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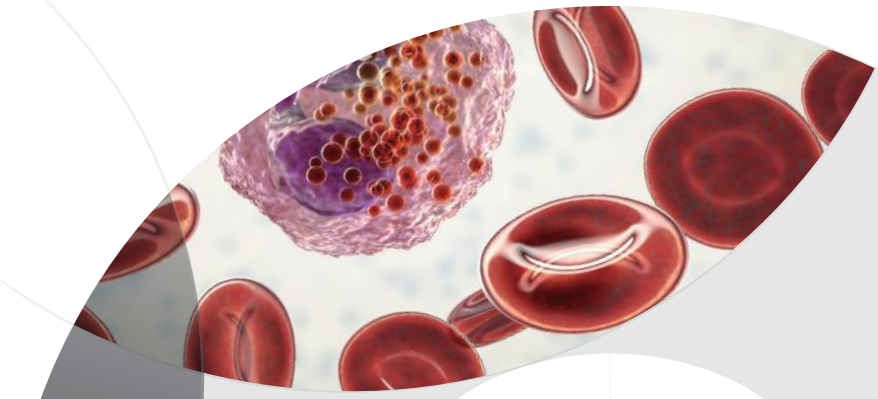
HemaCase

Clinical Case Booklet

By using Mindray Fully Automated Cellular Analysis Lines

Volume 2



We are excited to present our clinical case booklet on hematology. At Mindray, we are committed to making cutting-edge technology accessible to all, to ensure high-quality healthcare. As part of this commitment, we strive to enhance the accuracy and efficiency of hematology tests in clinical laboratories.

In this booklet, we provide real clinical cases that vividly illustrate the seamless integration of information from blood analyzers, morphological analysis, and clinical diagnostic data. With the assistance of our state-of-the-art Automated Digital Cell Morphology Analyzer MC-80, these cases showcase how early disease identification and diagnosis can be achieved.

Our goal is to empower laboratory personnel, like yourself, with invaluable insights in your daily work. By immersing yourself in these scenarios, we hope you will expand your knowledge and elevate the quality of patient care you provide.

Contents

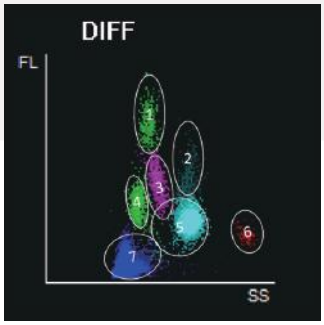
List of Abbreviations

WBC → White blood cell	Eos → Eosinophil	RET# → Reticulocyte count
Neu → Neutrophil	Eos# → Eosinophil count	RET% → Reticulocyte percentage
Neu# → Neutrophil count	Eos% → Eosinophil percentage	RHE → Reticulocyte hemoglobin expression
Neu% → Neutrophil percentage	Bas → Basophil	IRF → Immature reticulocyte fraction
Lym → Lymphocyte	Bas# → Basophil count	PLT → Platelet
Lym# → Lymphocyte count	Bas% → Basophil percentage	PLT-I → Platelet counting with impedance method
Lym% → Lymphocyte percentage	RBC → Red blood cell	PLT-O → Platelet counting with optical method
Mon → Monocyte	HGB → Hemoglobin	IPF → Immature platelet fraction
Mon# → Monocyte count	MCV → Mean corpuscular volume	
Mon% → Monocyte percentage	NRBC → Nucleated RBCs	

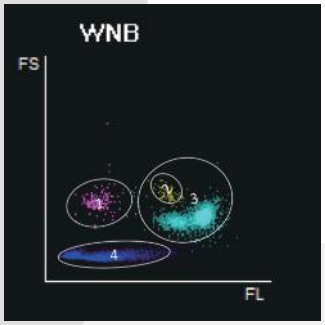
SF Cube™

DIFF Scattergram

1. Abnormal lymphocytes
2. Immature granulocytes
3. Monocytes
4. Lymphocytes
5. Neutrophils and basophils
6. Eosinophils
7. Ghost

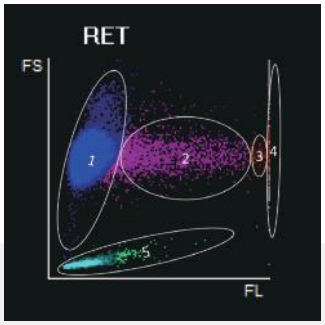


WNB Scattergram



1. Nucleated RBCs
2. Basophils
3. White blood cells
4. Ghost

RET Scattergram



1. Mature red blood cells
2. Low-fluorescence reticulocytes
3. Medium-fluorescence reticulocytes
4. High-fluorescence reticulocytes
5. Optical platelets

All morphological images in this case study book, unless otherwise noted, are stained with Wright-Giemsa solution

Case 01

Acute promyelocytic leukemia (APL)

01

Clinical information

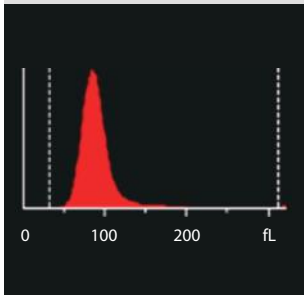
A 22-year-old female patient had fever for 1 month that worsened over the past week, accompanied by gingival bleeding. The patient was diagnosed as "thrombocytopenic purpura" by the local clinic. After treatment, gingival bleeding reoccurred and petechiae/ecchymosis in the lower limbs was observed.

CBC results

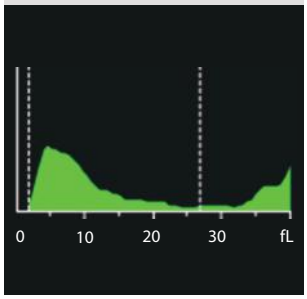
CBC results on Apr. 18

Parameter	Flags		Result	Unit
FR-CRP		H	40.50	mg/L
WBC	&	H	15.93	10^9/L
Neu#	& R		2.99	10^9/L
Lym#			****	10^9/L
Mon#			****	10^9/L
Eos#		L	0.01	10^9/L
Bas#			0.00	10^9/L
IMG#	R		0.00	10^9/L
Neu%	& R	L	18.7	%
Lym%			****	%
Mon%			****	%
Eos%		L	0.0	%
Bas%			0.0	%
IMG%	R		0.0	%
RBC		L	2.49	10^12/L
HGB		L	75	g/L
HCT		L	22.4	%
MCV			90.1	fL
MCH			30.2	pg
MCHC			335	g/L
RDW-CV			15.8	%
RDW-SD			49.7	fL
PLT		L	28	10^9/L
MPV			9.8	fL
PDW			17.0	
PCT		L	0.027	%
P-LCC		L	7	10^9/L
P-LCR			26.0	%
NRBC#			0.029	10^9/L
NRBC%			0.18	/100WBC

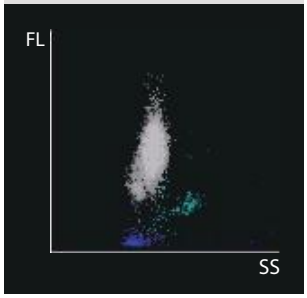
RBC



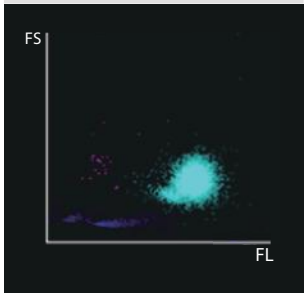
PLT



DIFF



WNB



Flags

-WBC Abn Scattergram
-Blasts?
-Abn Lymph/blast?
-Atyical Lymph?
-Anemia
-Thrombocytopenia

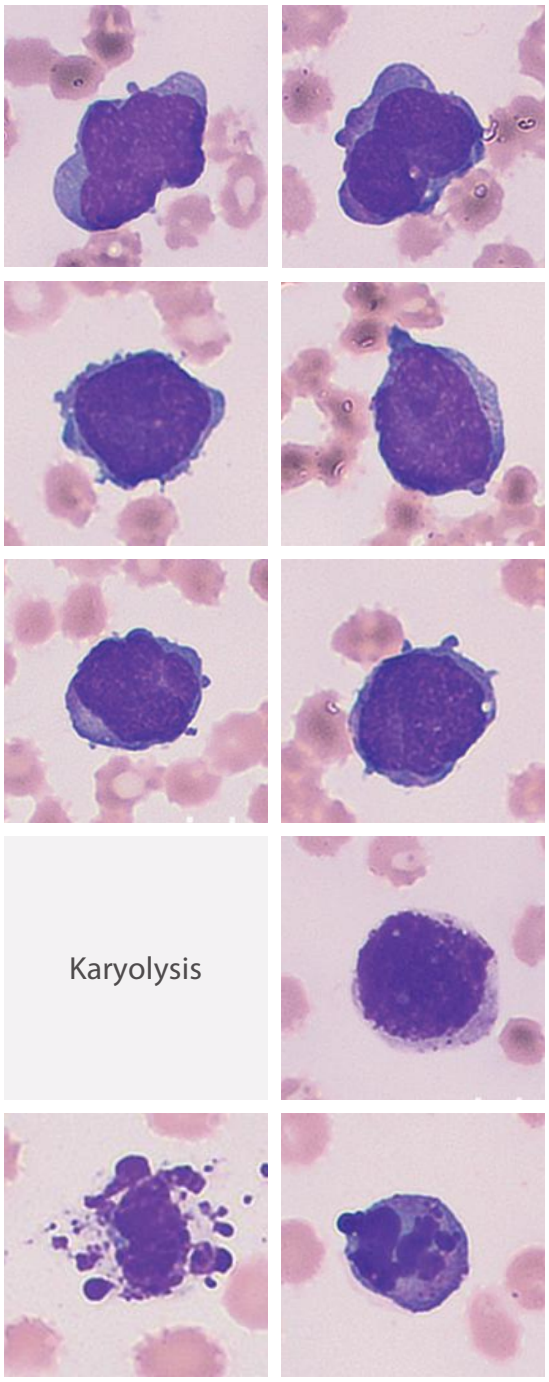
- WBC increased, Lym and Mon results were of poor reliability and were blocked; RBC and HGB both decreased, indicating moderate anemia; PLT count decreased.
- In the DIFF scattergram, the Lym and Mon group had unclear boundaries, the particles extended towards the upper right in general, and the Mon group was barely recognized as a spindle shape. A flag was raised for abnormal cells.

