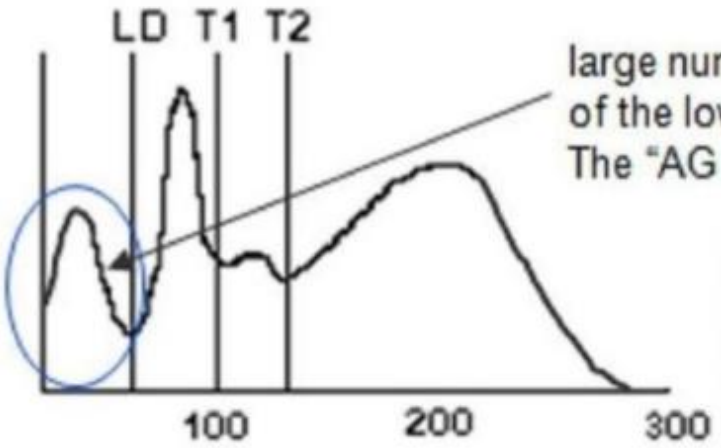
شکل ۲۷-۱۰: تصویر فلاگ F1 و F2 سل کانتر سیسمکس K-21 برای یک افزایش بلاست (F1) و افزایش ائوزینوفیل (F2)

WBCs Histogram
3-Part Differentiation

6 **AG flag** ➡ Aggregation

WBCs Histogram
3-Part Differentiation

Abnormal curve in front of lower discriminator



large numbers of particles are detected in front of the lower WBC discriminator.
The "AG flag is shown on the PLT result.

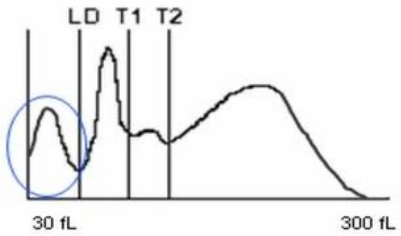
Large platelet clumps (> 30fl) are detected in the area before the lower WBC discriminator. Due to their enhanced size they may not affect the PLT histogram curve. If "AG" mark will be generated, the sample should be checked for platelet clumps (e.g. microscopic slide review).

WBCs Histogram
3-Part Differentiation

6 AG flag ➡ Aggregation

WBCs Histogram
3-Part Differentiation

Abnormal curve in front of lower discriminator



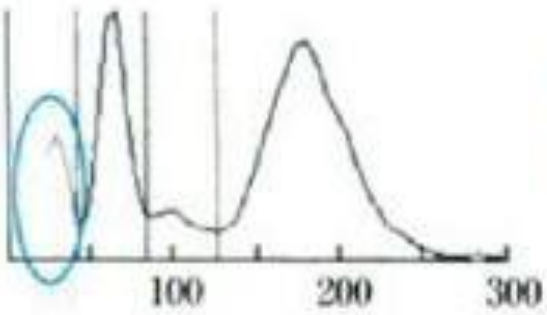
- Probable cause is PLT aggregation which does not alter WBC count but may result in decreased PLT count.
- Therefore this flag is added to the PLT parameters PLT count.
- Possible interference
  - » PLT aggregation
  - » EDTA incompatibility
  - » Lyse resistant RBC
  - » NRBC
  - » Large PLT Giant PLT
- Action:
  - » PLT count should be checked for PLT aggregation.
  - » The result is not correct and might be low.
  - » Sample should be recollected and measured again.

6 **AG flag** ➡ Aggregation

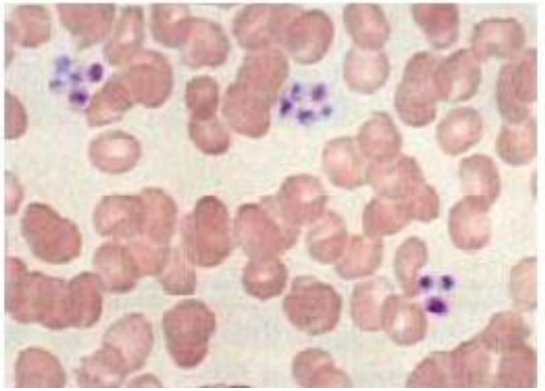
WBCs Histogram
3-Part Differentiation

Abnormal curve in front of lower discriminator

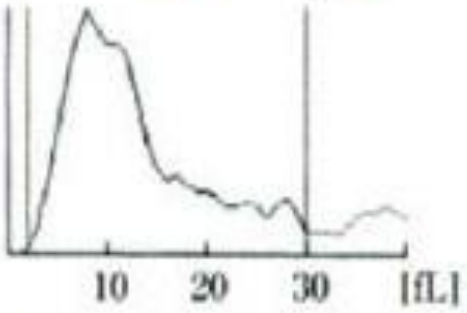
WBC-Histogram



Results	
WBC	6.0 x10⁹/L
LYM%	27.5%
MXD%	7.9%
NEUT %	64.4%



PLT-Histogram



Results		
PLT		86 x10⁹/L
PDW	+	18.6fl
MPV		12.8fl
P-LCR	+	43.7%

WBCs Histogram
3-Part Differentiation

WBCs Histogram
3-Part Differentiation

Questions

Which Histogram is suitable for the diagnosis ?

WBCs Histogram
3-Part Differentiation

Question 1

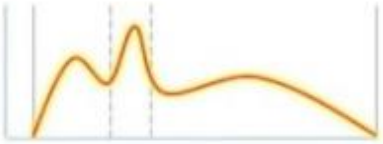
Which Histogram is suitable for the diagnosis ?

WBCs Histogram
3-Part Differentiation

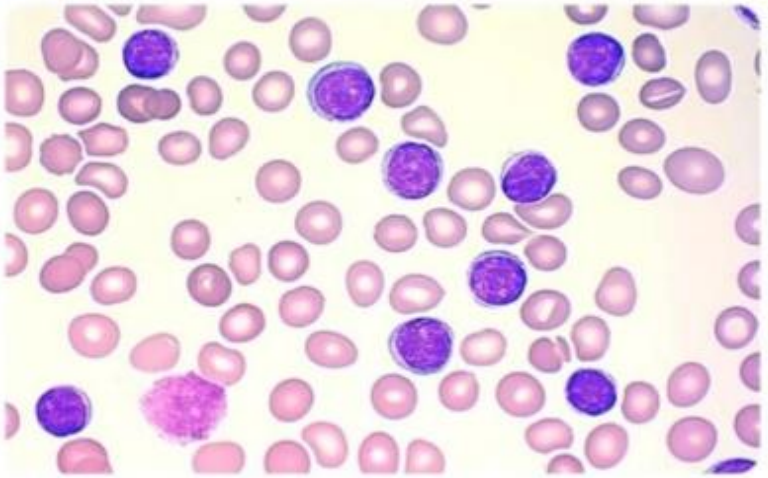
A

B

C



Chronic Lymphocytic Leukemia



WBCs Histogram
3-Part Differentiation

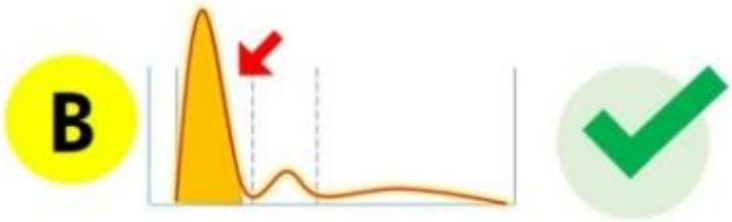
Question 1

Which Histogram is suitable for the diagnosis ?

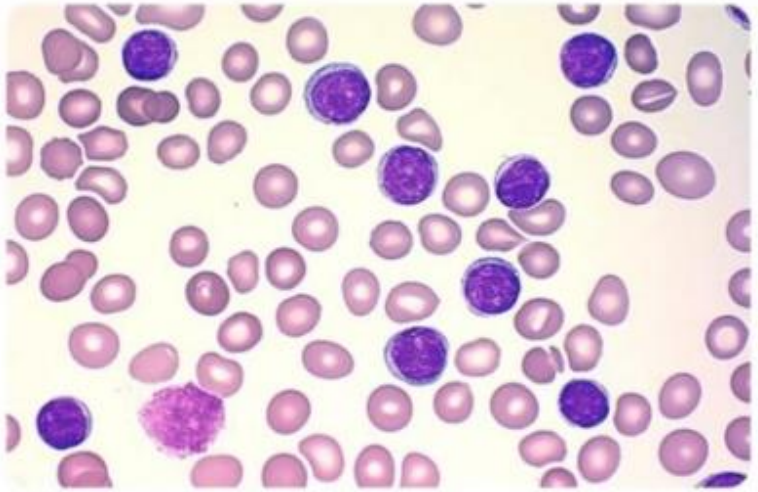
WBCs Histogram
3-Part Differentiation

Peak
At small cell region

Between **WL** and **T1**



Chronic Lymphocytic Leukemia

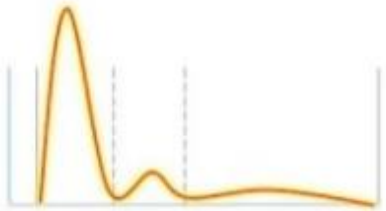


WBCs Histogram
3-Part Differentiation

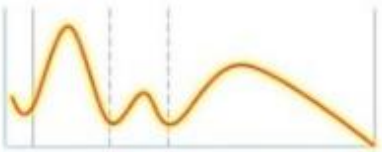
Question 2

Which Histogram is suitable for the diagnosis ?

A



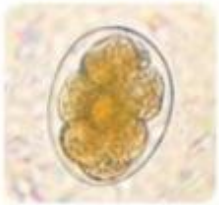
B

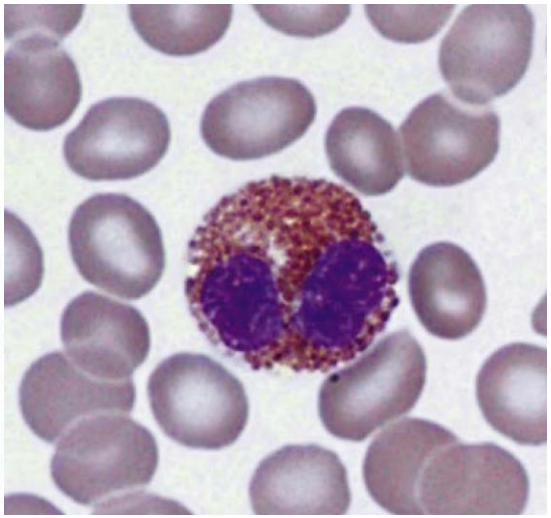


C

WBCs Histogram
3-Part Differentiation

Hookworm infection





WBCs Histogram
3-Part Differentiation

Question 2

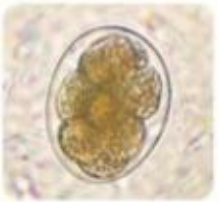
Which Histogram is suitable for the diagnosis ?

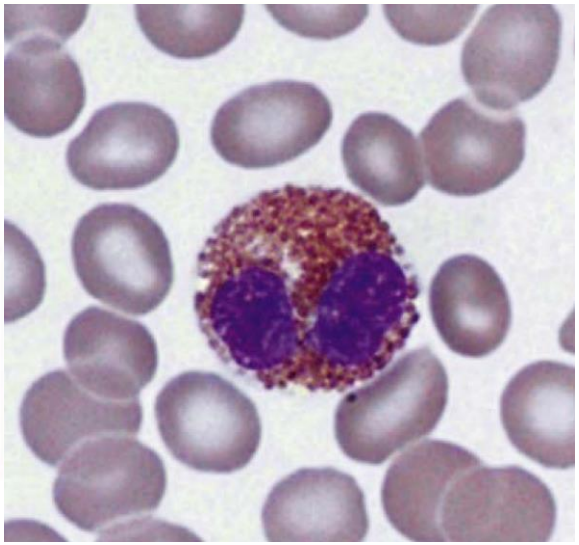
Peak
At medium cell region

Between **T1** and **T2**

WBCs Histogram
3-Part Differentiation

Hookworm infection





Eosinophils

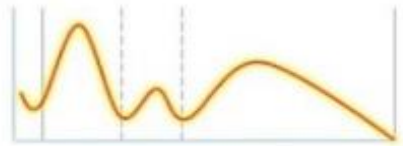
WBCs Histogram
3-Part Differentiation

Question 3

Which Histogram is suitable for the diagnosis ?

A

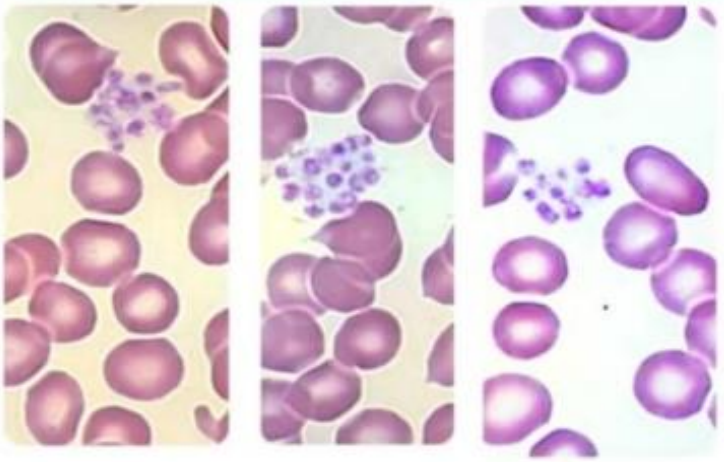
B



C

WBCs Histogram
3-Part Differentiation

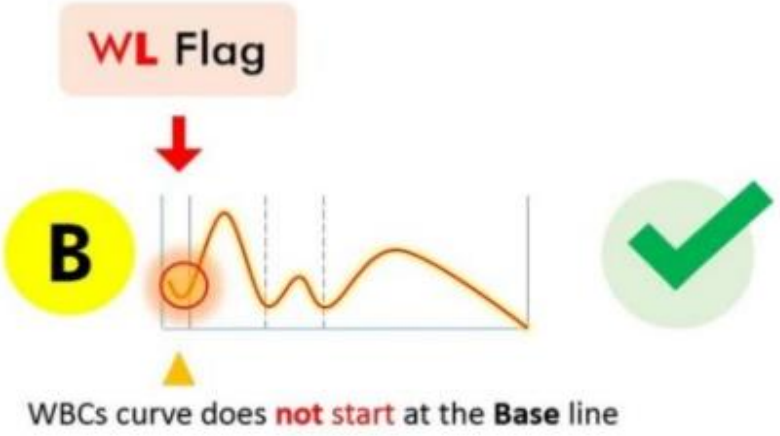
EDTA-induced
Pseudothrombocytopenia



WBCs Histogram
3-Part Differentiation

Question 3

Which Histogram is suitable for the diagnosis ?



WBCs Histogram
3-Part Differentiation

EDTA-induced
Pseudothrombocytopenia

WBCs Histogram
3-Part Differentiation

Question 4

Which Histogram is suitable for the diagnosis ?