Peripheral blood morphology examination

Cells pre-classification by MC-80 on Apr. 18

	WBC		
	WBC	**419**	**100%**
L	Lymphocyte	52	12.4
L	Monocyte	12	2.9
	Basophil	1	0.2
	Myelocyte	1	0.2
!	Abnormal promyelocyte	353	84.3
	Non-WBC	**257**	**%**
	Nucleated RBC	2	0.5
	Giant PLT	1	
	Large PLT	9	
	PLT aggregation	1	
	Smudge cell	201	48.0
	Sediment	43	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	43*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	0.5
!	Microcyte	2+	19.6
	Color	**Degree**	**%**
	Hypochromic RBC	0	1.4
	Polychromatic RBC	0	0.3
	Shape	**Degree**	**%**
!	Poikilocytosis	3+	
	Schistocyte	0	0.9
!	Echinocyte	2+	7.2
	Elliptocyte	0	0.2
!	Ovalocyte	3+	13.0
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	0.6
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Abnormal promyelocytes



Karyolysis

Manual microscopic result

The microscopic examination showed no presence of neutrophils, but presence of lymphocytes (12.4%), monocytes (2.9%), and abnormal promyelocytes (84.3%).

The abnormal promyelocytes varied in cell body shape, with nuclei deformity, curved and folded. The particles were fine, the cell bodies showed irregular protrusions, the nucleoli were clearly recognizable, and no Auer body was definitely observed. Karyolysis was widely observed.

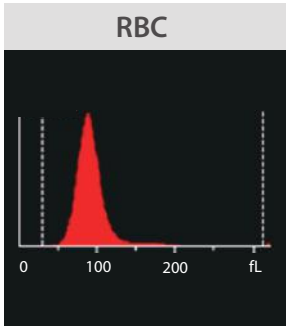
Other examinations

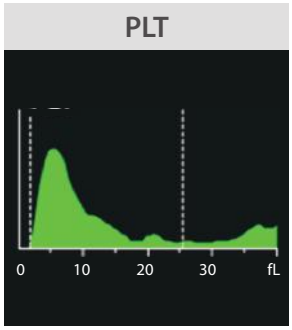
Item	Result	Reference range
LDH	323	120-250U/L
ESR	40	0-20mm/H
Bone marrow morphology	The microscopic bone marrow images showed acute myeloid leukemia M3, with presence of promyelocytes (86%)	
Immunophenotyping	Positive expression: HLA-DR, CD9, CD13, CD33, CD34, CD38, CD56, CD64, CD117, CD123, MPO	
FISH	PML-RARA fusion gene positive	
Fusion gene quantitative measurement	WT-1 positive	

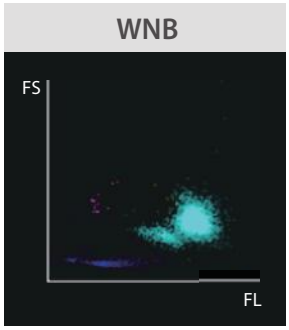
This patient was diagnosed as APL (Acute promyelocytic leukemia) accompanied by PML-RARA (M3). She was treated with retinoic acid combined with arsenic trioxide for induction therapy; platelets and red blood cells were infused; retinoic acid was used to treat the primary disease; anti-infection therapy, liver-protection therapy, and platelet elevation therapy were ongoing. After two weeks of treatment, the patient's conditions were improved.

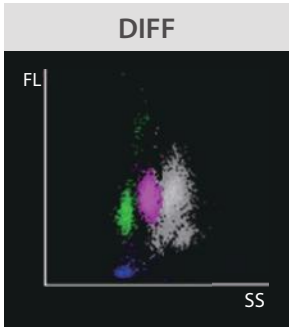
CBC results on May 1

Parameter	Flags	Result	Delta#	04-30	04-29	Unit
WBC	& H	12.27	-1.880	14.15	16.13	10^9/L
Neu#		****		****	****	10^9/L
Lym#	& R	1.11	-0.190	1.30	2.10	10^9/L
Mon#	R H	4.40	-0.810	5.21	6.72	10^9/L
Eos#	R L	0.00	0.000	0.00	0.00	10^9/L
Bas#	R	0.01	0.010	0.00	0.00	10^9/L
IMG#		****		****	****	10^9/L
Neu%		****		****	****	%
Lym%	& R L	9.0	-0.20	9.2	13.0	%
Mon%	R H	35.9	-0.90	36.8	41.7	%
Eos%	R L	0.0	0.00	0.0	0.0	%
Bas%	R	0.1	0.10	0.0	0.0	%
IMG%		****		****	****	%
RBC	L	2.80	-0.050	2.85	2.94	10^12/L
HGB	L	85	-2.0	87	90	g/L
HCT	L	26.2	-0.40	26.6	27.6	%
MCV		93.4	-0.10	93.5	93.9	fL
MCH		30.4	0.00	30.4	30.4	pg
MCHC		325	0.0	325	324	g/L
RDW-CV		15.2	-0.30	15.5	15.6	%
RDW-SD		49.9	-0.90	50.8	51.4	fL
PLT	L	45	5.0	40	38	10^9/L
MPV		9.1	-0.40	9.5	9.6	fL
PDW		17.0	-0.30	17.3	16.6	
PCT	L	0.041	0.0030	0.038	0.036	%
P-LCC	L	10	0.0	10	10	10^9/L
P-LCR		22.9	-2.60	25.5	26.6	%
NRBC#		0.022	-0.0280	0.050	0.039	10^9/L
NRBC%		0.18	-0.180	0.36	0.24	/100WBC









Flags

-WBC Abn Scattergram
-Blasts?
-Immature Gran?
-Left Shift?
-Monocytosis
-Anemia
-Thrombocytopenia

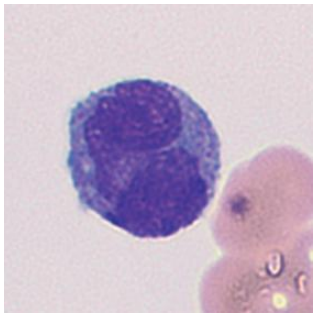
- WBC decrease was ongoing; RBC, HGB, and PLT were improving.
- Compared with the DIFF scattergram on Apr. 18, the number of particles in the Mon group decreased and the group location was significantly moving downward, indicating a decrease in abnormal promyelocytes; while in the Neu group, the number of particles increased and the group was extending towards the highly fluorescent region, indicating the presence of myelocytes and metamyelocytes.

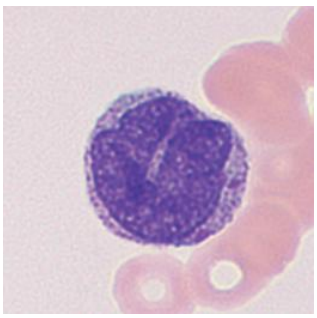
Other examinations

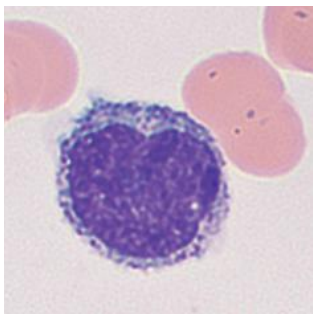
Cells pre-classification by MC-80 on May 1

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	17	8.5
L	Lymphocyte	20	10.0
H	Monocyte	95	47.5
!	Basophil	8	4.0
!	Myelocyte	18	9.0
!	Abnormal promyelocyte	42	21.0
	Non-WBC	**18**	**%**
	Nucleated RBC	1	0.5
	Large PLT	3	
	Smudge cell	12	6.0
	Sediment	2	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	34*10^9/L	Automated
	PLT concentration	34*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	0.4
!	Microcyte	2+	13.2
	Color	**Degree**	**%**
	Hypochromic RBC	0	3.7
	Polychromatic RBC	0	0.1
	Shape	**Degree**	**%**
!	Poikilocytosis	3+	
	Schistocyte	0	0.7
	Echinocyte	0	0.0
	Elliptocyte	0	0.2
!	Ovalocyte	3+	13.4
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	0.3
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Abnormal promyelocytes







Manual microscopic result

The microscopic examination showed the presence of neutrophils (8.5%), myelocytes (10%), and abnormal promyelocytes (21.0%), with the number of corresponding cells decreased compared with the previous examination. Karyolysis was observed in a small number of cells.

Case analysis

Acute promyelocytic leukemia (APL) is a malignant disorder of hematopoietic tissues. It is characterized by the infinite proliferation of abundant leukemic cells in the bone marrow. It is the mostly observed malignant disease in the young people and may be caused by viruses, radioactive elements, chemical toxins, etc.

AMLL-M3 often has the following features:

- Promyelocyte cytoplasm is filled with abnormal particles
- Often accompanied with a bleeding tendency
- A large number of patients are PML/RARA fusion gene positive
- These patients are sensitive to chemotherapy, but the mortality is high in the early stage, especially when treated with cytotoxic chemotherapy, about 10%–20% of the patients died from hemorrhage during the treatment
- Retinoic acid can induce the differentiation of APL cells into mature cells, while arsenical agents can induce their apoptosis
- The sustained remission duration is long. In the past, the treatment effect and prognosis of APL was very poor, often due to severe bleeding caused by concurrent DIC or primary fibrinolysis

In this case, the patient had experienced fever, severe gingival bleeding, and ecchymosis in the lower extremities for over a month before receiving a diagnosis. The lack of immunophenotyping and genetic diagnosis may have led to a misdiagnosis of thrombocytopenic purpura. Bleeding is a common cause of mortality in APL patients, so timely identification of abnormal cells from CBC results can minimize the negative effects of delayed conditions and treatment.

Additionally, karolysis was observed at the initial diagnosis, which may have been due to an autoimmune deficiency in the patient. Leukemia patients often have malfunctions in "immune surveillance" and "self-stabilization," which can cause aging or mutant cells to accumulate in the body. In some cases, the body may even treat its own tissue cells as foreign bodies.

Case 02

Acute promyelocytic leukemia (AML-M3)

02

Clinical information

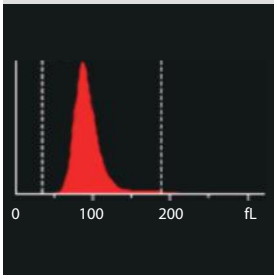
A 53-year-old female patient had hemoptysis for 3 days, accompanied with gingival bleeding. She had no symptoms of pyrexia, epistaxis, gross hematuria, or melena. Nor did she have dizziness, headache, loss of consciousness, cough, productive cough, tightness of the chest, shortness of breath, palpitations, or pericordial pain. Her hemoptysis was persistent. Physical examinations: T: 36.3 °C, P: 78 bpm, R: 18 times/min, BP: 146/86 mmHg. The patient was in good general conditions, with clear breath sounds in both lungs. HR: 78 bpm. The heart rhythm was normal and auscultation of each valve showed no pathological murmur. The abdomen was soft, with no tenderness or rebound tenderness. The liver and the spleen were not palpable.

CBC results

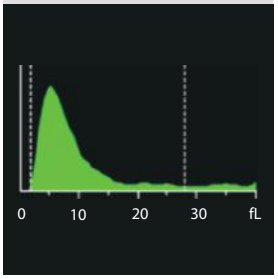
CBC results on Apr. 28

Parameter	Flagas			Result	Delta#	04-27	04-26	Unit
WBC	&			4.42	-0.510	4.93	3.31	10^9/L
Neu#	&	R	L	1.30		****	0.72	10^9/L
Lym#	&	R		1.05		****		10^9/L
Mon#		R	H	2.02		****		10^9/L
Eos#		R	L	0.00		****		10^9/L
Bas#		R		0.05		****		10^9/L
IMG#		R		0.12		****		10^9/L
Neu%	&	R	L	29.4		****	21.8	%
Lym%	&	R		23.8		****		%
Mon%		R	H	45.5		****	36.7	%
Eos%		R	L	0.1		****		%
Bas%		R	H	1.2		****		%
IMG%		R		2.7		****		%
RBC			L	3.02	-0.250	3.27		10^12/L
HGB			L	94	-6.0	100	117	g/L
HCT			L	27.6	-2.30	29.9		%
MCV				91.3	0.00	91.3		fL
MCH				31.2	0.60	30.6		pg
MCHC				342	7.0	335		g/L
RDW-CV				15.0	0.00	15.0		%
RDW-SD				49.3	-0.20	49.5		fL
PLT			L	54	43.0	11	19	10^9/L
MPV				9.1	-2.60	11.7		fL
PDW				17.0	-1.10	18.1		
PCT			L	0.049	0.0290	0.020		%
P-LCC			L	11	7.0	4		10^9/L
P-LCR				19.5	-19.50	39.0		%
NRBC#				0.054	-0.0290	0.083		10^9/L
NRBC%				1.23	-0.460	1.69		/100WBC

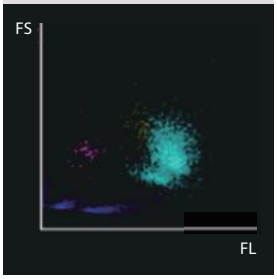
RBC



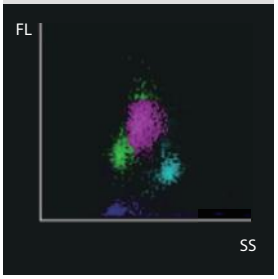
PLT



WNB



DIFF



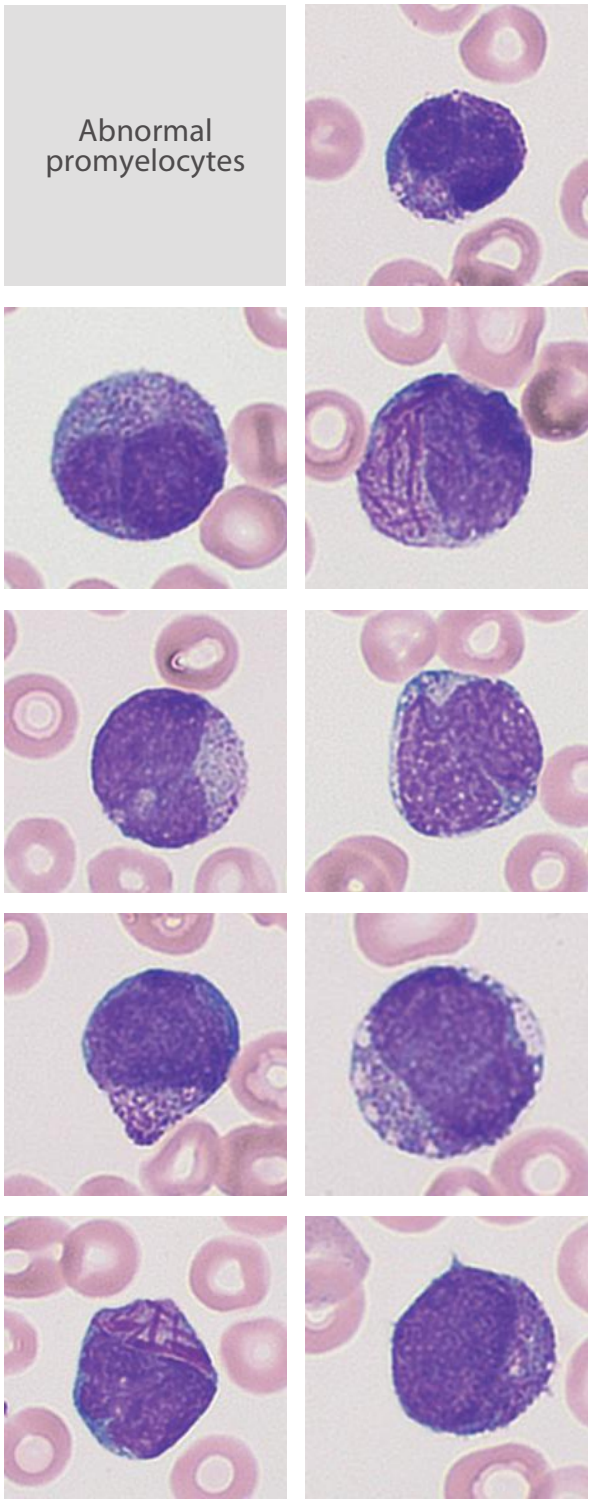
Flags

-Blasts?
-Abn Lymph/blasts?
-Immature Gran
-Atypical Lymph?
-NRBC
-Monocytosis
-Thrombocytopenia

- WBC was normal; Mon increased; mild anemia; PLT decreased.
- In the DIFF scattergram, the particles in the Neu group extended to the Mon group, while the particles in the Mon group significantly increased in number and were extending toward the highly fluorescent region, indicating the presence of abnormal cells.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	54	27.0
	Lymphocyte	50	25.0
L	Monocyte	2	1.0
	Basophil	1	0.5
!	Myelocyte	2	1.0
!	Myeloblast	8	4.0
!	Abnormal promyelocyte	83	41.5
	Non-WBC	**29**	**%**
	Nucleated RBC	3	1.5
	Large PLT	1	
	Smudge cell	21	10.5
	Sediment	4	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	43*10^9/L	Automated
	PLT concentration	62*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	3+	
	Macrocyte	0	0.7
	Microcyte	0	1.4
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	57.5
	Polychromatic RBC	0	0.2
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	0.6
	Echinocyte	0	0.1
	Elliptocyte	0	0.0
	Ovalocyte	0	3.8
	Stomatocyte	0	0.8
	Leptocyte	0	0.0
	Dacryocyte	0	0.5
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0



Manual microscopic result

The microscopic examination showed presence of neutrophils (27%), lymphocytes (25%), monocytes (1%), and abnormal promyelocytes (45.5%).

The abnormal promyelocytes varied in cell body shape, with nuclei twisted, curved, and folded. In the cytoplasm were coarse azurophilic granules. The bundle-like Auer bodies were easily observable.

Other examinations

Item	Parameter	Result	Reference range
Coagulation	PT	14.60	10.5-14.5 s
	PT-INR	1.13	0.75-1.15
	PT activity%	81.00	70%-150%
	APTT	34.10	28-43.5 s
	APTT ratio	1.00	0.8-1.28
	TT	16.40	14-21 s
	TT ratio	0.96	0.8-1.24
	Fibrinogen	1.54	2-4 g/L
	Antithrombin III	85.00	80%-120%
	D-dimer	3280.00	0-500 ng/mL
MPO	\	+	
BMIS	\	Extracellular iron (+); Intracellular iron: erythroblasts, rare	
Bone marrow morphology	\	Extremely active nucleated cell hyperplasia; presence of abnormal promyelocytes (82%), myelocytes and metamyelocytes were rarely observed. Suggested diagnosis: AML-M3a	

Case analysis

During the early stage of onset, the WBC count may still be normal in some M3 patients, hence leading to missed detection. Special alert should be paid to when abnormal Mon increase is observed. The abnormal cells are usually included in the Mon group due to high nucleic acid content and strong fluorescent signal. Special attention to the scattergram and alarms together with a comprehensive retesting rule can efficiently reduce the rate of missed detection.

Case 03

Acute myeloid leukemia (AML)

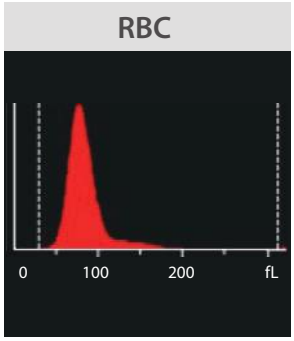
Clinical information

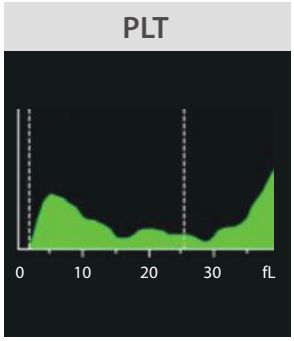
A 16-year-old female patient visited the local hospital due to pyrexia 2 weeks before. The CBC results showed WBC increased, Mon increased, mild anemia, and PLT decreased. The cell morphology examination showed presence of myeloblasts (46%). The patient was treated with hydroxy-urea to decrease WBCs and infused with PLTs, then transferred to our hospital.

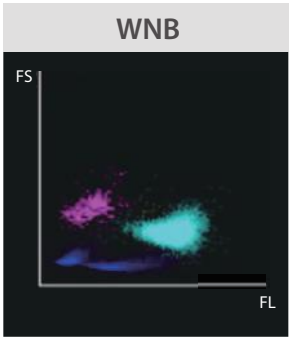
CBC results

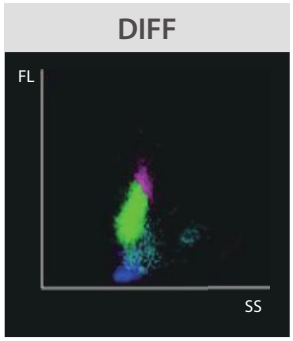
CBC results on Mar. 8

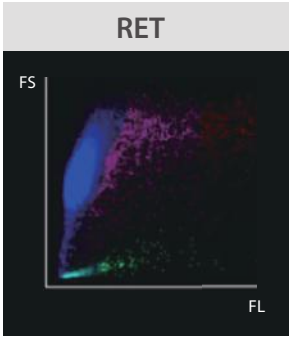
Parameter	Flags			Result	Delta#	02-22	Unit
WBC	&		H	14.90	-74.280	89.18	10^9/L
Neu#	&	R	L	0.55	-16.800	17.35	10^9/L
Lym#	&	R	H	13.75	-14.980	28.73	10^9/L
Mon#		R		0.58	-40.32	41.90	10^9/L
Eos#			L	0.01	-0.990	1.00	10^9/L
Bas#				0.01	-0.190	0.20	10^9/L
IMG#		R		0.00	0.000	0.00	10^9/L
Neu%	&	R	L	3.7	-15.80	19.5	%
Lym%	&	R	H	92.2	60.00	32.2	%
Mon%		R		3.9	-43.10	47.0	%
Eos%			L	0.1	-1.00	1.1	%
Bas%				0.1	-0.10	0.2	%
IMG%		R		0.0	0.00	0.0	%
RBC		R	L	2.74			10^12/L
HGB			L	84	4.0	80	g/L
HCT		R	L	26.1			%
MCV		R		95.1			fL
MCH		R		30.5			pg
MCHC		R		321			g/L
RDW-CV		R	H	17.2			%
RDW-SD		R		50.0			fL
PLT	&	R	L	42	23.0	19	10^9/L
MPV		R		11.3			fL
PDW		R	H	17.6			
PCT		R	L	0.055			%
P-LCC		R	L	16			10^9/L
P-LCR		R		38.1			%
IPF		R	H	12.0			%
RET#		R		0.10000			10^12/L
RET%			H	3.64			%
IRF			H	37.2			%
LFR			L	62.8			%
MFR				15.1			%
HFR			H	22.1			%
RHE			H	40.3			Pg
NRBC#				0.622			10^9/L
NRBC%				4.18			/100WBC