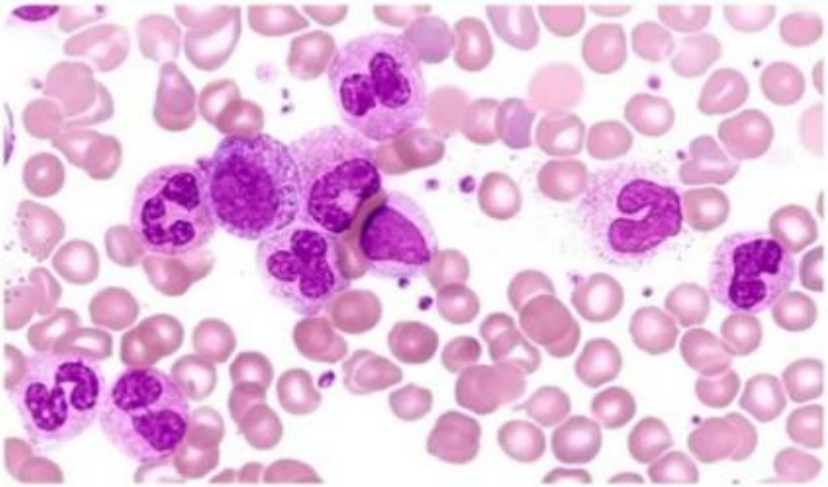
WBCs Histogram
3-Part Differentiation

A

B

C

Chronic **Myeloid** Leukemia

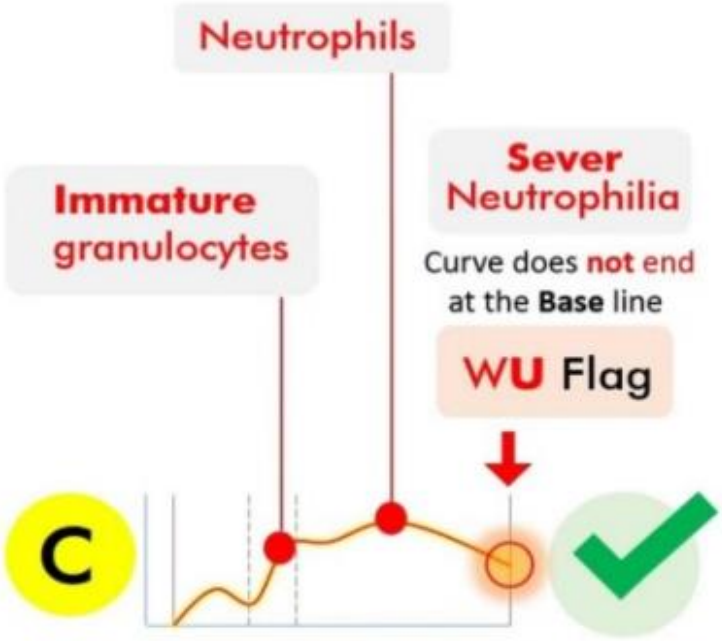


WBCs Histogram
3-Part Differentiation

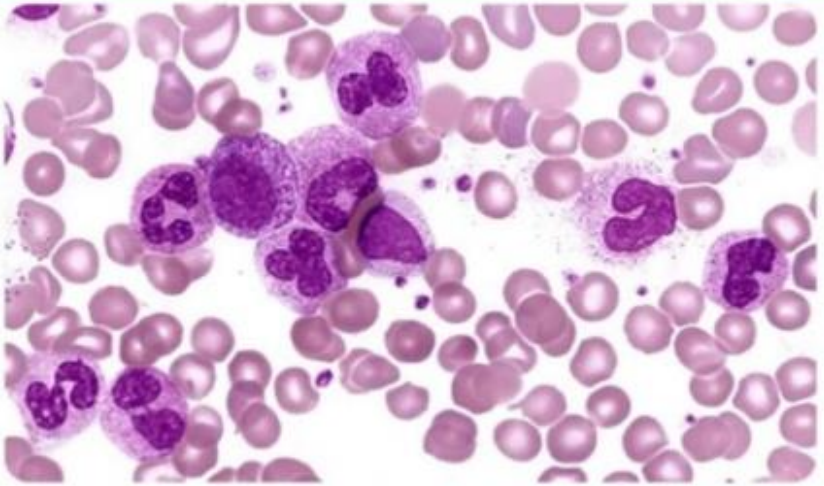
Question 4

Which Histogram is suitable for the diagnosis ?

WBCs Histogram
3-Part Differentiation



Chronic **Myeloid** Leukemia



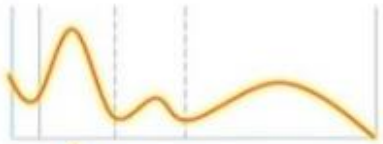
WBCs Histogram
3-Part Differentiation

Question 5

Which Histogram is suitable for the diagnosis ?

WBCs Histogram
3-Part Differentiation

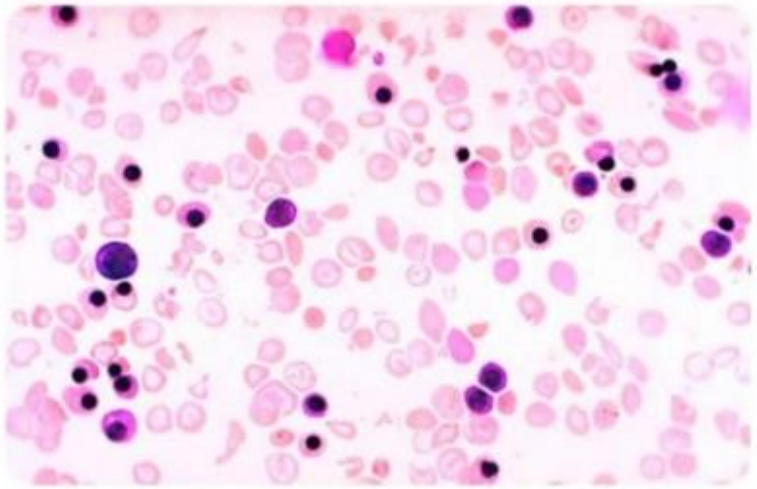
A



B

C

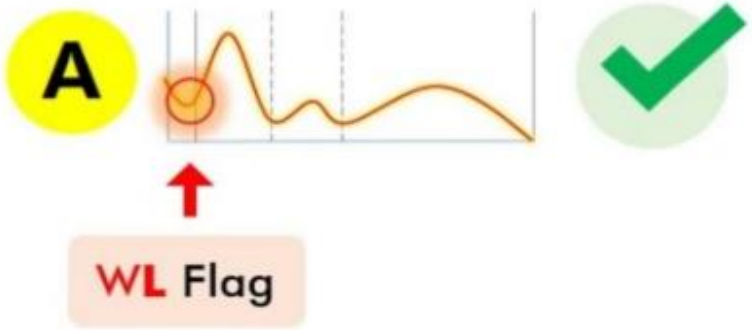
β Thalassemia Major



WBCs Histogram
3-Part Differentiation

Question 5

Which Histogram is suitable for the diagnosis ?



WBCs Histogram does not start at the Base line

WBCs Histogram
3-Part Differentiation

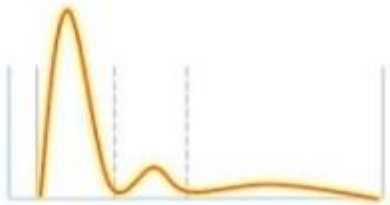
β Thalassemia Major

WBCs Histogram
3-Part Differentiation

Question 6

Which Histogram is suitable for the diagnosis ?

A

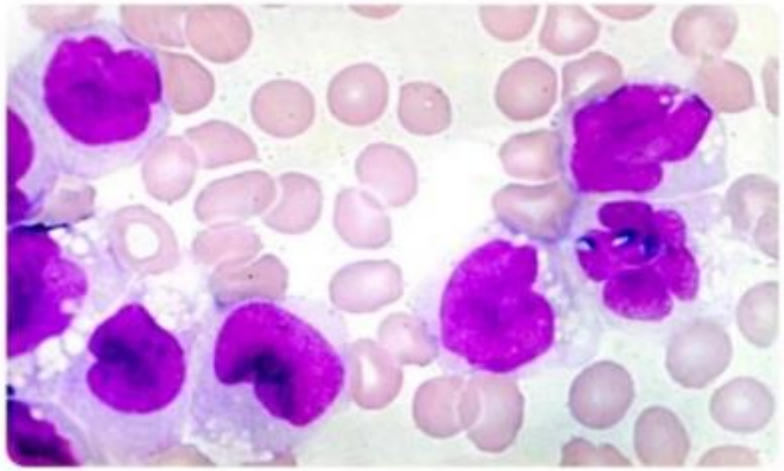


B

C

WBCs Histogram
3-Part Differentiation

AML M5



WBCs Histogram
3-Part Differentiation

Question 6

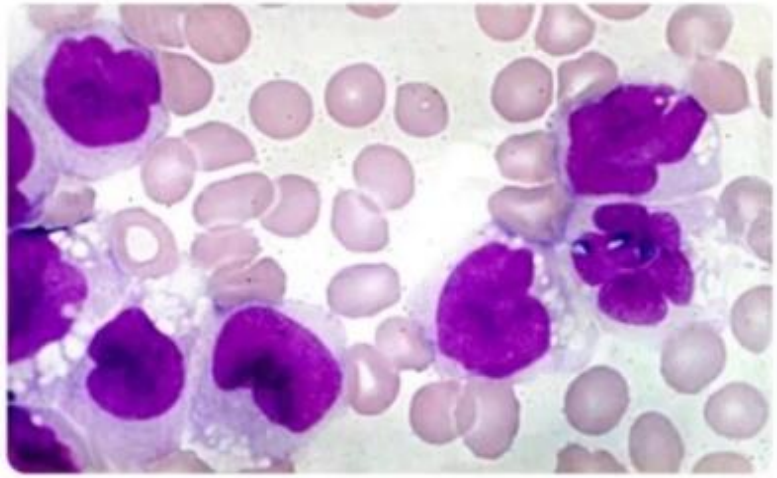
Which Histogram is suitable for the diagnosis ?

WBCs Histogram
3-Part Differentiation

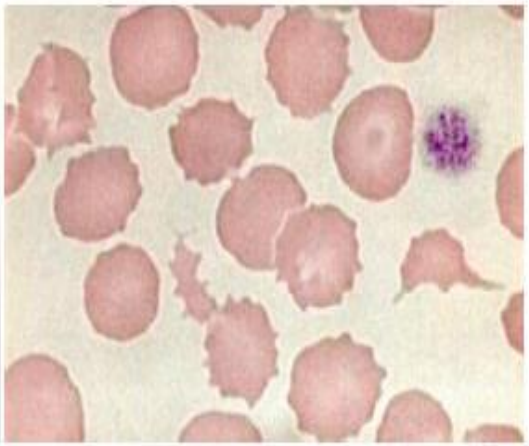
Peak
At medium cell region

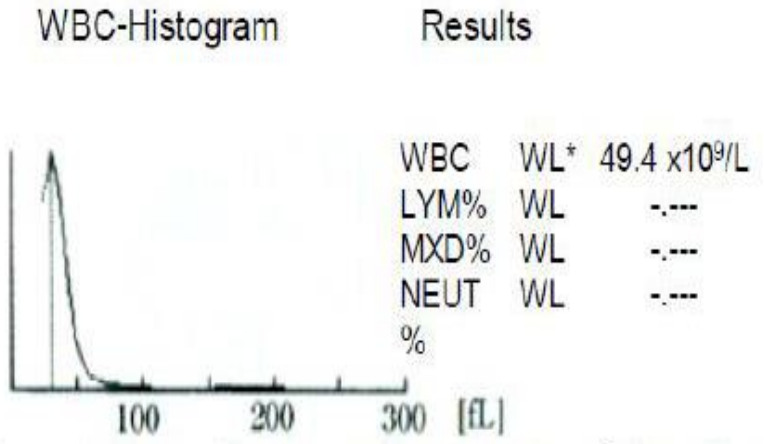
C

AML M5



Lysing resistant RBCs & WBC histogram





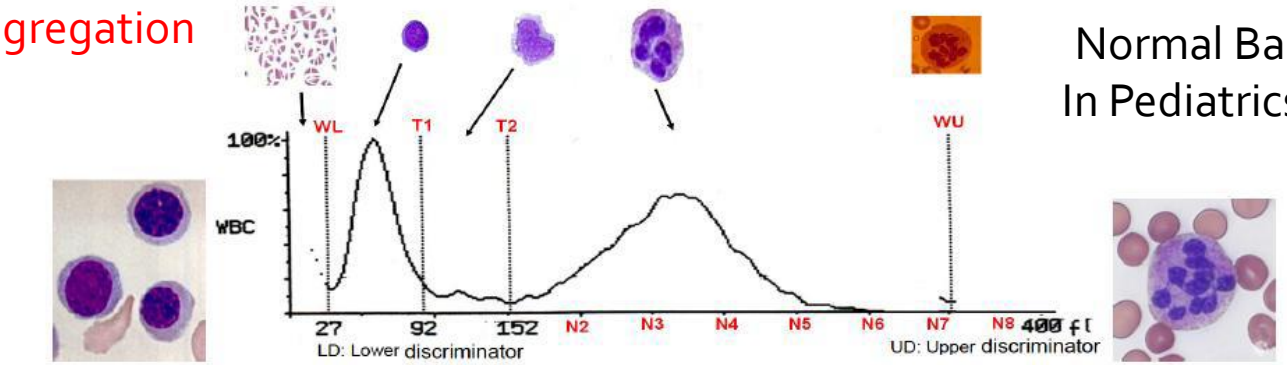
شکل ۱۸-۱۰: گاهاً در بیماران کبدی و نوزادان و برخی از هموگلوبینوپاتی‌ها (به خصوص C، S و F) و نمونه خون سرد یا یخچالی، RBCها نسبت به لیز مقاوم بوده و لذا به دلیل عدم لیز، قله بارزی را در مرز WL تشکیل می‌دهند که اغلب خط WL را در ارتفاع بالایی قطع کرده و علاوه‌بر افزایش کاذب WBC باعث بروز فلاگ WL و * (ستاره: علامت عدم اعتبار نتیجه) نیز می‌شود. در این موارد بهتر است پلاسمای خون برداشته و با محلول Cellpack (ایزوتون دستگاه) جایگزین شود یا اینکه خون با همین محلول رقیق شده و بعد از ۵ دقیقه به دستگاه داده شود. در بیماران کبدی مشاهده آکانتوسیت، جایانت پلاکت، تارگت سل و ماکروسیت کمک کننده می‌باشد.

علل لیز نشدن RBC : بالا بودن HbF (neonates)،
بیماریهای کبدی و اورمی و حضور تعداد زیاد nRBC

WBC Histogram & clinical Application

PLT aggregation

nRBC



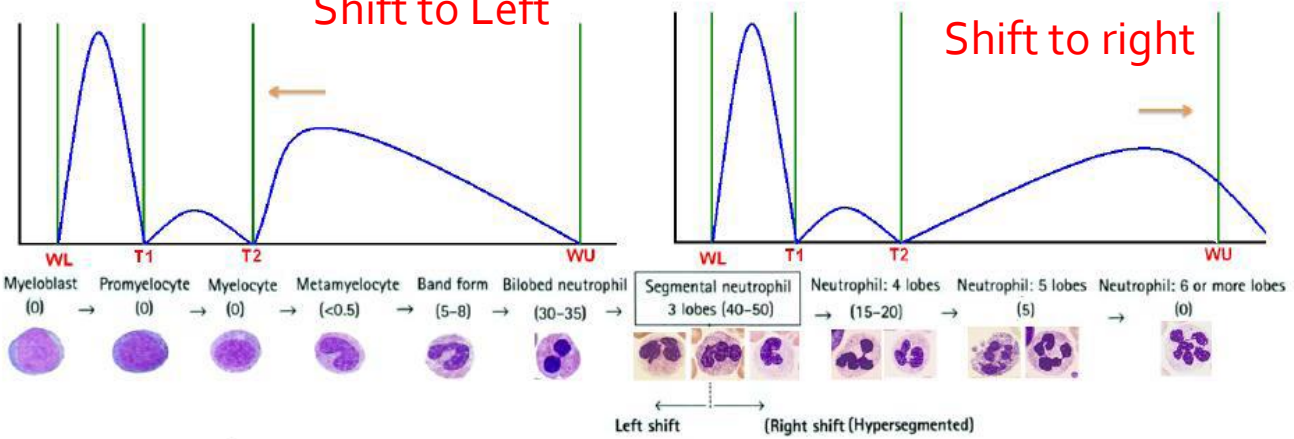
شکل ۱۹-۱۰: جایگاه نوتروفیل‌های ۲ تا ۸ سگمنته در ناحیه LCR که خطای WU می‌تواند نشانه حضور نوتروفیل هیپرسگمانته یا اگریگاسیون لکوسیتی باشد که در واکنش TRALI، آلوایمونیزاسیون لکوسیتی و عوارض ناشی از ضد انعقاد EDTA دیده می‌شود.