Flags

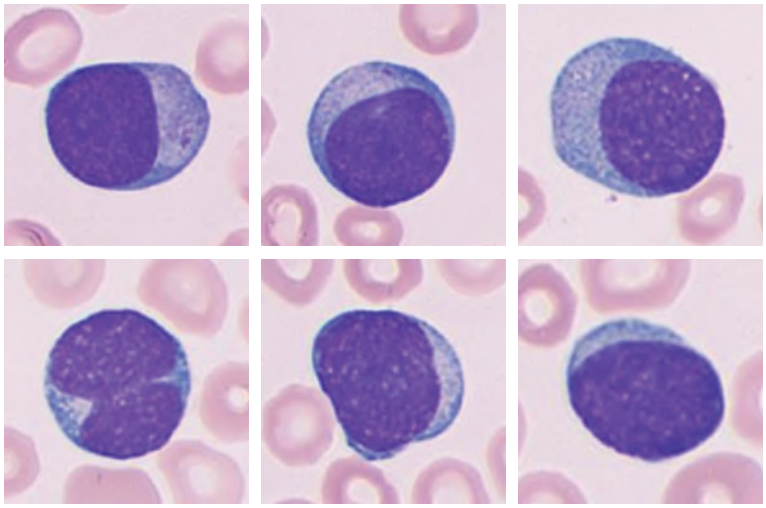
-WBC Abn Scattergram
-Blasts?
-Abn Lymph/blast?
-NRBC
-Lymphocytosis
-Neutropenia
-RBC
-Anemia
-PLT Clump?
-Thrombocytopenia

- Compared with 2 weeks before, WBC significantly decreased, especially Neu and Mon, indicating effective WBC reduction; HGB and PLT were slightly improved; IRF increased, indicating normal erythroid hyperplasia.
- In the DIFF scattergram, the number of particles significantly decreased in the Neu group and Eos group; a large quantity of particles existed between the Lym group and Mon group, leading to a fusion of Lym and Mon particles, showing a "long eggplant" shape. The RET scattergram showed a long tail of RBC particles downward, indicating fragmented RBCs.

Peripheral blood morphology examination

	WBC		
	WBC	**100**	**100%**
L	Segmented neutrophil	2	2.0
	Lymphocyte	34	34.0
L	Monocyte	1	1.0
!	Blast	63	63.0
	Non-WBC	**37**	**%**
!	Nucleated RBC	13	13.0
	Giant PLT	3	
	Large PLT	1	
	Smudge cell	10	10.0
	Sediment	10	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	48*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	1.9
	Microcyte	0	1.8
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	67.5
	Polychromatic RBC	0	1.6
	Shape	**Degree**	**%**
!	Poikilocytosis	1+	
!	Schistocyte	1+	2.4
	Echinocyte	0	1.0
	Elliptocyte	0	0.0
	Ovalocyte	0	4.0
	Stomatocyte	0	0.1
	Leptocyte	0	0.6
	Dacryocyte	0	1.9
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Blasts



Manual microscopic result

The microscopic examination showed presence of myeloblasts (63%) and nucleated red blood cells 15 cells/100 WBC.

The myeloblasts had large oval cell bodies. The nuclei were large, round or oval, and irregular shapes were occasionally observed; the nuclear chromatin was fine, some had visible nucleoli. Scant cytoplasm appeared pale blue, and a very small number of particles were observed.

Other examinations

Item	Result
Thalassemia gene mutation detection	Not detected
MDS FISH	Not detected
Bone marrow morphology	Markedly active bone marrow hyperplasia; myeloid (1%); erythroid (30%); decreased lymphocyte proportion, with normal shape; normal monocyte proportion and shape; presence of myeloblasts (63%); POX (+); compliant with the microscopic bone marrow images of acute myeloid leukemia.

Case analysis

This case was primarily diagnosed as Acute myeloid leukemia (AML). Further examinations are required, including flow cytometry, AML-related gene detection, fusion gene detection, and chromosomal examination.

Based on the peripheral blood morphology examination, the abnormal particles in the Lym and Mon regions should be myeloblasts in the CBC DIFF scattergram. These cells had low nucleic acid content due to WBC reduction therapy and were wrongly counted as Lym and Mon.

Case 04

Acute myeloid leukemia with maturation (AML-M2)

Clinical information

A 47-year-old male patient, previously healthy, initially visited the local hospital in the early October 2022 due to pyrexia accompanied with sore throat. The highest body temperature measured was 39 °C. His body temperature returned to normal after treatment with erythromycin in local hospital. On Oct. 14, the patient reexperienced pyrexia. The CBC showed WBC: 2.59*10^9/L, HGB: 72 g/L, PLT: 27*10^9/L. The patient was treated with cefuroxime (i.v.) but did not recover, and was also treated with anti-infective therapy (piperacillin, etc.).

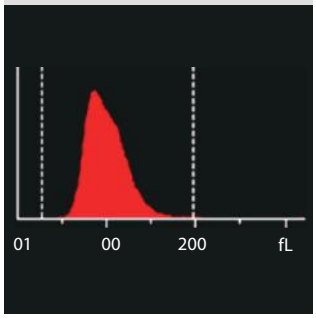
On Nov. 8, the patient visited the outpatient clinic due to pyrexia. The chest CT showed multiple exudative lesions in the left lower lung, subpleural atelectasis of lung tissue on the dorsal side of the right lung, and a small amount of left pleural effusion.

CBC results

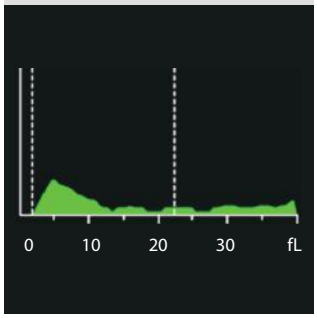
CBC results on Nov. 8

Parameter	Flags		Result	Unit
WBC			5.02	10^9/L
Neu#	R	L	0.06	10^9/L
Lym#	R	H	4.91	10^9/L
Mon#	R	L	0.02	10^9/L
Eos#			0.03	10^9/L
Bas#			0.00	10^9/L
IMG#	R		0.00	10^9/L
Neu%	R	L	1.1	%
Lym%	R	H	97.9	%
Mon%	R	L	0.4	%
Eos%			0.5	%
Bas%			0.1	%
IMG%	R		0.1	%
RBC		L	1.75	10^12/L
HGB		L	58	g/L
HCT		L	17.1	%
MCV			97.8	fL
MCH			33.0	pg
MCHC			337	g/L
RDW-CV		H	23.3	%
RDW-SD		H	83.2	fL
PLT		L	15	10^9/L
MPV			9.6	fL
PDW			16.7	
PCT		L	0.015	%
P-LCC		L	4	10^9/L
P-LCR			24.9	%
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC

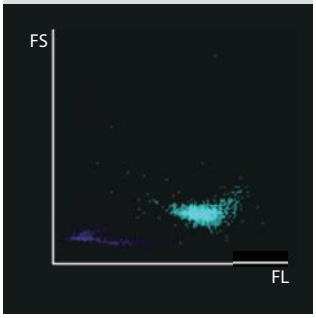
RBC



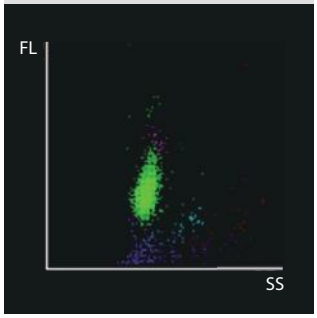
PLT



WNB



DIFF



Flags

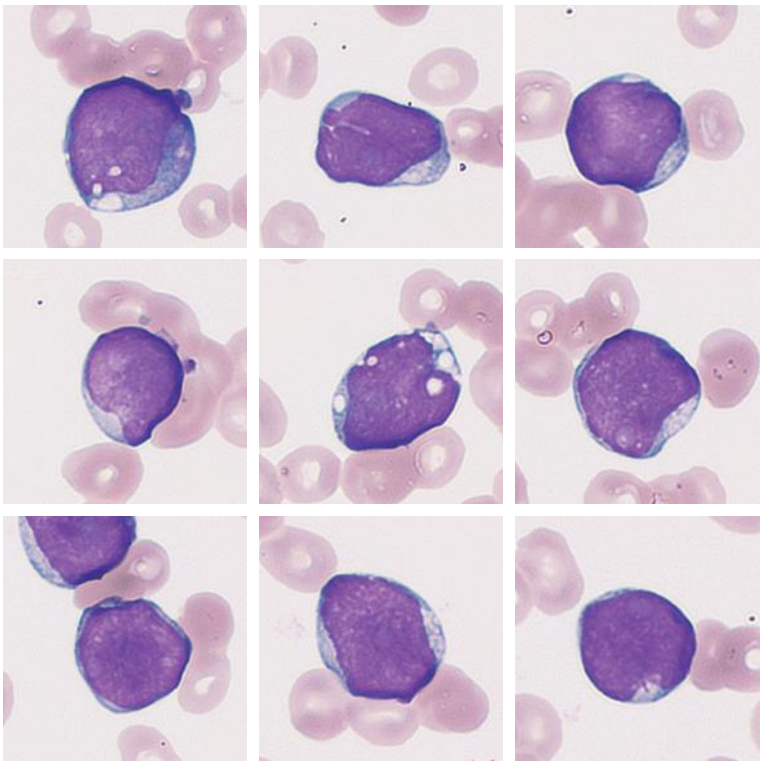
-WBC Abn Scattergram
-Abn Lymph/blast?
-Lymphocytosis
-Neutropenia
-Dimorphic population
-Anemia
-Thrombocytopenia

- WBC normal, but Lym abnormally increased; severe anemia; PLT extremely decreased.
- In the DIFF scattergram, the Lym particles fused with the Mon particles and extended towards the highly fluorescent region, appearing as a "long eggplant" or "baseball bat".

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	1	0.5
	Lymphocyte	68	34.0
!	Myeloblast	104	52.0
!	Reactive lymphocyte	27	13.5
	Non-WBC	**56**	**%**
	Large PLT	3	
	PLT aggregation	1	
	Smudge cell	26	13.0
	Sediment	26	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	46*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	3.9
	Microcyte	0	4.9
	Color	**Degree**	**%**
	Hypochromic RBC	0	0.3
	Polychromatic RBC	0	0.0
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	0.7
	Echinocyte	0	0.1
	Elliptocyte	0	0.6
	Ovalocyte	0	10.8
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	1.1
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Blasts



Manual microscopic result

Presence of myeloblasts (60%) with large round cell bodies and large, round or oval nuclei with fine and sand-like chromatins. Some had visible nucleoli and scant cytoplasm that appeared pale blue; thin and long single Auer body can be seen in some cytoplasm; vacuoles were observable in individual cytoplasm.

Other examinations

Item	Result
Bone marrow morphology	Markedly active bone marrow hyperplasia, M:E = 13.54:1. Markedly blasts portion increased (approx. 88%); Auer bodies were easily recognized in cytoplasm. A total of 13 megakaryocytes were counted and no megakaryocyte platelet was observed.
Bone marrow immunophenotyping	A group of abnormal cells can be seen in the myeloid blasts extended distribution area, accounting for approx. 88.6% of nucleated cells, expressing CD7, CD13, CD34, CD38, CD117, and MPO; some cells expressed HLA-DR, CD5, and CD64. Suggested diagnosis: AML (M2 possible)
Chromosome	47, XY, +10[10]. Leukemia-related fusion gene detection was all negative. Gene mutation showed that IDH1 detected missense mutation c.394C>T(p.Arg132Cys) (mutation frequency 44.52%).

Case analysis

Auer bodies are commonly observed in AML-M2, APL, MDS, and MPN. This case can be diagnosed as AML-M2 with reference to the flow cytometry and chromosomal genotype results. For M2 patients, their peripheral blood WBCs may be increased, normal, or decreased. Special attention should be paid to the scattergram and alarms. Retesting should be timely conducted when abnormal distributions of Lym and Mon particles are observed.

Case 05
Acute myeloid leukemia (AML)

05

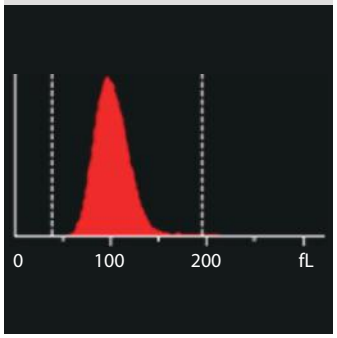
Clinical information

A 60-year-old male patient visited the Department of Hematology and was discovered pancytopenia.

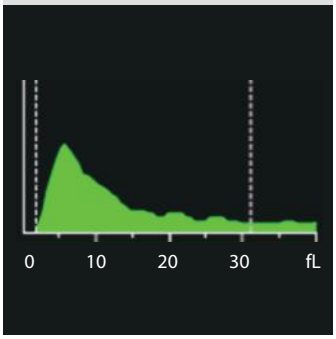
CBC results

Parameter	Flags			Result	Unit
WBC	&		L	1.66	10^9/L
Neu#	&	R	L	0.17	10^9/L
Lym#	&	R		1.22	10^9/L
Mon#		R		0.24	10^9/L
Eos#				0.02	10^9/L
Bas#				0.01	10^9/L
IMG#		R		0.00	10^9/L
Neu%	&	R	L	10.5	%
Lym%	&	R	H	73.0	%
Mon%		R	H	14.7	%
Eos%				1.2	%
Bas%				0.6	%
IMG%		R		0.0	%
RBC			L	2.22	10^12/L
HGB			L	77	g/L
HCT			L	22.9	%
MCV			H	102.9	fL
MCH			H	34.6	pg
MCHC				336	g/L
RDW-CV			H	17.4	%
RDW-SD			H	63.9	fL
PLT	&		L	40	10^9/L
RET#				0.0205	10^12/L
RET%				0.92	%
IRF				23.8	%
NRBC#				0.103	10^9/L
NRBC%				6.20	/100WBC

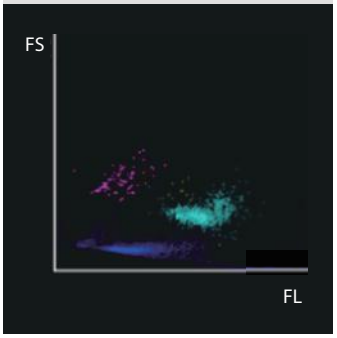
RBC



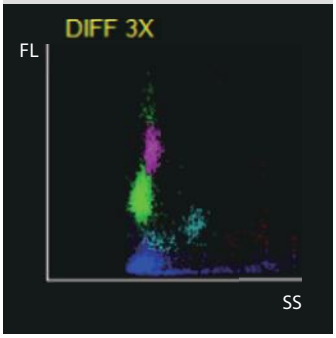
PLT



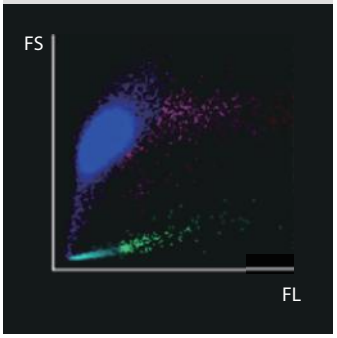
WNB



DIFF



RET



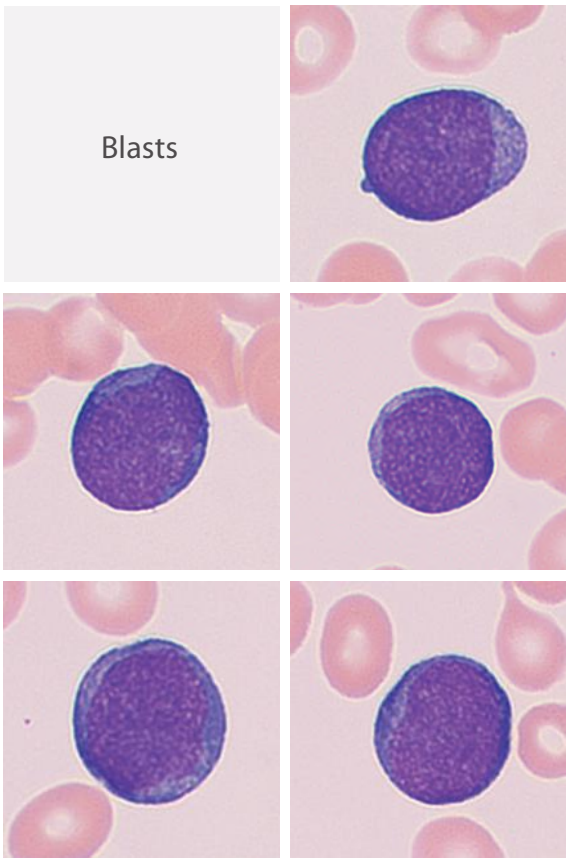
Flags

-Pancytopenia
-Blasts?
-Abnormal Lymph/blast?
-NRBC
-Neutropenia
-Leukocytopenia
-Anemia
-Thrombocytopenia

- WBC decreased, the retest rule was triggered, Lym% and Mon% increased; HGB and PLT both decreased.
- The DIFF scattergram showed that the Mon particles were in the highly fluorescent region, half a group position higher than the normal Mon group, which were suspected as abnormal cells.

Peripheral blood morphology examination

	WBC		
	WBC	**189**	**100%**
L	Segmented neutrophil	13	6.9
	Band neutrophil	2	1.1
H	Lymphocyte	141	74.7
	Monocyte	8	4.2
	Basophil	1	0.5
	Metamyelocyte	1	0.5
!	Myeloblast	15	7.9
	Reactive lymphocyte	3	1.6
	Others	5	2.6
	Non-WBC	**54**	**%**
!	Nucleated RBC	2	1.1
	Giant PLT	9	
	Large PLT	7	
	Smudge cell	15	13.2
	Sediment	21	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	41*10^9/L	Automated
	PLT concentration	58*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	4.8
	Microcyte	0	5.2
	Color	**Degree**	**%**
	Hypochromic RBC	0	0.1
	Polychromatic RBC	0	0.0
	Shape	**Degree**	**%**
!	Poikilocytosis	3+	
	Schistocyte	0	0.3
	Echinocyte	0	0.0
	Elliptocyte	0	1.1
!	Ovalocyte	3+	25.6
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	1.7
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0



Manual microscopic result

Presence of myeloblasts (7.9%), with uneven cell body sizes, most round or oval; moderate amount of cytoplasm, which appeared blue or dark blue, with darker edges; a small number of cells contained few azurophilic granules; the nuclei were round or oval and few were retracted, folded, or kidney-shaped; the chromatins were fine and evenly distributed, some had visible nucleoli.

Other examinations

Item	Result
Bone marrow morphology	Markedly active bone marrow hyperplasia, M:E = 0.48:1; presence of myeloblasts (35.0%); POX: 13% positive. Suggested diagnosis: microscopic bone marrow images of acute leukemia.
Flow cytometry	Presence of abnormal immature myeloid cells (29.2%); expressing: CD38, CD117, CD13, CD33 bri; partially expressing: CD7; not expressing: MPO, CD15, CD64, CD11b, CD11c, CD56, CD19, CD24, cCD79a. Suggested diagnosis: AML
Gene detection	A total of 42 leukemia-related fusion genes were detected: WT1 copy number 855337.0, ABL copy number 3518728, WT1 quantitative measurement 24.3081%, the rest were all negative. The myeloid leukemia prognostic gene detection showed NPM1 positive.

Case analysis

NPM1 mutation is one of the most common gene mutations in AML. NPM1 protein is a nucleolar protein. The mutant protein can be released from the nucleoli into cytoplasm, hence resulting in AML. Studies have shown that the NPM1 mutant protein (NPM1c) can bind to the chromatin, induce Hox gene high expression, and promote the occurrence of AML. At present, there is no specific treatment regimen for NPM1 gene mutant AML. The treatment is mainly referring to the clinical treatment regimen for AML.

Case 06

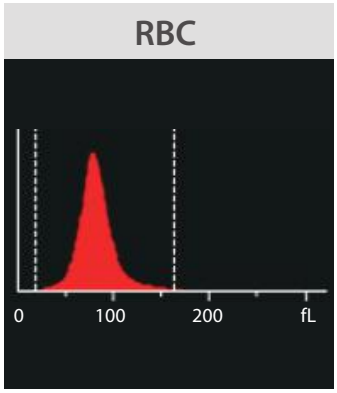
Acute myeloid leukemia (AML)

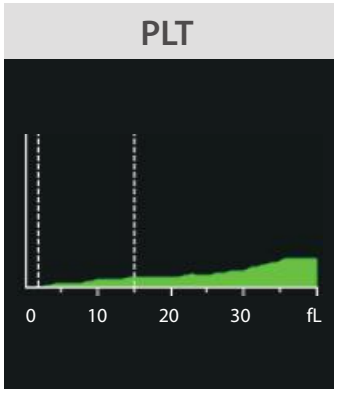
Clinical information

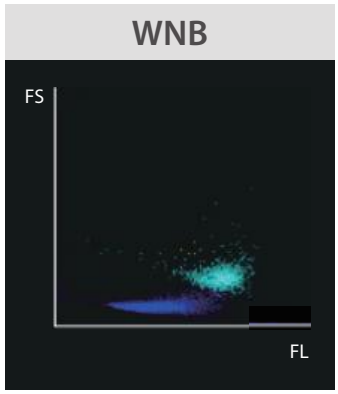
A 68-year-old male patient had dizziness for 2 months and aggravated for 3 days. The physical examinations in April reported anemia and platelets decreased. No symptoms of melena or active hemorrhage were observed.