Normal Band in Adults<5%

In Pediatrics <8%

Shift to Left

Shift to right



Number of lobes

	1	2	3	4	5
% of neutrophils	35%	25%	21%	17%	2%

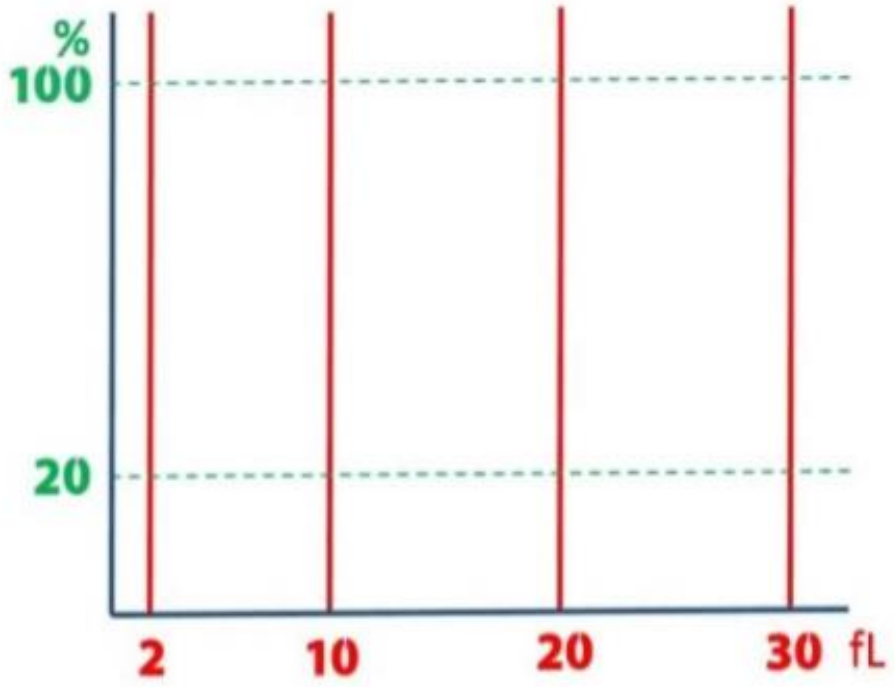
Number of lobes

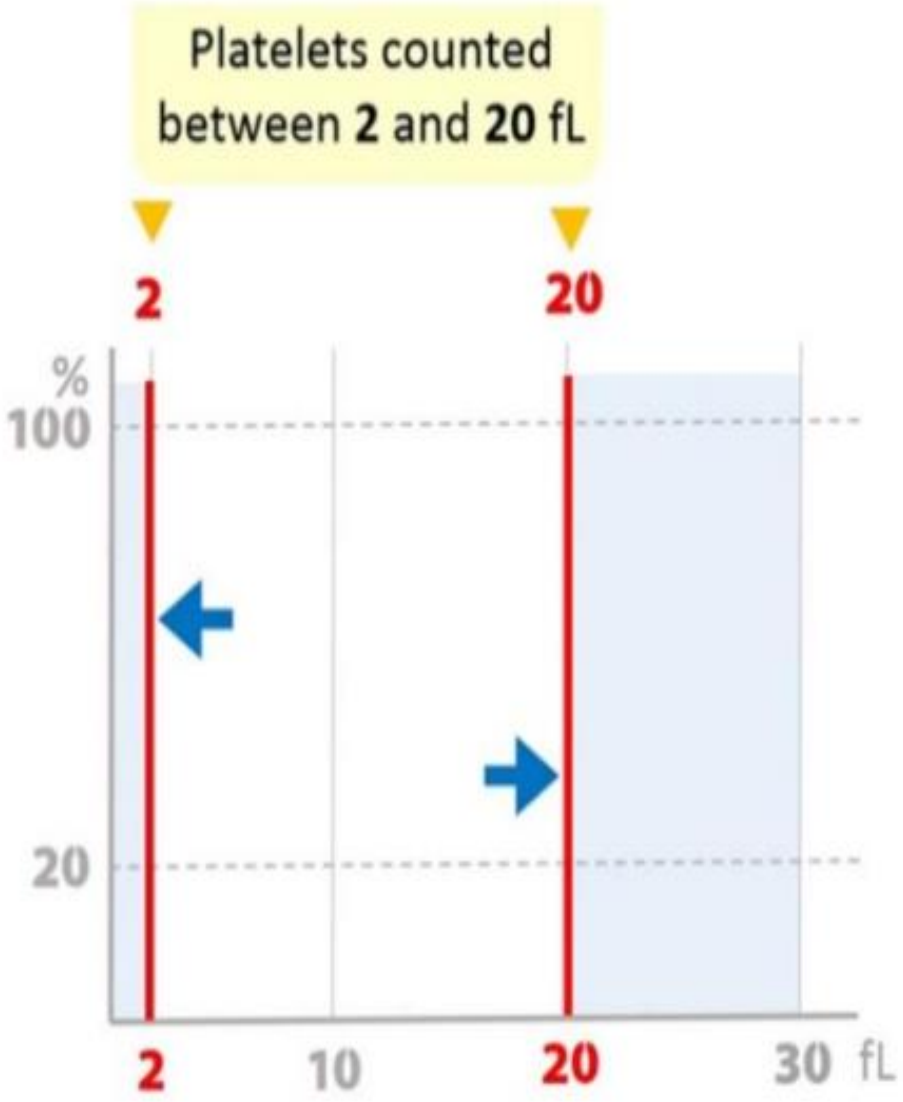
	1	2	3	4	5
%	1%	10%	33%	34%	22%

شکل ۲۰-۱۰: درصد رده‌های مختلف نوتروفیلی در خون محیطی که بیشترین آنها را نوتروفیل‌های ۳ لوبه تشکیل می‌دهند. برای تخمین شمارش لکوسیت از روی PBS می‌بایست میانگین لکوسیت-های ۱۰ میدان 400X را در عدد ۳۰۰۰ ضرب نمود.

CGP-MGP

Platelet Histogram





Platelet Histogram

Platelets counted between 2 and 20 fL.

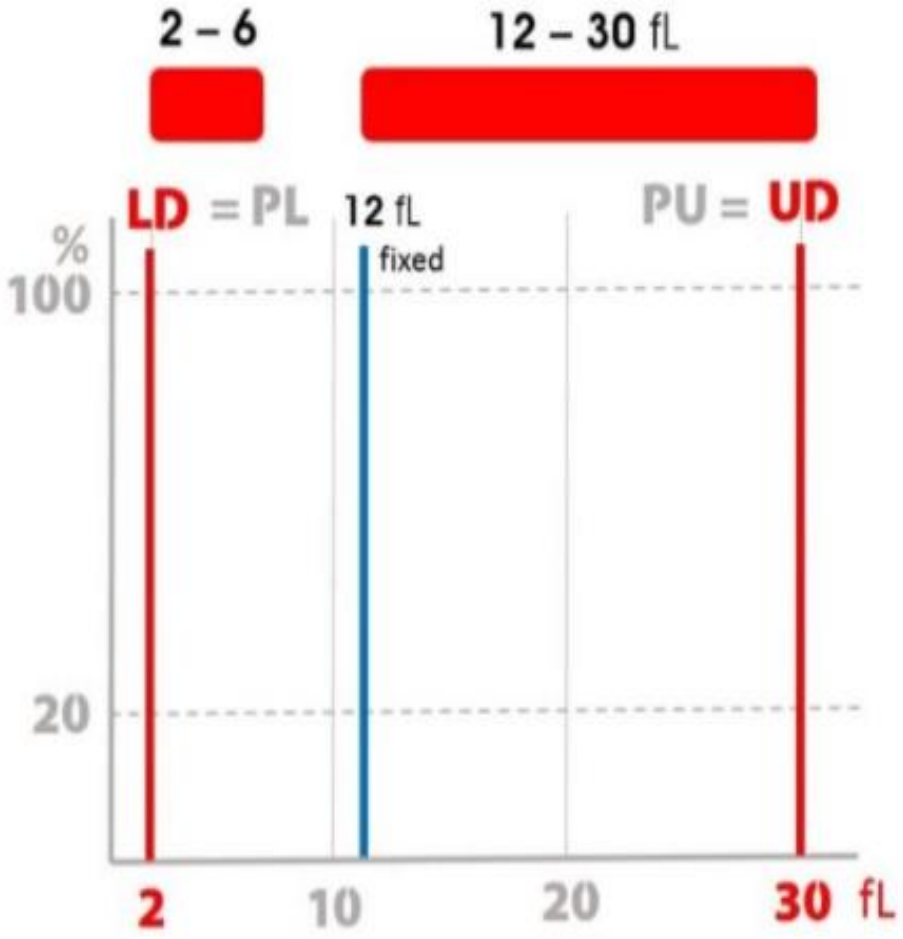
2 fL interference

- **Dust**
- **EDTA** particles
- **Air** bubbles
- **Electric Noise**

20 fL interference

- **RBCs** fragments
- **WBCs** fragments
- **Large PLTs**
- **Giant PLTs**

Platelet Histogram



2 flexible Discriminators are used

LD (Lower **D**iscriminator)

Sometimes called **PL** (Platelet **L**D)

Flexible Discriminator between **2 – 6** fL

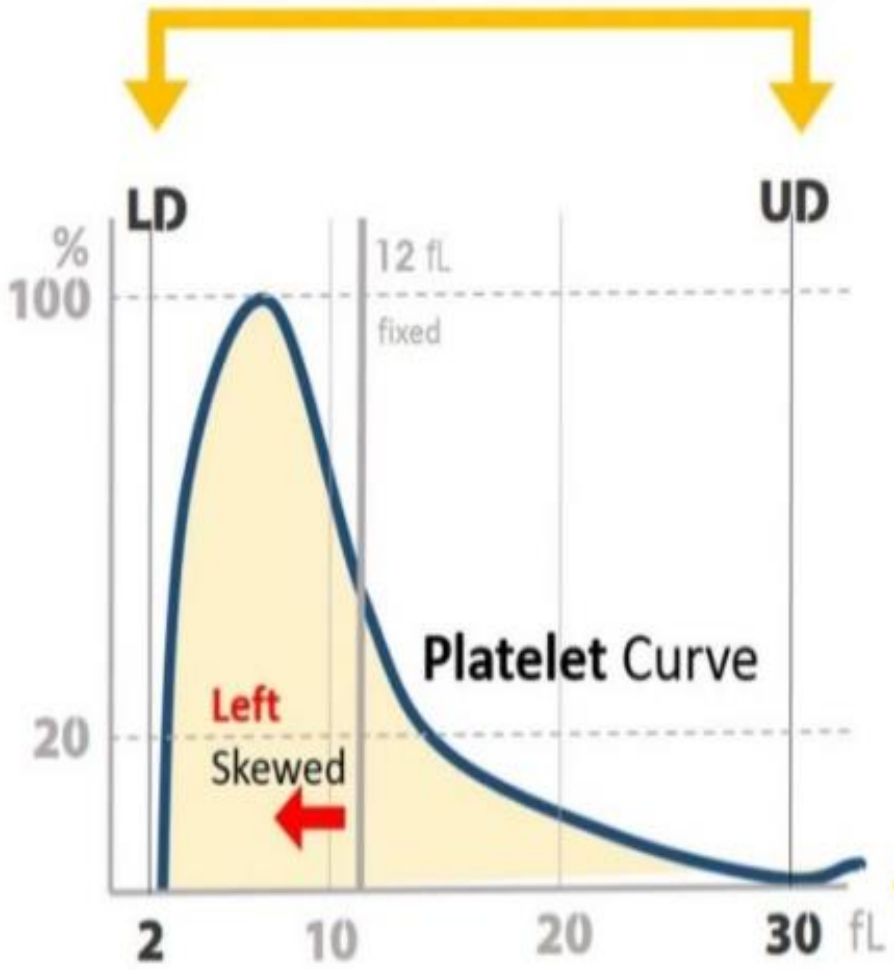
UD (Upper **D**iscriminator)

Sometimes called **PU** (Platelet **U**D)

Flexible Discriminator between **12 – 30** fL

A **3rd Fixed** Discriminator at **12** fL may be used.

Platelet Histogram

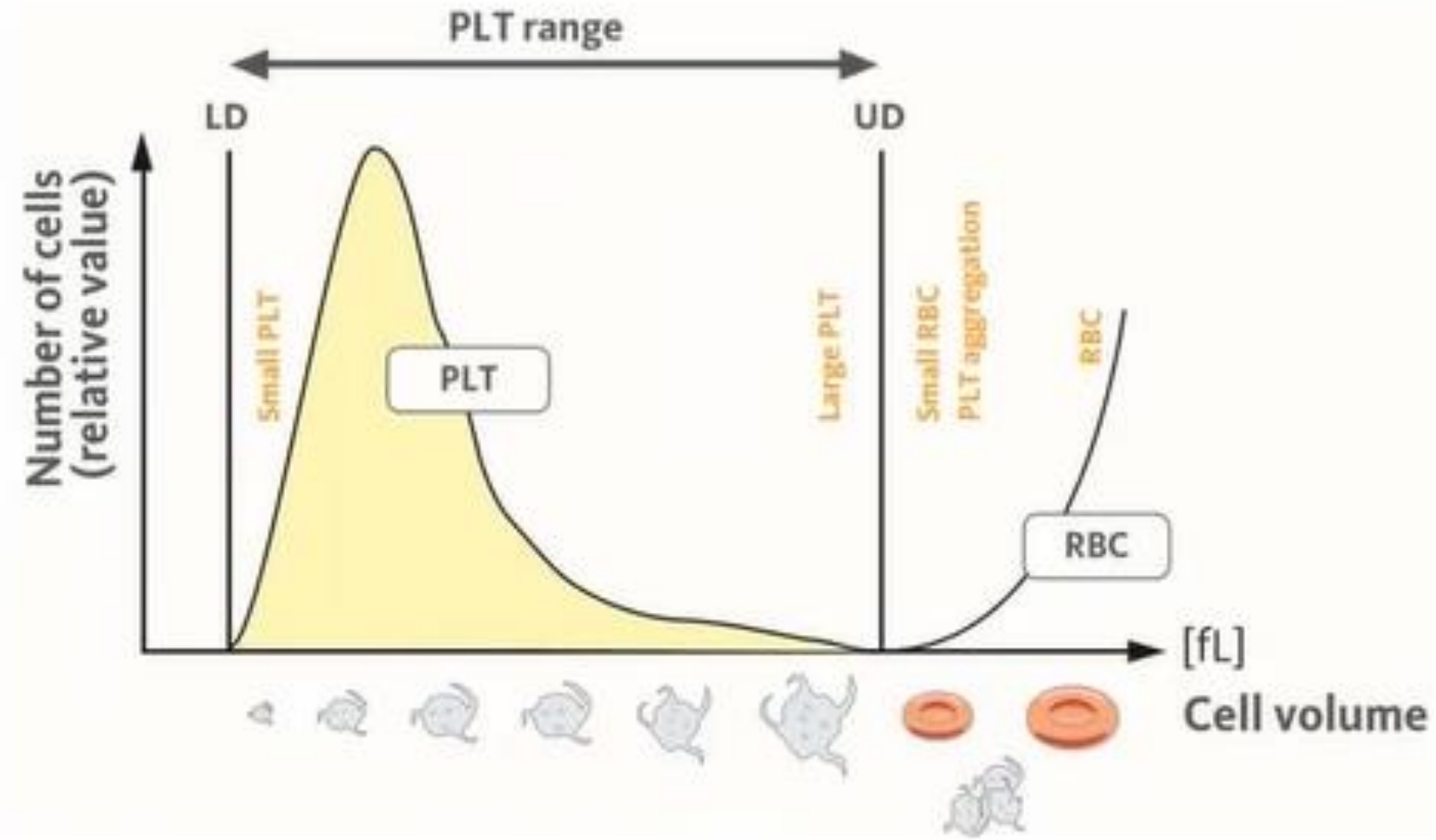


- The platelet histogram curve should lay **within** the **LD** and **UD**.

Normally, The platelet curve is **left-skewed**.

The platelet histogram curve **starts** and **ends** on the **base line**.