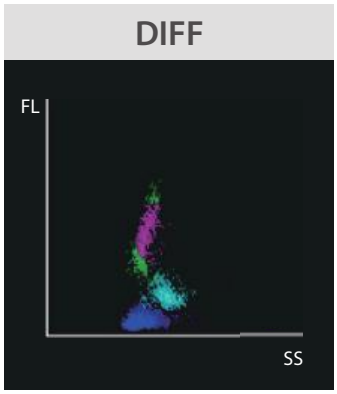
CBC results

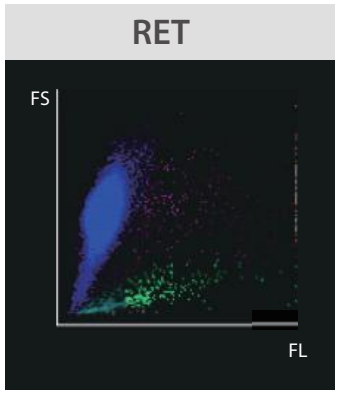
Parameter	Flags		Result	Unit
WBC		L	2.37	10^9/L
Neu#	R	L	1.37	10^9/L
Lym#	R	L	0.37	10^9/L
Mon#	R		0.62	10^9/L
Eos#		L	0.00	10^9/L
Bas#			0.01	10^9/L
IMG#	R		0.01	10^9/L
Neu%	R		57.7	%
Lym%	R	L	15.5	%
Mon%	R	H	26.4	%
Eos%			0.1	%
Bas%			0.3	%
IMG%	R		0.6	%
RBC		L	1.91	10^12/L
HGB		L	51	g/L
HCT		L	15.9	%
MCV			83.0	fL
MCH		L	26.4	pg
MCHC		L	318	g/L
RDW-CV		H	17.6	%
RDW-SD			51.9	fL
PLT	& R	L	26	10^9/L
RET#		L	0.0083	10^12/L
RET%			0.44	%
IRF			14.1	%
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC











Flags

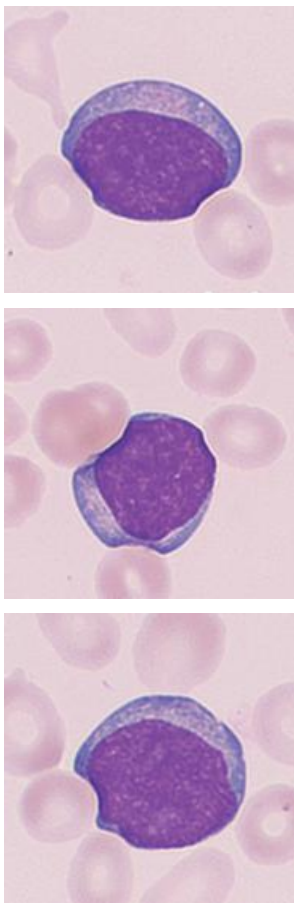
-Pancytopenia
-Blasts?
-Abn Lymph/blast?
-Atypical Lymph?
-Lymphopenia
-Leukopenia
-Fragments?
-Anemia

- Pancytopenia, Mon% increased.
- In the DIFF scattergram, the Mon group extended from lower left to upper right, which were suspected as abnormal cells; in the RET scattergram, there were few PLT particles and most of them were located in the highly fluorescent region, indicating low PLT count and predominantly immature PLTs.

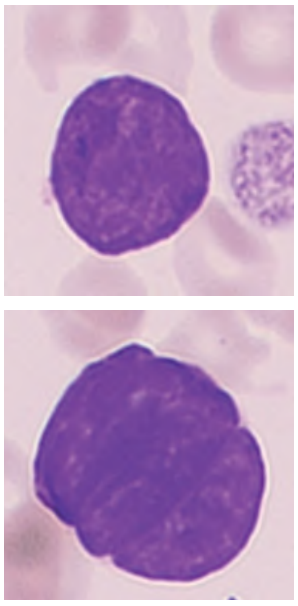
Peripheral blood morphology examination

	WBC		
	WBC	**223**	**100%**
	Segmented neutrophil	110	49.3
	Band neutrophil	2	0.9
L	Lymphocyte	30	13.5
L	Monocyte	2	0.9
	Metamyelocyte	4	1.8
!	Myeloblast	75	33.6
	Non-WBC	**187**	**%**
	Giant PLT	18	
	Large PLT	43	
	Smudge cell	21	9.4
	Sediment	92	
!	Megakaryocyte	13	5.8
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	41*10^9/L	Automated
	PLT concentration	58*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	0.9
!	Microcyte	2+	17.8
	Color	**Degree**	**%**
!	Hypochromic RBC	2+	12.6
	Polychromatic RBC	0	0.0
	Shape	**Degree**	**%**
!	Poikilocytosis	3+	
!	Schistocyte	3+	4.8
	Echinocyte	0	1.6
	Elliptocyte	0	1.8
!	Ovalocyte	3+	26.0
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	3.1
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Blasts



Megakaryocytes



Manual microscopic result

Presence of myeloblasts (33.6%), with uneven cell body sizes, most round or oval; moderate amount of cytoplasm, which appeared caeruleous, with darker edges; no azurophilic granules were observed; the nuclei were round or oval; the chromatins were fine, some had 1–2 visible nucleoli. Presence of megakaryocytes (5.8%).

Other examinations

Item	Result
Bone marrow morphology	Decreased bone marrow hyperplasia, M:E = 10.57; presence of myeloblasts (23.0%); myeloids accounted for approx. 37.0% of total nucleated cells; a total of 27 megakaryocytes were observed, and binucleated, multinucleated, and micro-megakaryocytes were observed. POX negative, NAE weakly positive, NAE-NaF inhibition, NAP score: 256; Suggested diagnosis: microscopic bone marrow images of acute leukemia, the cell morphology and cytochemical staining features were unclear, please refer to flow cytometry, gene detection, and other examinations for further comprehensive diagnosis and treatment.
Flow cytometry	Abnormal immature myeloid cells (34.6%). Expressing: CD34, CD117, CD13, HLA-DR, CD7, CD123, etc.; not expressing: MPO, CD15, CD38, CD14, CD56, CD4, CD24, cCD79a, CD16, CD19, CD41, CD42B. Suggested diagnosis: AML possible.
Gene detection	A total of 42 leukemia-related fusion genes were detected: WT1 copy number 814.00, ABL copy number 32462.00, WT1 quantitative measurement 2.5075%, the rest were all negative. The myeloid leukemia prognostic gene detection showed NPM1 negative.

Case analysis

The patient was diagnosed with Acute myeloid leukemia (AML). Normally, megakaryocytes cannot pass through the blood sinusoids and appear in the peripheral blood. When there are megakaryocytes in the peripheral blood, it may be due to:

- Excessive production of megakaryocytes caused by myeloproliferative disorders;
- Bone-marrow barrier damage caused by inflammation, tumor factors, or other reasons;
- Extramedullary hematopoiesis;
- Impaired splenic clearance;
- Abnormalities in apoptosis or apoptosis-inducing factors.

Case 07

Acute myelomonocytic leukemia (AMMOL)

07

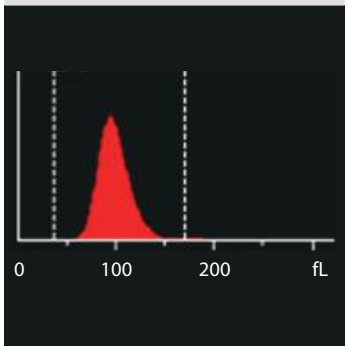
Clinical information

The patient was a 52-year-old female.

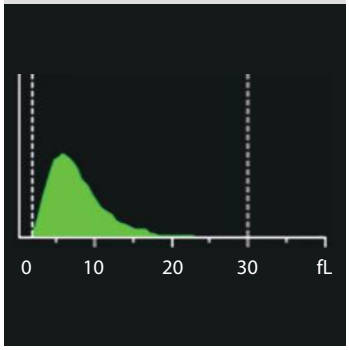
CBC results

Parameter	Flags		Result	Unit
WBC		L	1.55	10^9/L
Neu#	R	L	0.25	10^9/L
Lym#	R	L	0.66	10^9/L
Mon#	R		0.63	10^9/L
Eos#		L	0.01	10^9/L
Bas#			0.00	10^9/L
IMG#	R		0.01	10^9/L
Neu%	R	L	16.4	%
Lym%	R	H	41.9	%
Mon%	R	H	40.8	%
Eos%			0.8	%
Bas%			0.1	%
IMG%	R		0.4	%
RBC		L	1.48	10^12/L
HGB		L	52	g/L
HCT		L	15.1	%
MCV		H	101.7	fL
MCH		H	34.8	pg
MCHC			342	g/L
RDW-CV		H	16.8	%
RDW-SD		H	60.0	fL
PLT		L	34	10^9/L
MPV			8.5	fL
PDW			15.9	
PCT		L	0.029	%
P-LCC		L	4	10^9/L
P-LCR			13.2	%
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC