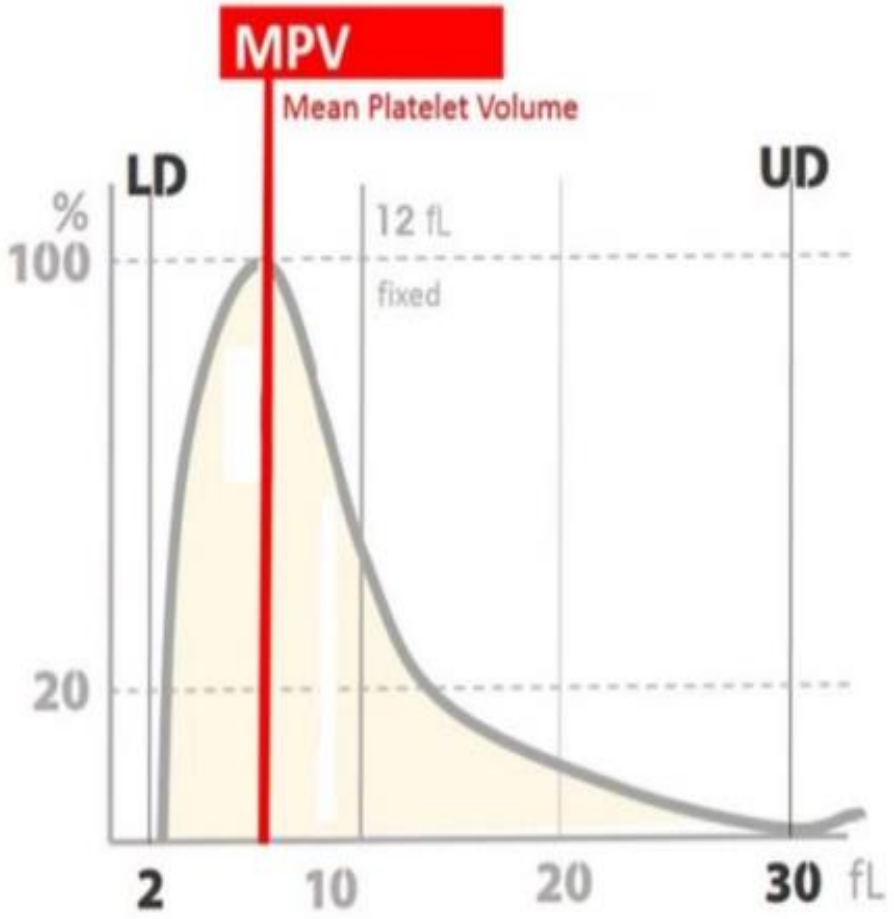
Platelet Histogram



Parameters of Platelets Histogram

- MPV
- PDW
- P-LCR

Platelet Histogram

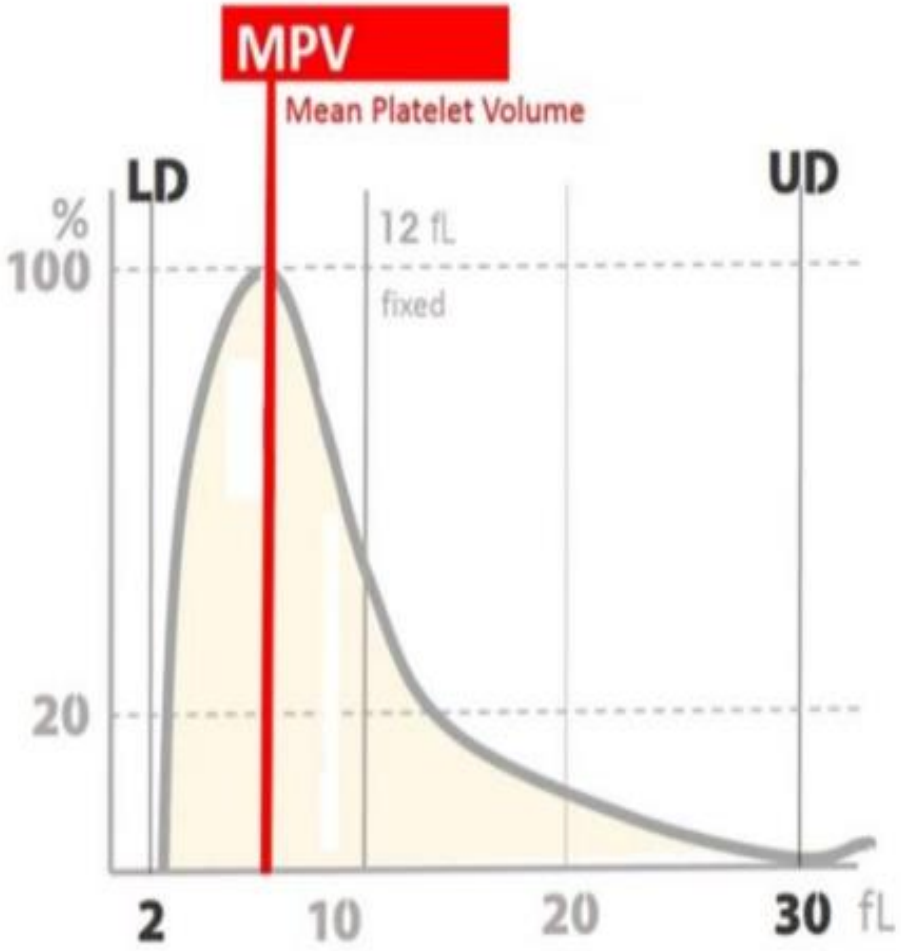


- The MPV is a measure of the **average volume** of the counted platelets. (analogous to the erythrocytic MCV)

$$\text{MPV (fL)} = \frac{\text{Platelet crite}\ \textbf{PCT (\%)}}{\textbf{PLT} (\text{x } 10^3/\mu\text{L})\ \text{Platelet count}}$$

- **Reference Range** : 8 – 12 fL

Platelet Histogram



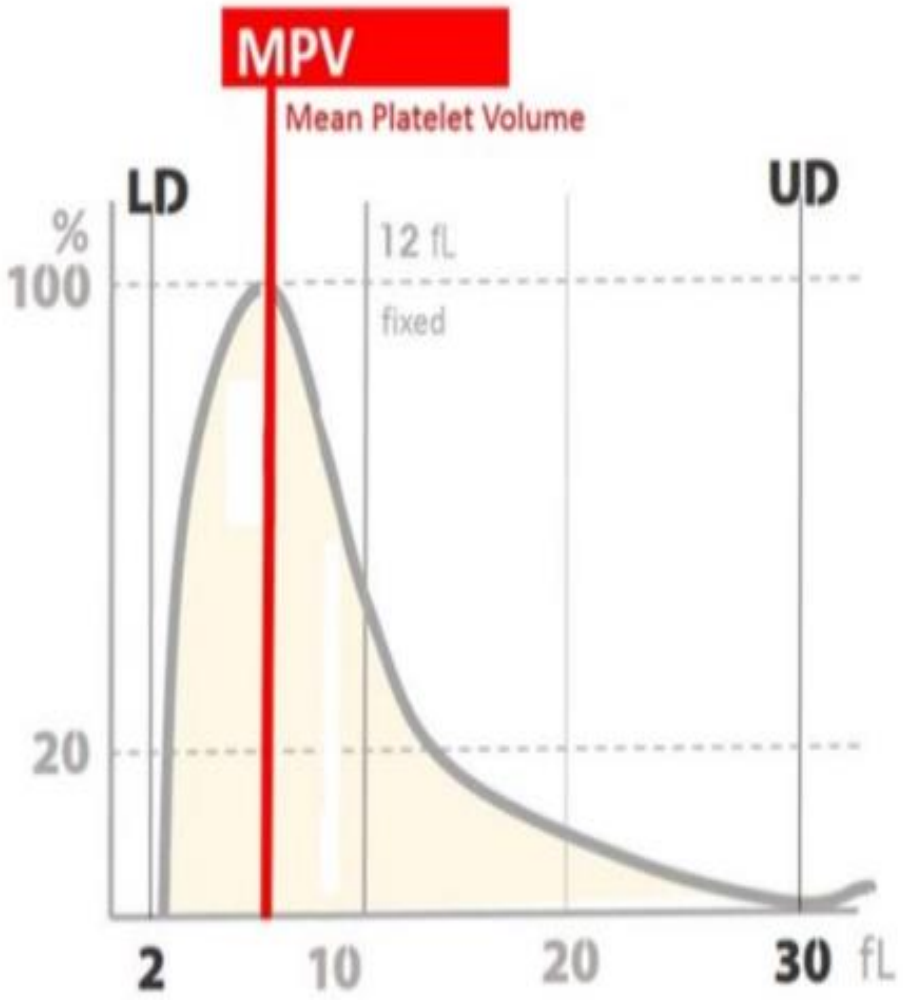
- The range of platelet size (MPV) **varies** according to the platelet count.

- In normal patients, MPV has an **inverse relationship** with platelet count.
  [↑ MPV is seen in thrombocytopenia]

- MPV is used to **discriminate** between :

Reactive Thrombocytosis	**Malignant** Thrombocytosis
↑ PLT Count	↑ PLT Count
Normal MPV	↑ **MPV**

Platelet Histogram



Causes of ↑ MPV

- Splenectomy
- CML
- Myelofibrosis
- ITP
- Sickle Cell Anemia

Causes of ↓ MPV

- Hypersplenism
- Aplastic Anemia
- Megaloblastic a.
- Chemotherapy

20 MAR '18 09:59

ID 14381218484
MODE (OPEN)
SAMPLE TYPE : Normal

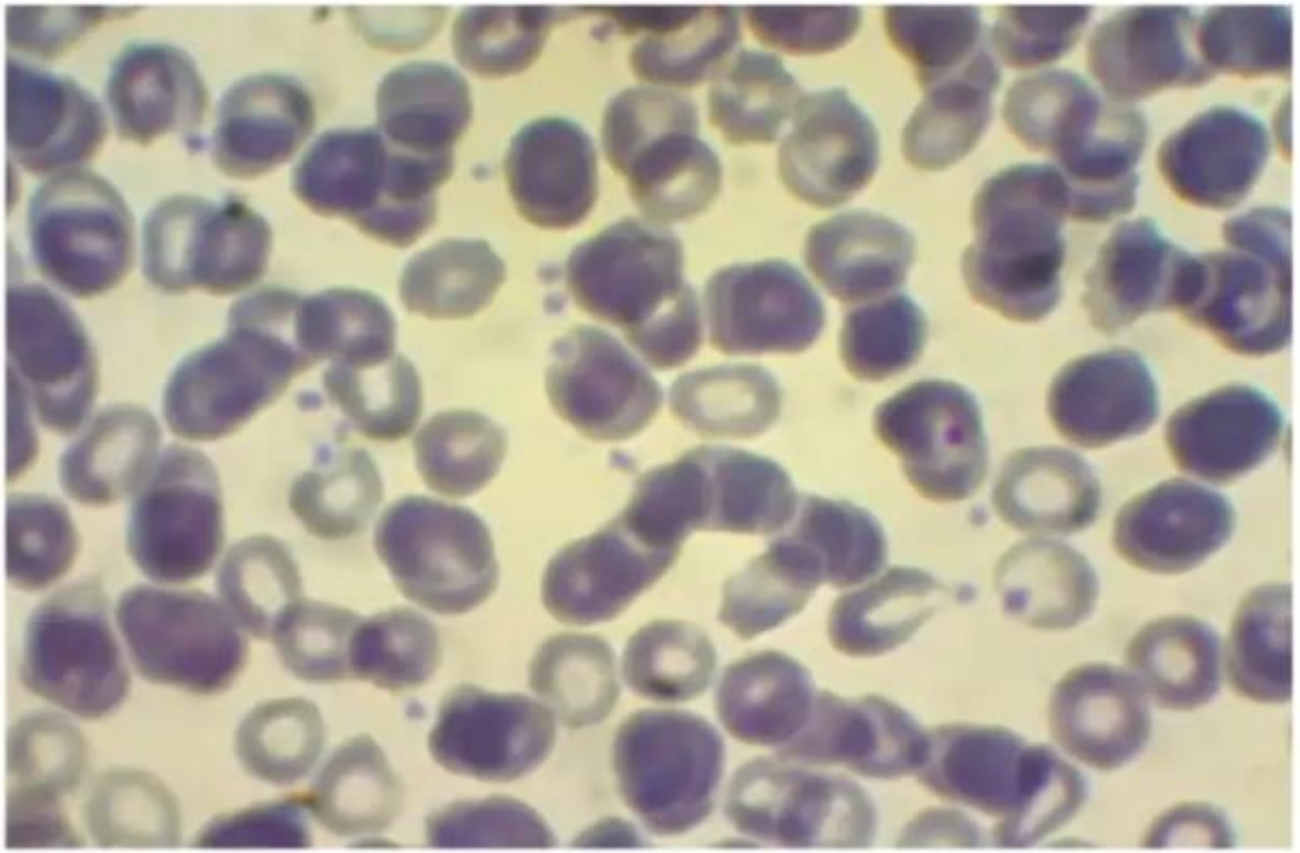
WBC	13.5H	10³/uL
RBC	5.33H	10⁶/uL
HGB	14.2	g/dL
HCT	44.1	%
MCV	82.7	fL
MCH	26.6L	pg
MCHC	32.2	g/dL
PLT	578H	10³/uL
LY	4.5H	[33.5 %]
MO	0.8	[5.8 %]
GR	8.2H	[60.7 %]
RDW	14.3	%
PCT	0.26	%
MPV	4.5L	fL
PDW	16.6	%

WBC

RBC

PLT

Thrombocytosis →Low MPV



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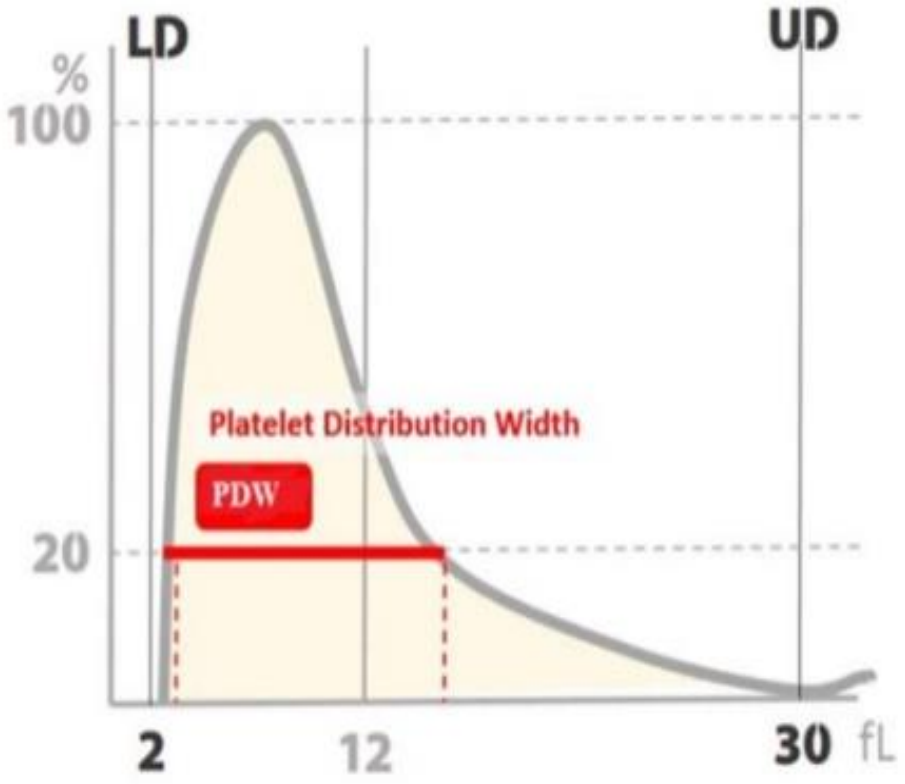
PDW

Platelet Distribution Width



Platelet Histogram

- It is a measure of variation of platelet size.
- It is a **coefficient of variation** percentage which is calculated by **SD**/MPV x 100.
- **Reference range** : 9 – 14% **(15%)**
- PDW also could be expressed by drawing an arbitrary line at a height of **20%**.

Causes of ↑ PDW

- Aplastic Anemia
- Megaloblastic a.
- CML
- Chemotherapy

Causes of False ↑ :

- PLT Clumps
- Micro RBCs
- Fragments
- **(Schistocytes)**

P-LCR

Platelet Large Cell Ratio

Platelet Histogram

- It's a ratio of **large** platelets.
- Reference range : 15 - 35 %
- Causes of ↑ P-LCR :
  - **(Schistocytes)**

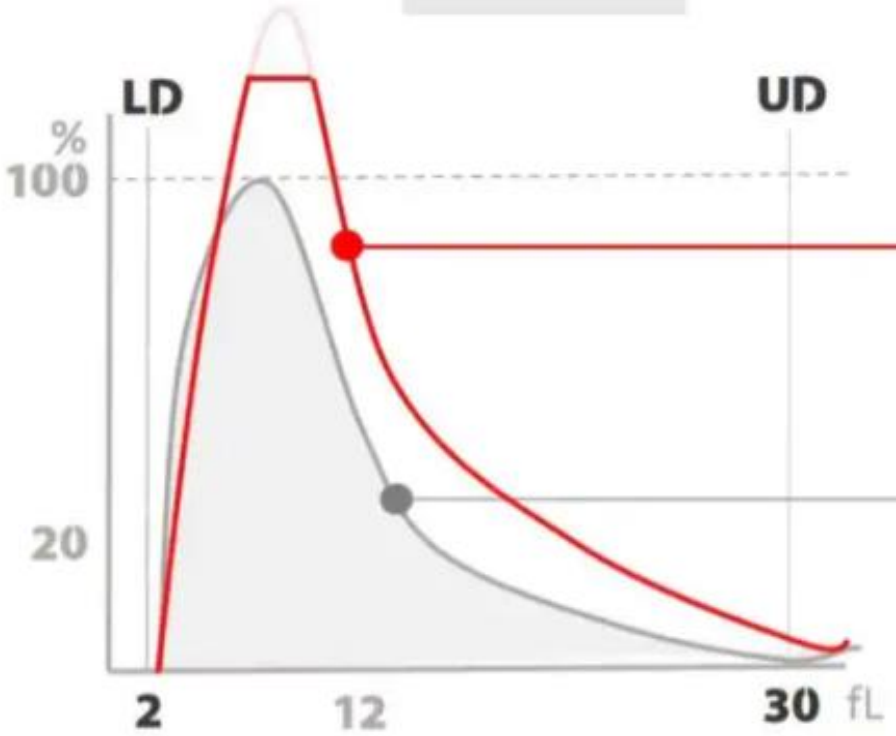
Parameters of Platelets Histogram

↑ PDW + ↑ P-LCR + ↑ MPV

Autoimmune thrombocytopenic purpura (ITP)

Thrombocytosis ▲

Platelet Histogram



Thrombocytosis Curve

Normal Curve

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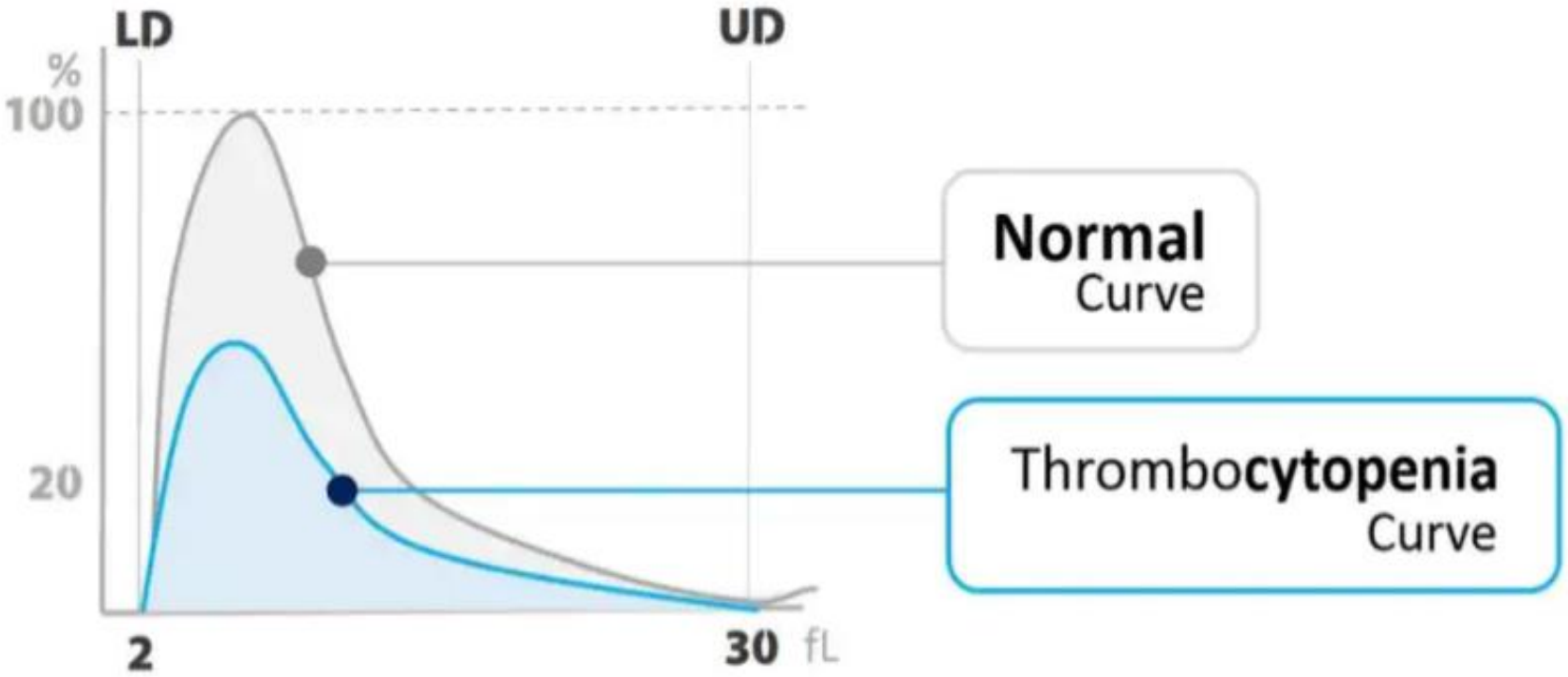
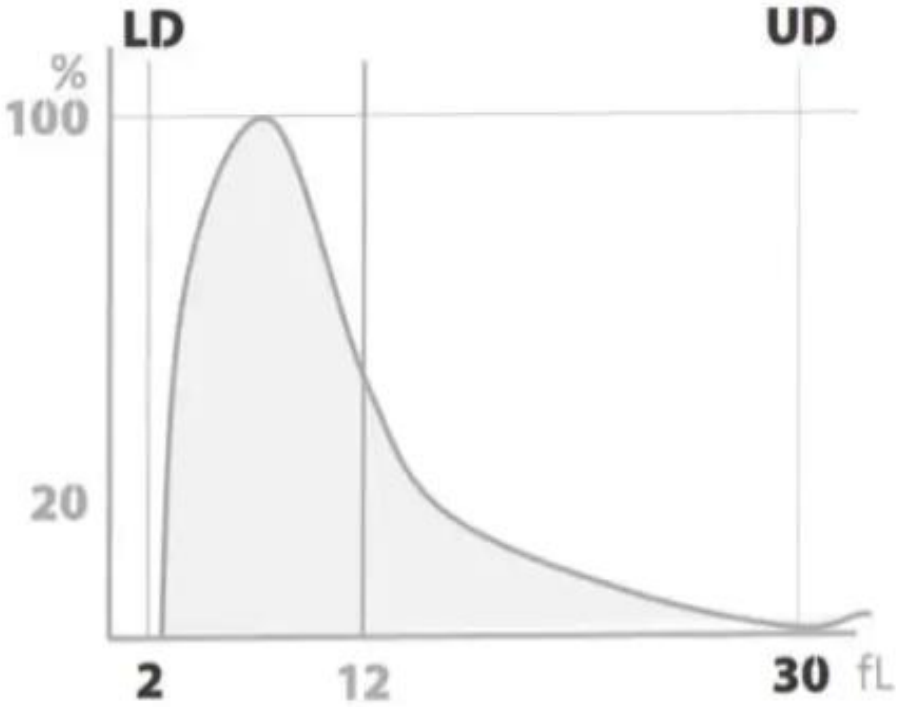
Thrombo**cytopenia**

Platelet Histogram



Platelet Histogram



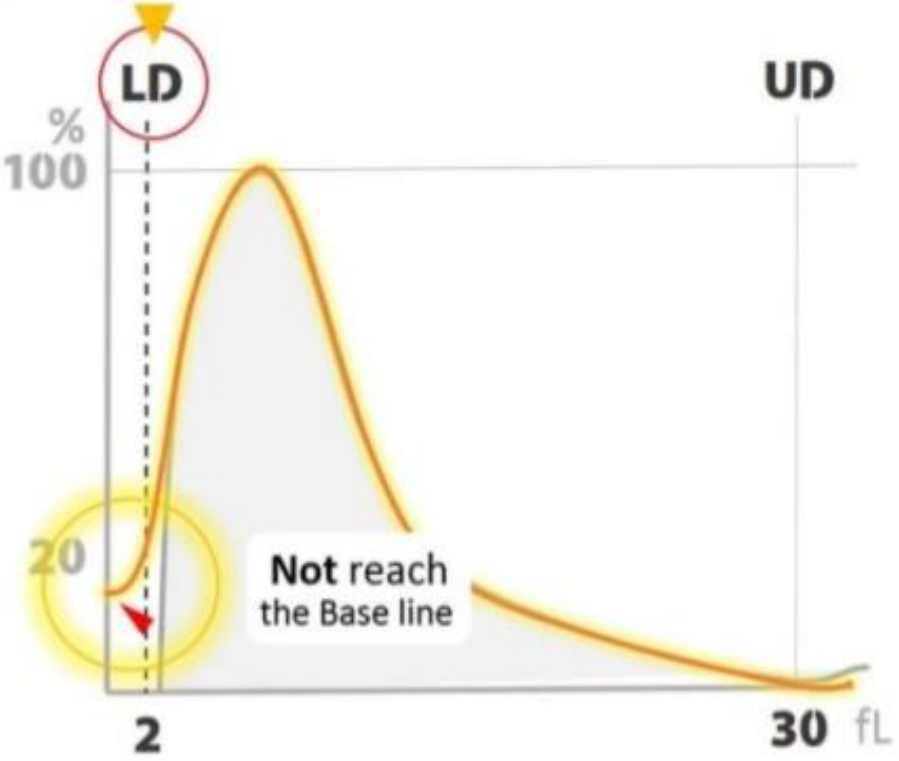
Platelet Histogram

List of PLT error flags in order of priority

PL	Relative frequency for LOWER discriminator (LD) exceeds the range. May be caused by electrical noise.
PU	Relative frequency for the UPPER discriminator (UD) exceeds the range. May be caused by electrical noise, platelet clumps, etc.
MP	Two or more peaks in the histogram.
DW	Particle distribution width error when the 20% frequency does not cross the histogram two times. The peak is taken as 100%.
AG	The particle count equal to or less than the LD exceeds a prescribed range. Probable cause is platelet agglutination, which does not alter the WBC count, but may result in decrease platelet count.

Platelet Histogram

1 LD Flag (PL Flag)



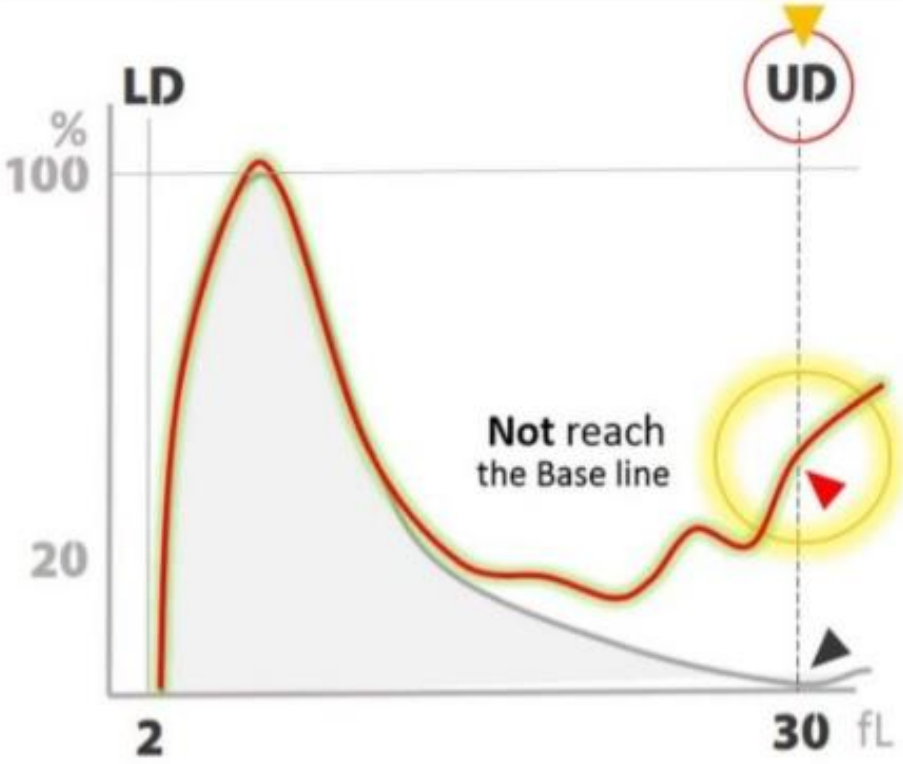
This flag appears when lower discriminator (LD) exceeds **preset height** by **10%.**

Possible Causes :

- High blank value
- Cell fragments
- Contaminated reagent
- High numbers of bacteria

PLTs count, P-LCR and MPV show PL flag

2 UD Flag (PU Flag)



Platelet Histogram

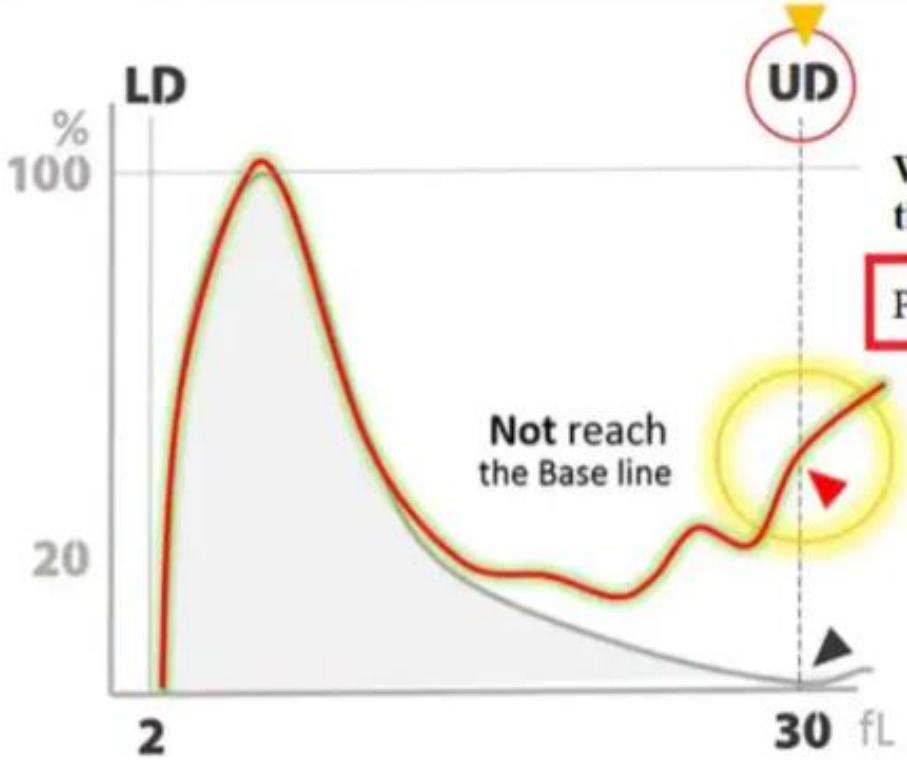
- Abnormal **height** at upper discriminator.
- This flag appears when UD exceeds the preset height by **> 40% .**

Possible Causes :

- PLT **Clumps** | Clotted sample
  | EDTA-Incombatibility
  [Re-collect on citrate]
  (X1.1)
- **Giant** Platelets
- Micro RBCs
- **(Schistocytes)**

2 UD Flag (PU Flag)

Platelet Histogram



When collect blood in citrate, multiply by 1.1 or use this formula ?

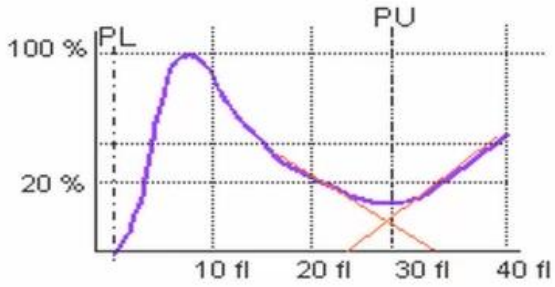
PLT count + (PLT count X Dilution with citrate)

Dilution with citrate= 10%

10% of citrate present with 90% blood

2 UD Flag (PU Flag)

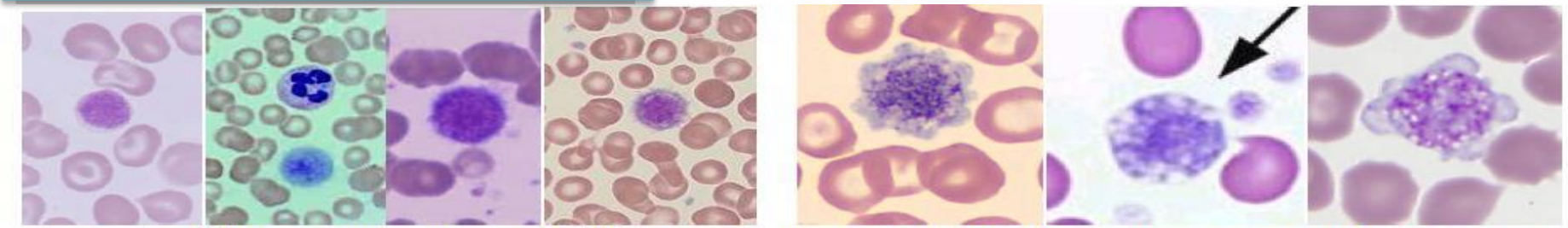
Platelet Histogram



- Example A curve
  - » Overlapping of both populations (PLT / RBC) is equal.
- Note:
  - » Extreme low MCV and the presence of many RBC fragments might interfere with the PLT result.
- Actions:
  - » The platelet result might be false and should be checked and controlled with alternative methods.