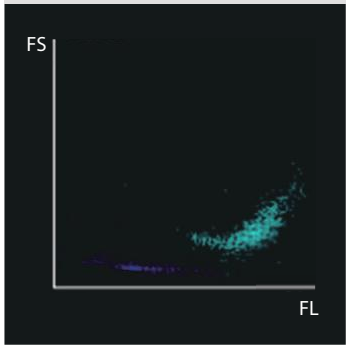
RBC



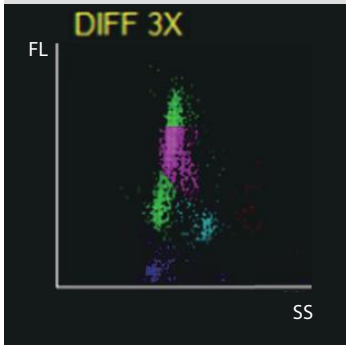
PLT



WNB



DIFF



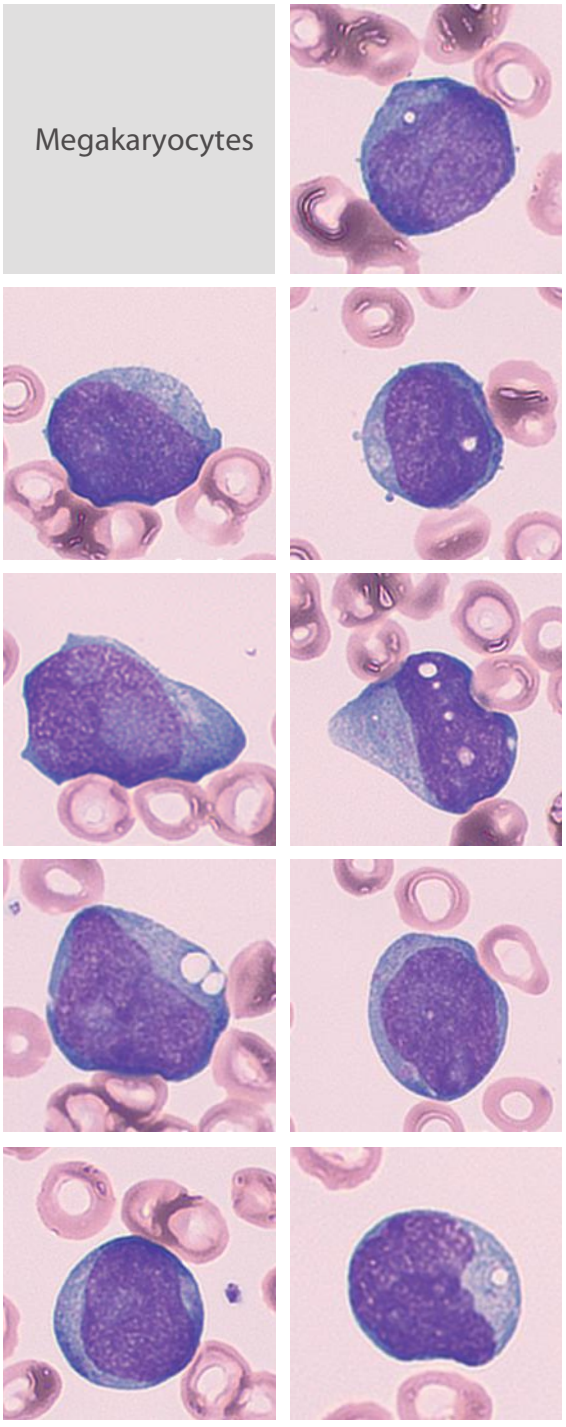
Flags

-Pancytopenia
-Blasts?
-Abn Lymph/blast?
-Atypical Lymph?
……

- Pancytopenia, Lym% and Mon% increased.
- DIFF-3X was initiated due to WBC decreased. In the DIFF scattergram, the Lym particles fused with the Mon particles and extended towards the highly fluorescent region, appearing as a "pencil" shape, indicating presence of myeloblasts.

Peripheral blood morphology examination

	WBC		
	WBC	**110**	**100%**
L	Segmented neutrophil	3	2.7
	Band neutrophil	2	1.8
	Lymphocyte	26	23.6
	Monocyte	7	6.4
	Metamyelocyte	1	0.9
!	Myeloblast	71	64.6
	Non-WBC	**23**	**%**
	Nucleated RBC	1	0.9
	Smudge cell	1	0.9
	Sediment	21	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	40*10^9/L	Automated
	PLT concentration	22*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	0.3
!	Microcyte	3+	45.1
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	73.2
	Polychromatic RBC	0	0.2
	Shape	**Degree**	**%**
!	Poikilocytosis	2+	
	Schistocyte	0	0.3
	Echinocyte	0	0.2
	Elliptocyte	0	0.2
!	Ovalocyte	2+	5.7
	Stomatocyte	0	0.1
	Leptocyte	0	0.1
	Dacryocyte	0	0.3
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.1



Manual microscopic result

Presence of myeloblasts (65%), with large cell body and irregular shapes; the chromatins were coarse particles, with 1–2 large and pronounced nucleoli; the cytoplasm was dark blue, and cytoplasm of some cells contained dust-like granules.

Other examinations

Item	Result
Bone marrow morphology	Extremely active bone marrow hyperplasia; presence of leukemia cells (73%), with round cell bodies, round nuclei, some twisted or folded, the chromatins were fine. 1–3 nucleoli were visible. Scant cytoplasm appeared dusty blue. Fine purple particles were visible in some cells. Cytochemical staining: POX (+), PAS (+), AS-DCE (partial +), a-NAE (+), NAF (partial inhibition), a-NBE (partial +); the eosinophil portion increased (16%), particle decreased was observed in some cells, uneven amount of basophilic particles were visible. Suggested diagnosis: M4EO.
Flow cytometry	Presence of abnormal myeloid blasts (61.19%) (nucleated cells). Expressing: CD34, CD117, CD13, CD33, CD38, cMPO; partially expressing: CD15, HLA-DR, CD64; not expressing: CD10, CD7, CD19, CD56, cCD3, cCD79a, etc. Compliant with the immunophenotype of AML, probable AML-M5 or M4.
Chromosomal examination	47, XX, inv(16)(p13q22), +22[14]/46, XX, inv(16)(p13q22)[6]

Case analysis

A unique type of AML is acute myelomonocytic leukemia with eosinophilia (AML-M4EO). This subtype is an M4 with good prognosis, so increasing the detection rate of AML-M4EO is of great clinical significance. Most M4EO cases are indicated with abnormalities of chromosome 16 structure, and the more distinct and common type is chromosome 16 inversion. inv(16) is a characteristic abnormal karyotype of M4EO. It is involved in the formation of CBFβ-MYH11 fusion gene, which can be used as a molecular biology indicator for M4EO. This has important clinical value for the clinical diagnosis and prognosis prediction of M4.

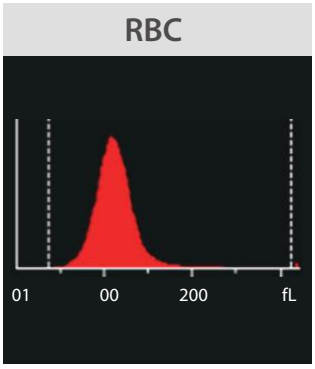
Case 08
Acute monocytic leukemia (AMOL)

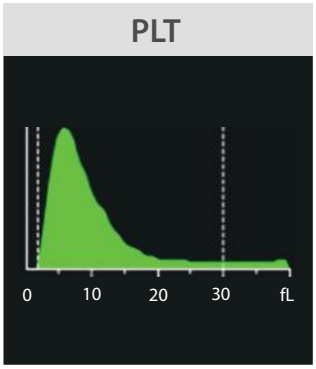
Clinical information

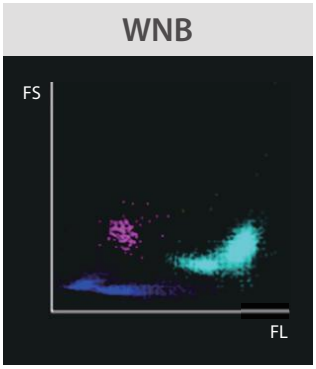
A 52-year-old male patient was admitted to the hospital due to infection accompanied by anemia.

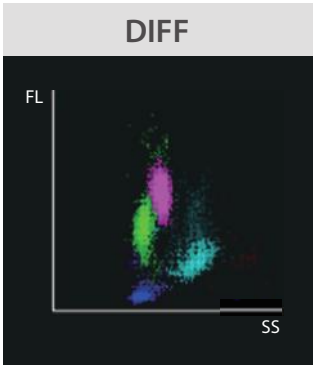
CBC results

Parameter	Alarm			Result	Unit
WBC	&		H	14.87	10^9/L
Neu#	&	R		4.00	10^9/L
Lym#	&	R		3.01	10^9/L
Mon#		R	H	7.83	10^9/L
Eos#				0.03	10^9/L
Bas#				0.00	10^9/L
IMG#		R		0.56	10^9/L
Neu%	&	R	L	26.9	%
Lym%	&	R		20.2	%
Mon%		R	H	52.7	%
Eos%			L	0.2	%
Bas%				0.0	%
IMG%		R		3.8	%
RBC			L	1.76	10^12/L
HGB			L	63	g/L
HCT			L	20.3	%
MCV			H	115.2	fL
MCH			H	35.8	pg
MCHC			L	311	g/L
RDW-CV			H	17.9	%
RDW-SD			H	72.8	fL
PLT			L	91	10^9/L
MPV				9.7	fL
PDW				16.9	
PCT			L	0.088	%
P-LCC			L	21	10^9/L
P-LCR				23.6	%
NRBC#				0.257	10^9/L
NRBC%				1.73	/100WBC









Flags

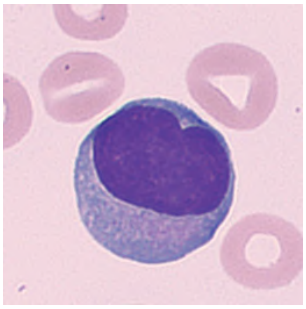
-Blasts?
-Abn Lymph/blasts?
-Immature Gran?
-NRBC
……

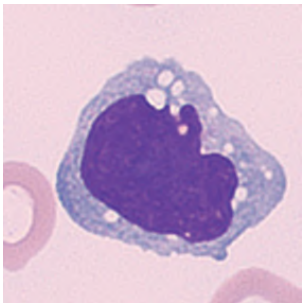
- WBC increased, mainly Mon; HGB decreased; low PLT count.
- In the WNB scattergram, marked red particles were visible, indicating nucleated red blood cells; in the DIFF scattergram, the number of particles markedly increased in the Mon region and most particles were in the highly fluorescent region, indicating presence of immature monocytes.

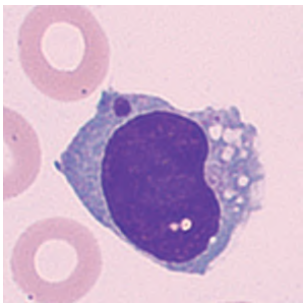
Peripheral blood morphology examination

	WBC		
	WBC	**110**	**100%**
L	Segmented neutrophil	17	15.5
	Band neutrophil	3	2.7
	Lymphocyte	38	34.5
H	Monocyte	45	41.0
!	Myelocyte	2	1.8
!	Myeloblast	5	4.5
	Non-WBC	**45**	**%**
!	Nucleated RBC	6	5.5
	Giant PLT	1	
	Large PLT	9	
	Smudge cell	6	5.5
	Sediment	23	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	90*10^9/L	Automated
	PLT concentration	50*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	3.9
	Microcyte	0	10.3
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	40.8
!	Polychromatic RBC	2+	6.4
	Shape	**Degree**	**%**
!	Poikilocytosis	1+	
!	Schistocyte	1+	0.7
	Echinocyte	0	0.1
	Elliptocyte	0	0.2
	Ovalocyte	0	3.3
	Stomatocyte	0	0.5
	Leptocyte	0	1.1
	Dacryocyte	0	1.2
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.2

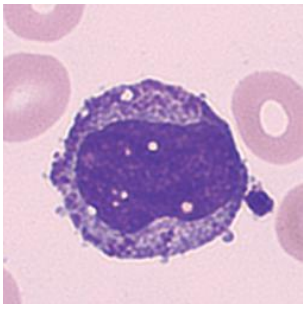
Blasts

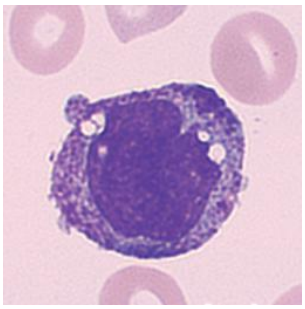


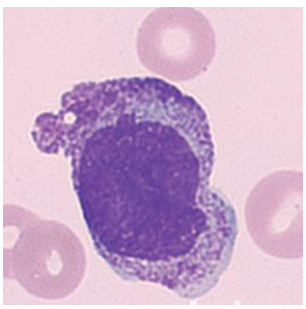




Immature monocytes







Manual microscopic result

Results from manual re-differentiation: Myeloblasts accounted for 45.5%.