Possible cause:

- EDTA incompatibility
- Clotted sample
- Microcytes/schistocytes
- Giant Platelets
- PLT aggregates

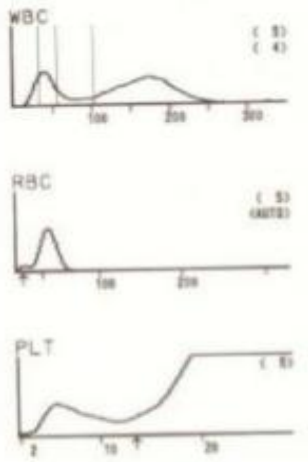


شکل ۳۸-۱۰: تفاوت جایانت پلاکت رتیکولار (جوان) با یک جایانت پلاکت معمولی که هردو باعث افزایش اندکس P-LCR می‌شوند ولی فقط پلاکت رتیکولار مقدار IPF را افزایش می‌دهد.

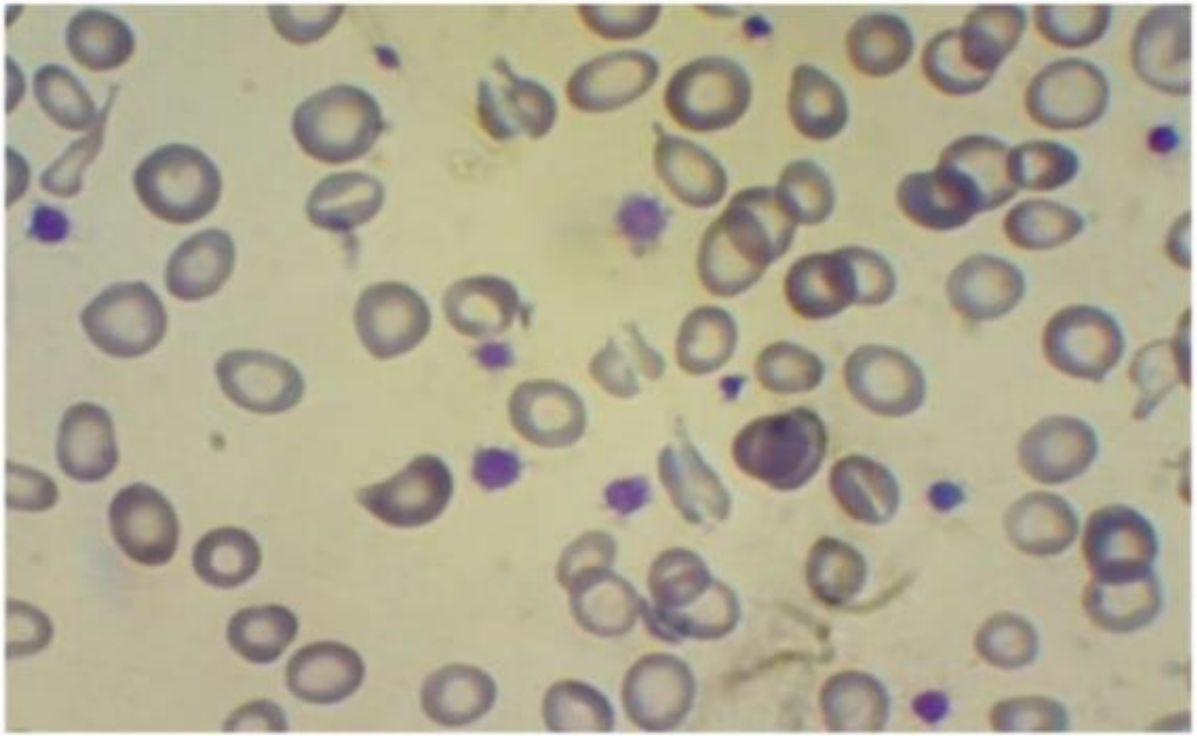
2 UD Flag (PU Flag)

Platelet Histogram

SAMPLE	TYPE :	Normal
WBC	7.6	10³/uL
RBC	3.65L	10⁶/uL
HGB	4.7L	g/dL
HCT	17.8L	%
MCV	48.8L	fL
MCH	12.9L	pg
MCHC	26.4↓	g/dL
PLT	267	10³/uL
LY	2.4	[31.5 %]
MO	0.2	[3.0 %]
GR	5.0	[65.5 %]
RDW	20.1H	%
PCT	0.17	%
MPV	6.0	fL
PDW	14.7	%



Giant PLTs and Micro RBCs→ PLT/RBC overlap



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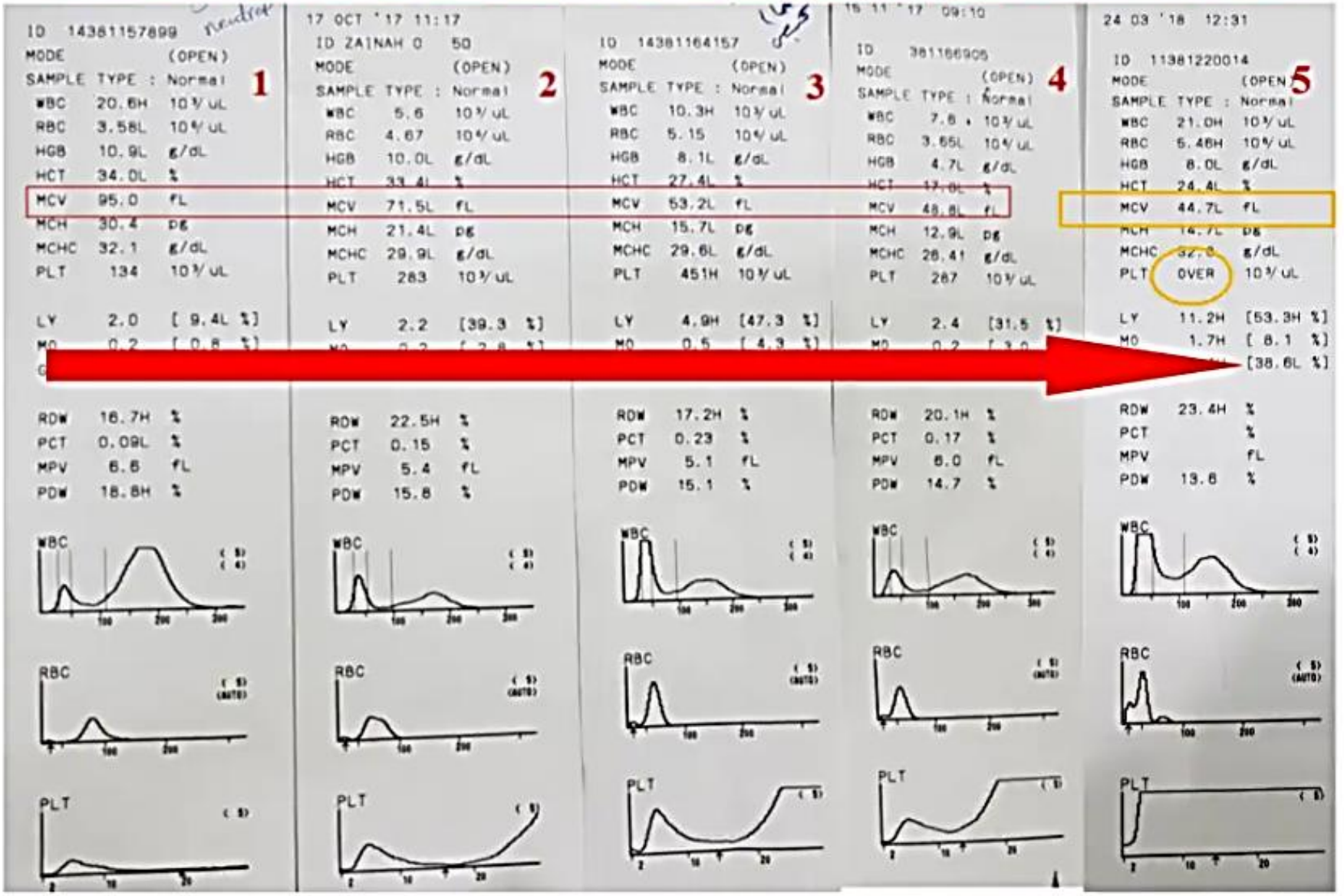
PLT/RBC overlap: Extreme microRBC's→ no clear separation in volume between PLT & RBCs



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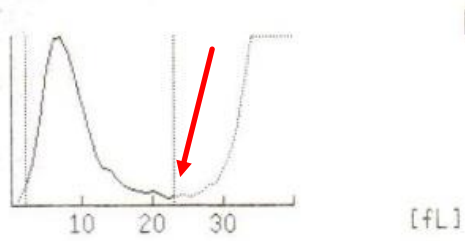
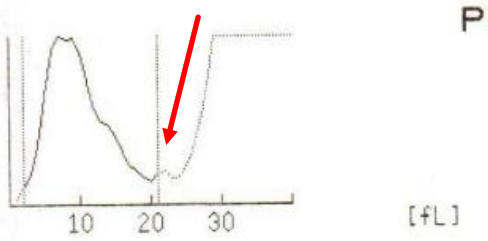
2 UD Flag (PU Flag)

Platelet Histogram



PDW	PL*	11.8fL
MPV	PL*	8.6fL
P_LCR	PL*	16.6%

WBC		7.0×10³/μL
RBC		6.01×10⁶/μL
HGB		13.3g/dL
HCT		42.1%
MCV	-	70.0fL
MCH	-	22.1pg
MCHC		31.6g/dL
PLT	PL*	194×10³/μL



PDW		15.2fL
MPV		10.0fL
P_LCR		28.3%

WBC		9.3×10³/μL
RBC	!	7.67×10⁶/μL
HGB		15.5g/dL
HCT		49.5%
MCV	-	64.5fL
MCH	-	20.2pg
MCHC		31.3g/dL
PLT		229×10³/μL

PDW	DW	---.-fL
MPV	PU	---.-fL
P_LCR	PU	---.-%

WBC		7.7×10³/μL
RBC		5.30×10⁶/μL
HGB	-	9.5g/dL
HCT	-	32.4%
MCV	-	61.1fL
MCH	-	17.9pg
MCHC	-	29.3g/dL
PLT	PU*	216×10³/μL

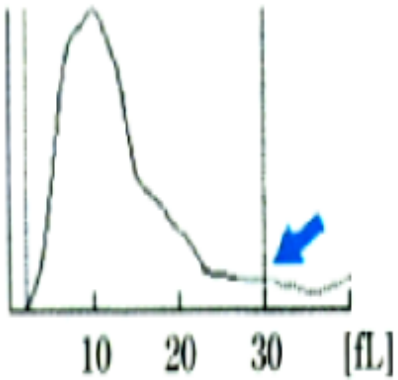
PLT is incorrect Low/high??

- In case of platelet aggregation, the PLT count is incorrect low.
  - Check EDTA incombatibility –e.g. re-collect the sample and use citrate as anticoagulance to avoid clocking caused by EDTA → X 1.1 or
  - Add Amikacin to CBC vial let stay for 15 min. then shake for 1-2 min and apply to cell counter
- In case of extreme microerythrocytes or fragmented RBC the PLT count might be incorrect high.
  - PLT results should be confirmed with alternative methods

2 (PU & DW Flag)

Platelet Histogram

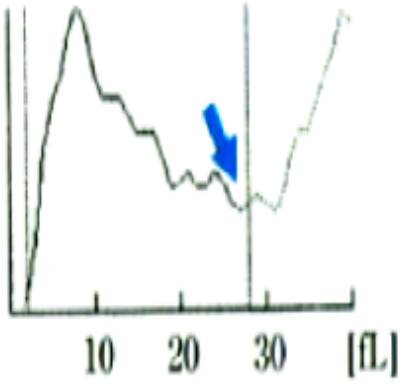
PLT-Histogram



Results

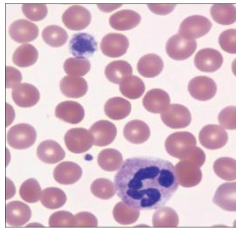
PLT		237 x10⁹/L
PDW	+	18.0fl
MPV		12.4fl
P-LCR	+	44.1%

PLT-Histogram



Results

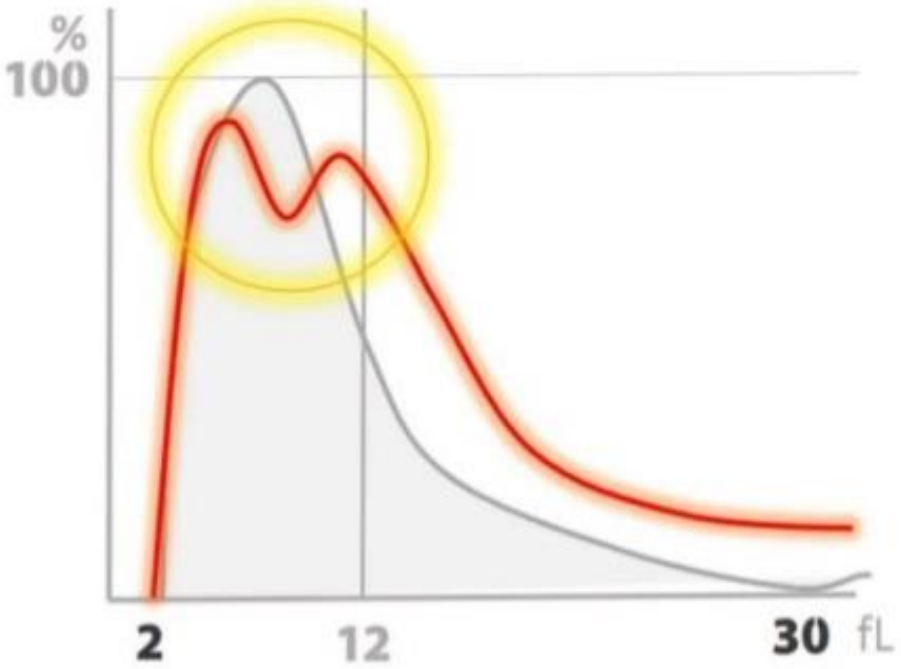
PLT	PU	71 x10⁹/L
PDW	DW	---.-fl
MPV	DW	---.-fl
P-LCR	DW	-.---%



شکل ۴۰-۱۰: هرچند هردو گراف به دلیل میل منحنی به سمت راست با حضور جایانت پلاکت همراه هست، ولی در گراف سمت چپ، دم سمت راست هیستوگرام در ارتفاع پایینی ممیز UD/PU را قطع کرده و لذا شمارش آن صحیح می‌باشد ولی در گراف راست، محل قطع شدن ممیز PU در ارتفاع بالاتری بوده و احتمالاً تعدادی از پلاکت‌های خیلی بزرگ و رتیکولار وارد محدوده شمارش RBC شدند و حتی احتمال دارد قسمتی از RBCهای خیلی کوچک یا شیستوسیت نیز وارد محدوده شمارش پلاکت شده باشند. لذا به دلیل فلاگ PU و DW، نتایج آن به صورت نقطه چین بوده و قطعاً شمارش دستگاه می‌بایست با PBS تایید و چک شود. در گراف سمت راست، پلاکت‌ها بزرگ‌تر و رتیکولارتر از گراف سمت چپ هستند. لازم به ذکر است که پلاکت رتیکولار و رتیکولوسیت هر دو مانند جایانت پلاکت و ماکروسیت بزرگ هستند ولی برخلاف آنها به دلیل داشتن RNA با تیازول یا آکریدین نارنجی فلورسنت هم می‌شوند و لذا IPF و IRF بالایی هم دارند.

3 MP Flag Multiple Peaks

Platelet Histogram



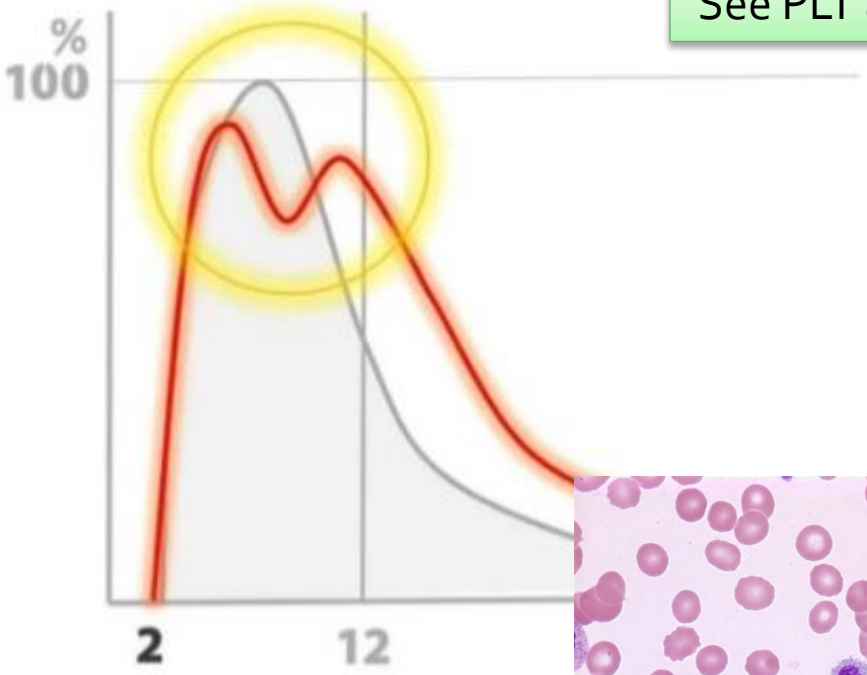
Possible Causes :

- Platelet transfusion
- Recovery from chemotherapy
- Platelet aggregation

3 MP Flag Multiple Peaks

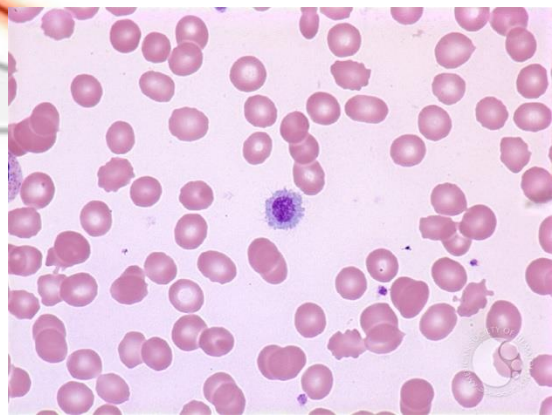
Platelet Histogram

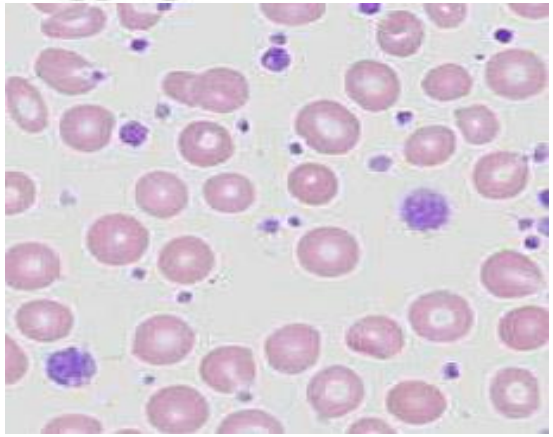
See PLT anisocytosis after chemotherapy



Possible Causes :

- Platelet transfusion
- Recovery from chemotherapy
- Platelet aggregation





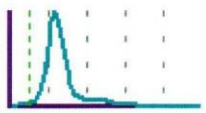
Beta-Thal- minor

Platelet Histogram

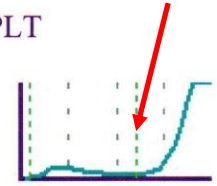
Parameters			Normal Ranges
WBC	9.94	[10^3/uL]	(4.50 - 11.50)
RBC	6.14 +	[10^6/uL]	(4.10 - 5.10)
HGB	11.5 -	[g/dL]	(12.0 - 16.0)
HCT	35.2 -	[%]	(36.0 - 46.0)
MCV	57.3 -	[fL]	(78.0 - 90.0)
MCH	18.7 -	[pg]	(25.0 - 35.0)
MCHC	32.7	[g/dL]	(31.0 - 36.0)
RDW-SD	36.4 -	[fL]	(37.0 - 54.0)
RDW-CV	20.0 +	[%]	(11.0 - 14.5)
PLT	230 *	[10^3/uL]	(150 - 450)
PDW	----	[fL]	(9.0 - 14.0)
MPV	----	[fL]	(9.0 - 12.0)
P-LCR	----	[%]	(13.0 - 43.0)
PCT	----	[%]	(0.17 - 0.35)

NEUT	8.23 +	[10^3/uL]	82.8 +	[%]	(37.0 - 72.0)
LYMPH	0.95 -	[10^3/uL]	9.6 -	[%]	(20.0 - 50.0)
MONO	0.51 +	[10^3/uL]	5.1	[%]	(0.0 - 14.0)
EO	0.23 +	[10^3/uL]	2.3	[%]	(0.0 - 1.0)
BASO	0.02	[10^3/uL]	0.2	[%]	(0.0 - 6.0)

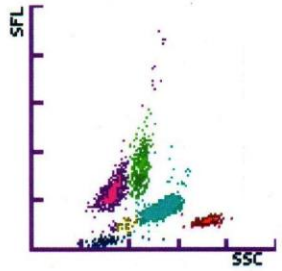
RBC



PLT



DIFF



WBC IP Message(s)

RBC IP Message(s)

Anisocytosis
Microcytosis
Erythrocytosis

PLT IP Message(s)

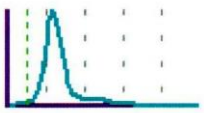
PLT Abn Distribution

Beta-Thal- minor

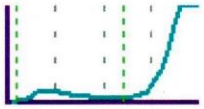
Platelet Histogram

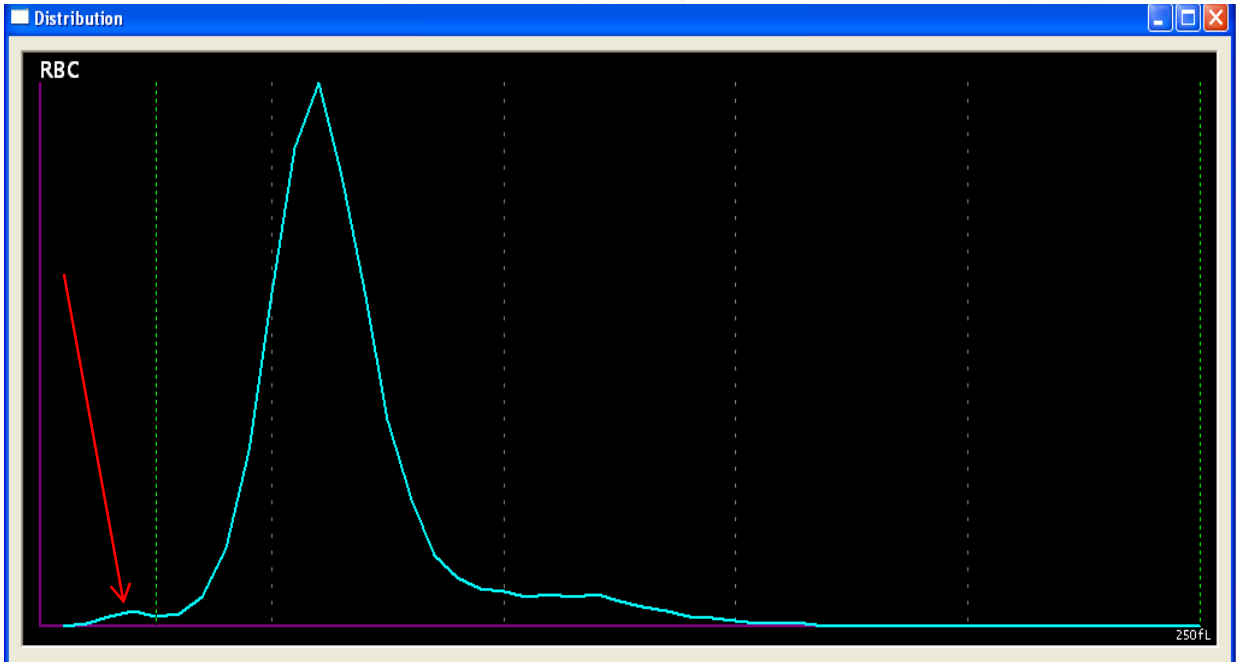
Parameters			Normal Ranges
WBC	9.94	[10^3/uL]	(4.50 - 11.50)
RBC	6.14 +	[10^6/uL]	(4.10 - 5.10)
HGB	11.5 -	[g/dL]	(12.0 - 16.0)
HCT	35.2 -	[%]	(36.0 - 46.0)
MCV	57.3 -	[fL]	(78.0 - 90.0)
MCH	18.7 -	[pg]	(25.0 - 35.0)
MCHC	32.7	[g/dL]	(31.0 - 36.0)
RDW-SD	36.4 -	[fL]	(37.0 - 54.0)
RDW-CV	20.0 +	[%]	(11.0 - 14.5)

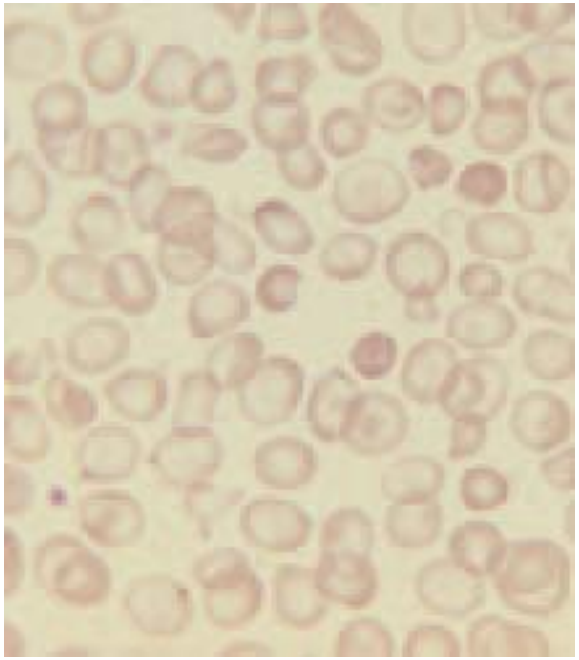
RBC



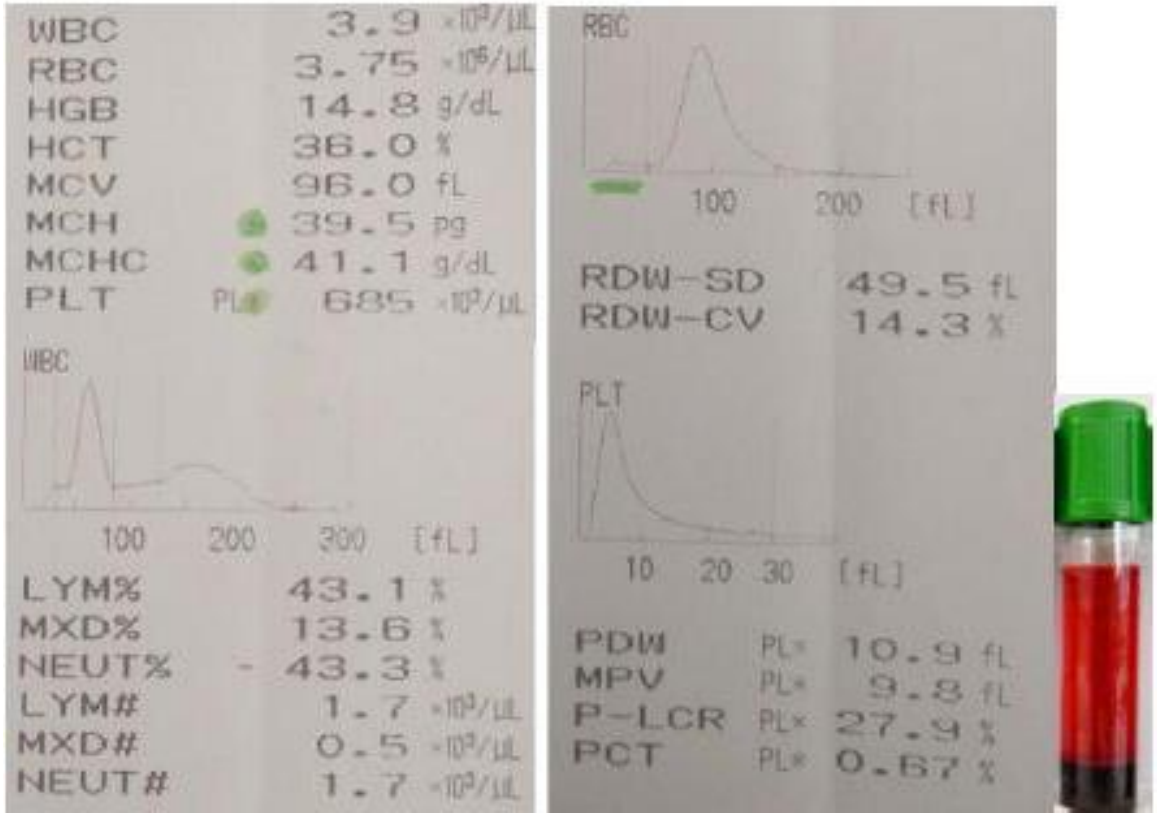
PLT





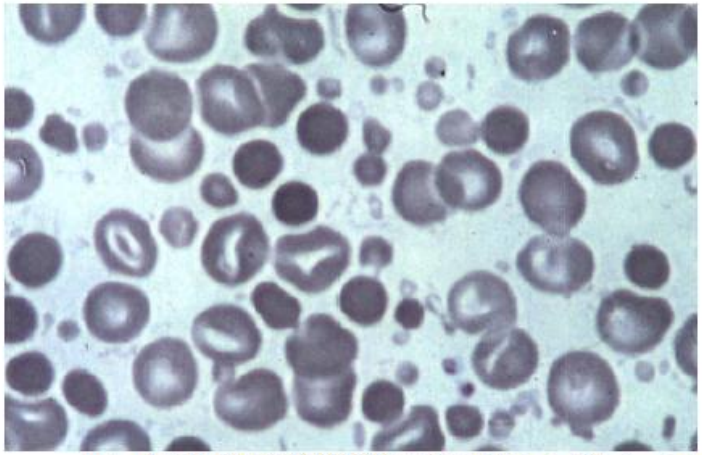


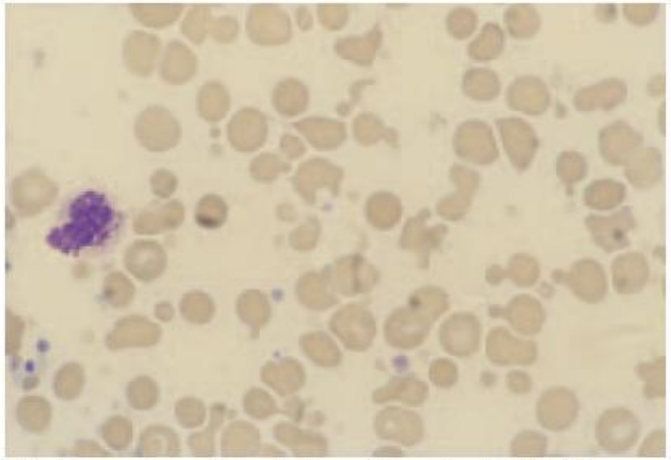
تاثیر همولیز شدید بر نتایج سل کانتر



نمونه خون همولیز شده و نتایج آزمایش اشتباه و کاذب است. در این نمونه مقدار Hgb و MCV تغییر نمی کند اما بدلیل لیز شدن شمارش RBC کاهش می یابد و مقدار MCH و MCHC بطور غیر منتظره ای افزایش می یابد.
توجه نمایید که MCHC بالاتر از ۳۶ امکان پذیر نیست و هموگلوبین شروع به کریستالیزه شدن می کند.
در نمونه ای که لیز شده ذرات و بقایای RBC با پلاکت ها شمرده می شوند که لازم است اسمیر بررسی شود.

تاثیر میکروسیتوز و شیستوسیتوز شدید در منحنی RBC و PLT

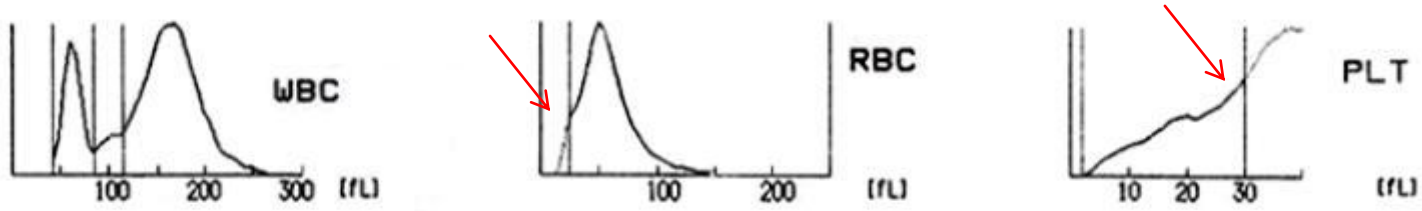




شکل ۱۰-۱۳۵: میکروسیتوز شدید ناشی از سوختگی و حرارت دیدن نمونه که با شمارش بجای پلاکت باعث افزایش PLT، PDW، MPV، RDW و MCV می‌شوند.

WBC		5.8×10³/μL	LYM%	21.0%				
RBC	RL*	5.65×10⁶/μL	MXD%	7.2%				
HGB	-	8.4g/dL	NEUT%	71.8%				
HCT	RL*	32.5%	LYM#	1.2×10³/μL				
MCV	RL*	57.5fL	MXD#	0.4×10³/μL				
MCH	RL*	14.9pg	NEUT#	4.2×10³/μL				
MCHC	RL*	25.8g/dL						
PLT	PU!	1884×10³/μL	RDW	RL* 32.3%				

PDW	DW	---.-fL
MPV	PU	---.-fL
P-LCR	PU	---.-%



شکل ۱۰-۹۰: افزایش شدید ولی کاذب پلاکت در اثر حضور شیستوسیت‌ها در خون محیطی که در دستگاه‌های روش امپدانس اغلب به‌عنوان پلاکت شمرده می‌شوند.

Examples of PLT, MPV

- PLT….decreased
- MPV…increased
  - **ITP, TTP, hepatits C, thyrotoxicosis, Lupus, H.pylori infections, HIV**

- PLT….increased
- MPV…increased
  - **MPN(ET,CML,MF,…)**

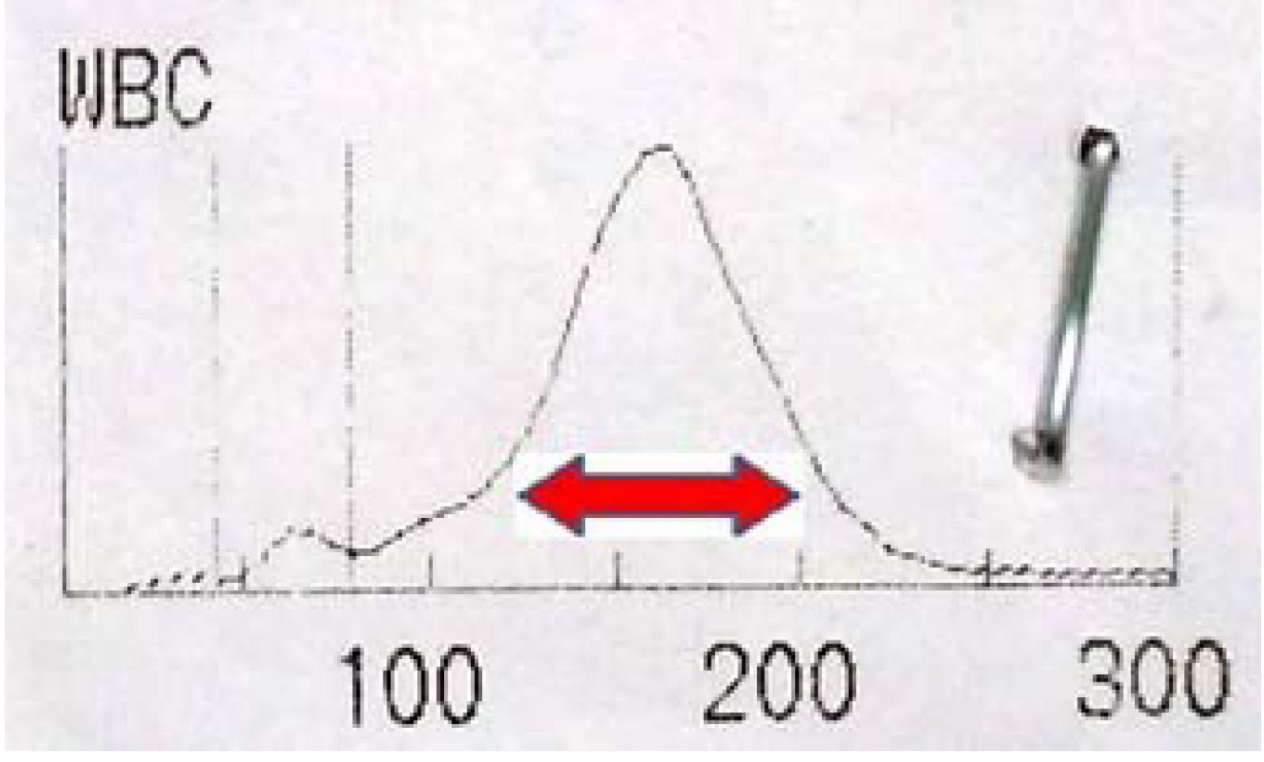
- PLT….decreased
- MPV…normal
  - **BM failure(malignancies,metastasis, AA,…)**

- PLT….increased
- MPV…decreased
  - **Reactive states, inflammation, rheumatologic diseases infections…..Kawasaki,…**

  - **Wiskott–Aldrich syndrome**: **MPV….very low & PLT count decreased**

Clinical Utility of Blood Cell Histogram Interpretation Case-1

- Case 1: A 56-year-old male presented with tiredness and early satiety. He had a massive splenomegaly. His Hb= 9.7 g/dl, WBC = of 64,000 per mm

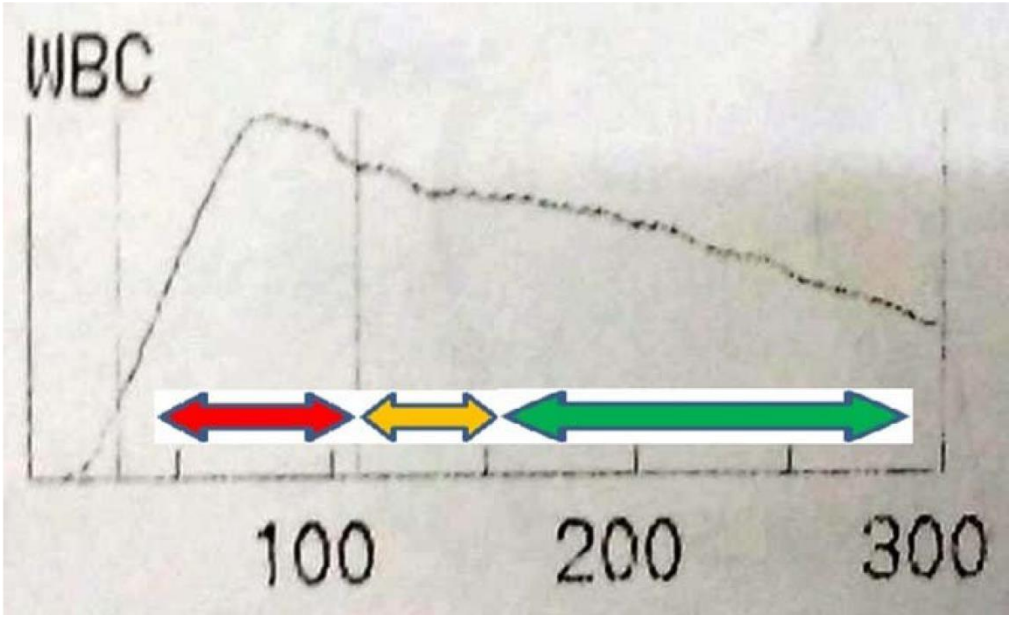


Clinical Utility of Blood Cell Histogram Interpretation Case-1

- Patient in the case 1 has leukocytosis with WBC distribution curve showing a peak in the region of neutrophils
- The two differential diagnoses for this WBC distribution were **CML** in chronic phase and leukemoid reaction
- As the patient was having massive splenomegaly, diagnosis was in favour of CML
- The myelocytes out number the more mature metamyelocytes in CML and are seen as the myelocyte bulge in WBC histogram (red arrow)

Clinical Utility of Blood Cell Histogram Interpretation Case-2

- Case 2: A 44-year-old male presented with tiredness and massive splenomegaly. His Hb =8.0 g/dl, WBC =2,57,000 per mm , PLT= 96,000 per mm



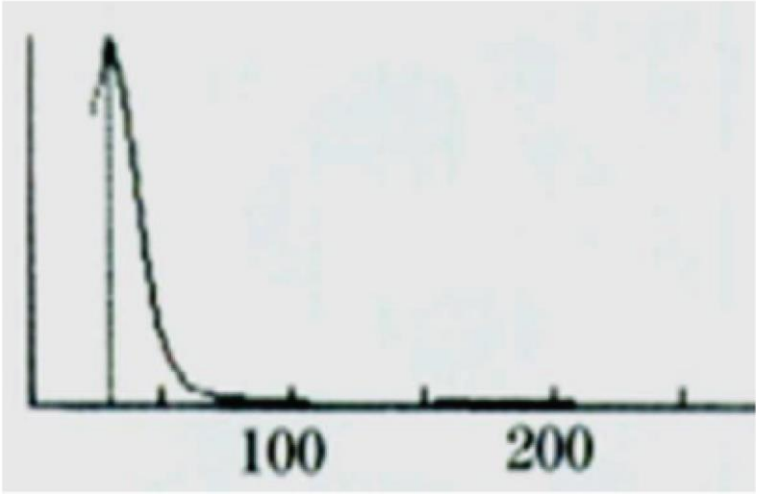
Blast cells -red arrow, basophils -yellow arrow, and cells at various stages of myeloid maturation are shown in green arrow.

Clinical Utility of Blood Cell Histogram Interpretation Case-2

- The patient in case 2 was in **blast crisis of CML**
- In the WBC distribution curve, the maximum number of cells was seen in the region of blasts (Red arrow)
- Blast cells occupy the region between 70-120 fL
- Cells at various stages of myeloid maturation were also increased (Green arrow)
- There was also marked basophilia (Yellow arrow)
- Diagnosis of blastic phase of CML from peripheral blood requires ≥20% blasts, which was obvious in this histogram

Clinical Utility of Blood Cell Histogram Interpretation Case-3

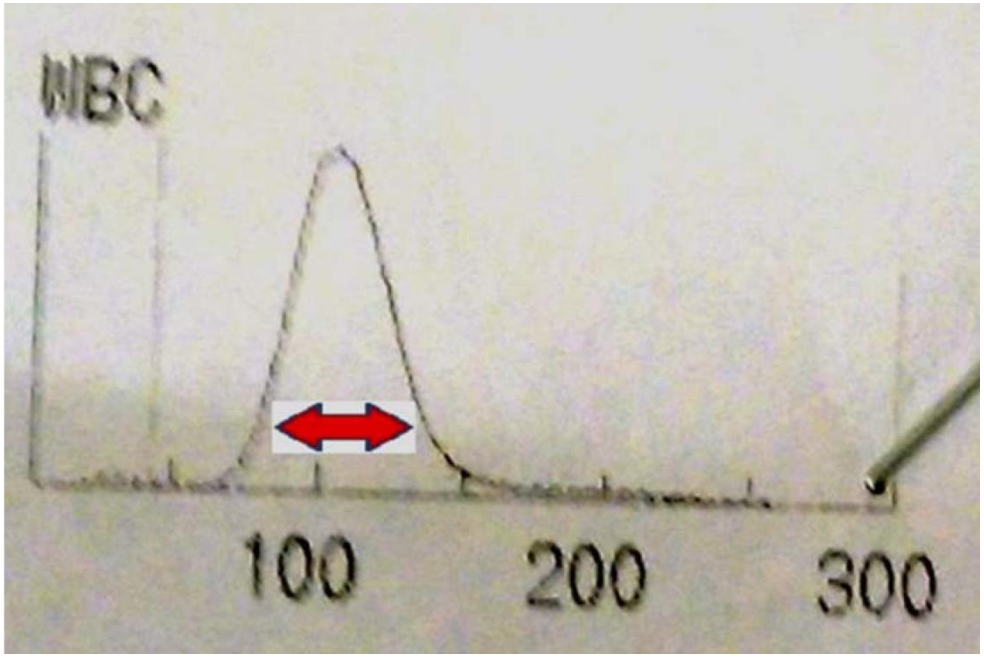
- Case 3: CBC of a 30-year-old female was done as a part of preoperative evaluation for an elective surgery. The WBC =3.49 million/micL



- The WBC count in case 3 was 3.49 million/mm^3 , which is in the range of RBC count. The histogram here shows a sliding curve. **Insufficient lysis of RBCs** due to the lack of stromatolyser solution resulted in the entry of RBCs into the WBC counting block, causing a spuriously high count. The ***differential diagnoses*** for spurious elevations of the WBC count are platelet clumps, nucleated RBCs, incomplete lysis of RBCs, cryoglobulins, and cryofibrinogen

Clinical Utility of Blood Cell Histogram Interpretation Case-4

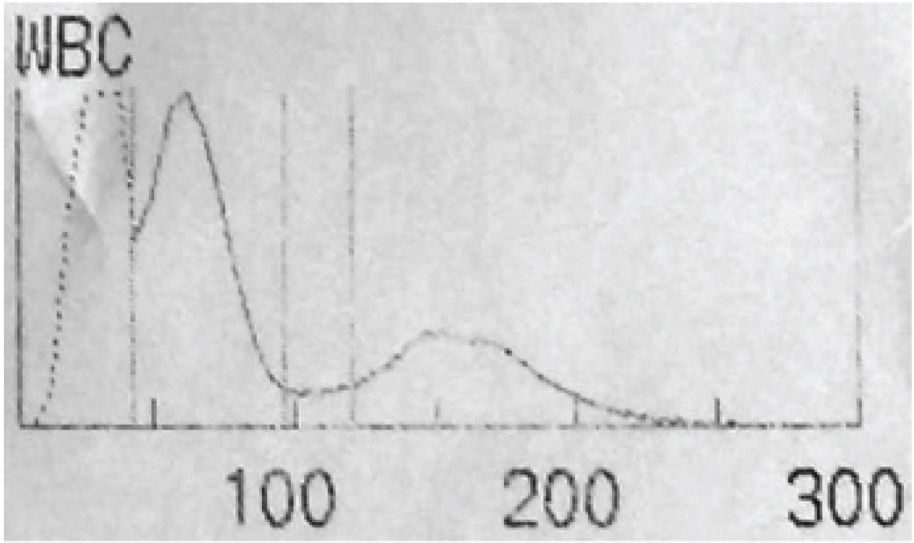
- A 63-year-old male came to Outpatient Department (OPD) with **tiredness** and intermittent **fever**. His Hb =6.6 g/dl, WBC =41,500, and PLT=20,000

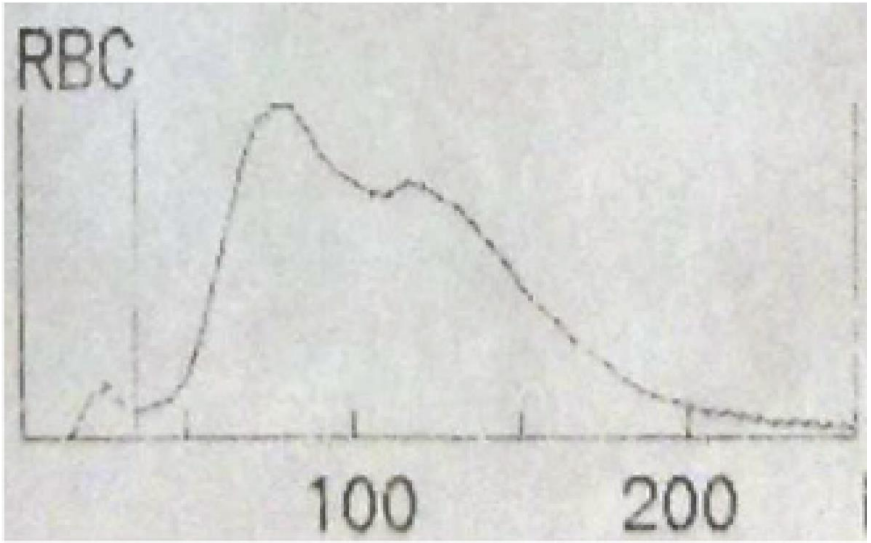


- The patient in case 4 has very high WBC count, all seen in the area of blasts (Red arrow). This is suggestive of acute leukemia

Clinical Utility of Blood Cell Histogram Interpretation Case-5

- A 17-year-old female presented with **tiredness**. Hb =7.8 g/dl and WBC =24,200





- In the WBC histogram, the dotted curve before the lymphocyte peak indicates nRBC. nRBCs will be counted as WBC in the cell counter. Looking into the RBC distribution curve, there are two peaks. The second peak in the RBC distribution (with higher MCV) curve indicates **reticulocytes**. Presence of significant number of nRBCs and reticulocytes are highly suggestive of **hemolytic anemia**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