The abnormal cells can be differentiated into two clusters morphologically:

One cluster of the cells had large cell bodies, round or irregular; the chromatins were fine and loose, the nuclei were retracted, twisted, or folded, like wrinkles, the nucleoli were barely visible; the cytoplasm was blue, with no granules inside but vacuoles visible. These cells were probably monoblasts.

The other cluster of the cells had large cell bodies, most were irregular; the nuclei were twisted or folded in a more marked manner, the nucleoli were barely visible; the cytoplasm was dusty blue, with azurophilic granules and vacuoles visible. These cells were probably promonocytes. The automated cell morphology analyzer wrongly differentiated most monoblasts and promonocytes as monocytes.

Other examinations

Item	Result
Bone marrow morphology	Active bone marrow hyperplasia; presence of leukemia cells (54%), cytochemical staining results: POX (+); PAS (+), AS-DCE (+), a-NAE (+), NAF (inhibition), a-NBE (+). Suggested diagnosis: AML-M5 probable.
Flow cytometry	CD34+CD117+ myeloid blasts accounted for 0.37% of the nucleated cells, with no marked abnormality in phenotypes. Immature monocytes accounted for 26.5% of the nucleated cells. Mature monocytes accounted for 35.17% of the nucleated cells. Granulocytes accounted for 15.43% of the nucleated cells. Nucleated red blood cells accounted for 14.98% of the nucleated cells. The results were compliant with the immunophenotype of AML. Suggested diagnosis: AML-M5 possible.

Case analysis

This patient was diagnosed with AML-M5.

AML-M5 is acute monocytic leukemia and can be classified into two subcategories:

❶ M5a (undifferentiated): In the bone marrow, marked hyperplasia of monoblasts can be observed, accounting for not less than 80% (NEC), and promonocytes are rarely observed. The leukemia cells are uniformed, quasi-circular or irregular shaped. The nuclei are retracted or folded, the chromatins are loose, fine, and net-like. The nucleoli are clearly visible. The cytoplasm is dusty blue, with pseudopods. Thin and long Auer bodies can be observed in some cytoplasm.

❷ M5b (partially differentiated): In the bone marrow, leukemia cells of variable differentiation mononuclear lineage can be seen. Monoblasts account for less than 80% (NEC), and promonocytes are significantly more than that in M5a, reaching more than 20%. The leukemia cells vary in size, are irregular in shape, and can be with a lagged tail; The nuclei are folded and are shown in various shapes, such as pen-holder, horseshoe, kidney-like, S-shape, etc., the chromatins are reticular or cord-like, the cell mass is rich in dusty blue, purple-red granules at different thickness are visible, and obvious pseudopods can be observed.

Hepatomegaly, splenomegaly, lymphodenopathy, and hemorrhage are mainly observed in clinical practice.

Clinical manifestations:

- Gingival hyperplasia, swelling, bleeding, ulcers, necrosis, etc., are common;
- Nasal mucosal infiltration, nasal obstruction, hyposmia, palatal ulcers, asphyxia caused by pharyngeal/ laryngeal edema, etc.
- Leukemia cutis lesions are common, with manifestations of diffuse macular/papular, hard nodules, masses, dermatitis pustular/bullous/exfoliative, etc.
- Intestinal wall infiltration, ulcer, gastrointestinal dysfunction, etc., are relatively more observed;
- Renal failure and proteinuria are common, which are related to the formation of lysozyme anemia and lysozyme urine caused by the rich lysozymes in monocytes and granulocytes;
- Joint pain and swelling are relatively common;
- The treatment efficacy of acute myelomonocytic leukemia and acute monocytic leukemia is poor compared with the other acute non-lymphocytic leukemias.

Case 09
B-lymphoblastic lymphoma

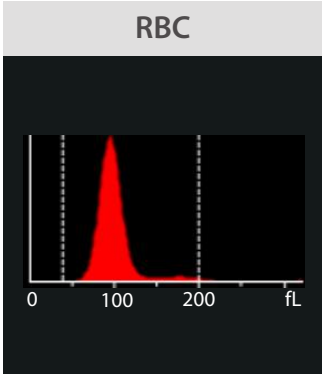
09

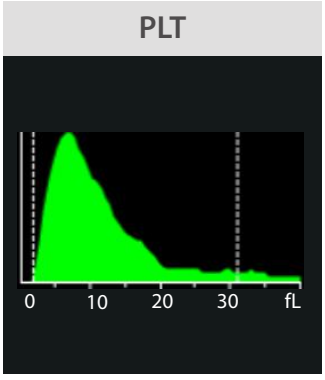
Clinical information

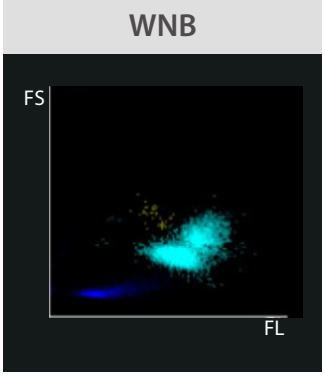
A 64-year-old male patient was admitted to the hospital due to "mass in the left subcostal region for more than 2 months". The upper abdominal CT (dynamic with contrast) showed markedly enlarged spleen. The lower abdominal CT (dynamic with contrast) showed multiple enlarged retroperitoneal lymph nodes.

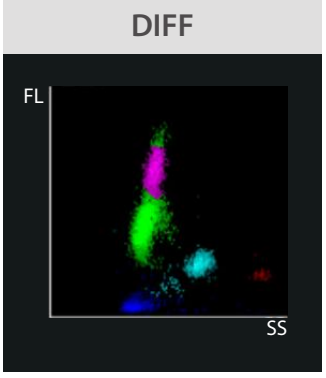
CBC results

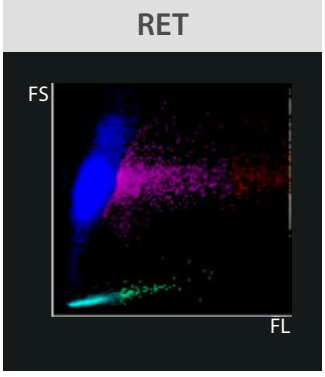
Parameter	Flags		Result	Unit
WBC		H	10.91	10^9/L
Neu#	R	L	1.57	10^9/L
Lym#	R	H	7.66	10^9/L
Mon#	R	H	1.59	10^9/L
Eos#			0.05	10^9/L
Bas#			0.04	10^9/L
IMG#	R		0.00	10^9/L
Neu%	R	L	14.4	%
Lym%	R	H	70.1	%
Mon%	R	H	14.6	%
Eos%			0.5	%
Bas%			0.4	%
IMG%	R		0.0	%
RBC			4.06	10^12/L
HGB			129	g/L
HCT		L	38.8	%
MCV			95.5	fL
MCH			31.8	pg
MCHC			332	g/L
RDW-CV			12.9	%
RDW-SD			45.2	fL
PLT	&	L	81	10^9/L
MPV			11.0	fL
PDW			16.8	
PCT		L	0.089	%
P-LCC		L	26	10^9/L
P-LCR			32.4	%
IPF			5.4	%
RET#			0.0840	10^12/L
RET%			12.07	%
IRF			13.7	%
LFR			86.3	%
MFR			11.5	%
HFR			2.2	%
RHE			31.5	pg
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC











Flags

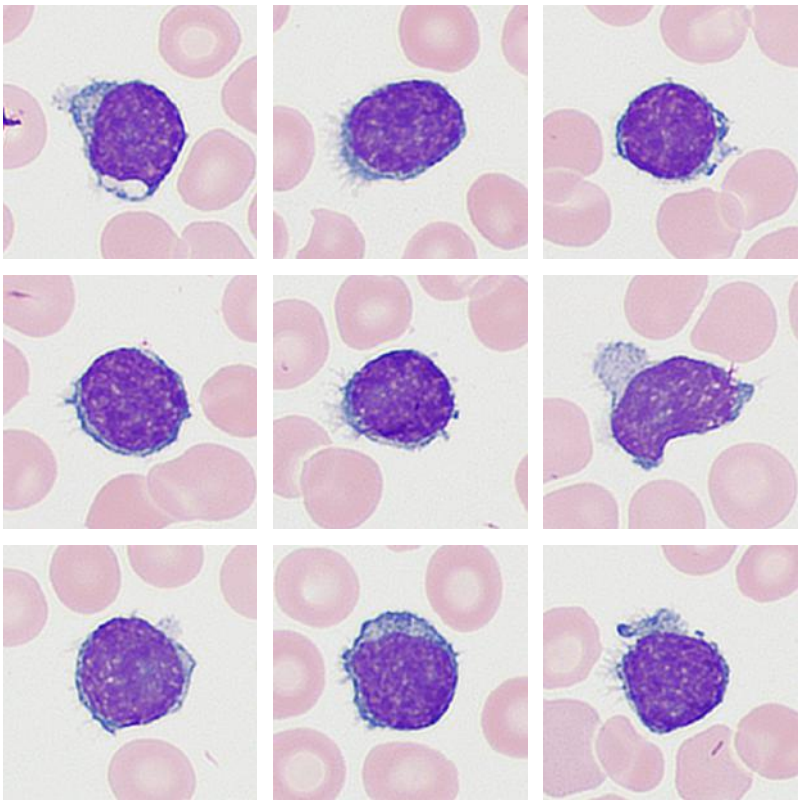
-Blasts?
-Abn Lymph/blast?
-Atypical Lymph?
-Monocytosis
-Lymphocytosis

- WBC increased, Lym and Mon significantly increased; erythroids normal; low PLT count.
- In the DIFF scattergram, the Lym particles extended towards the highly fluorescent region, appearing as a "knife", the abnormal cells in the higher region were counted as Mon.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	24	12.0
	Lymphocyte	50	25.0
L	Monocyte	5	2.5
	Eosinophil	2	1.0
	Basophil	1	0.5
!	Myeloblast	88	44.0
!	Reactive lymphocyte	30	15.0
	Non-WBC	**66**	**%**
	Giant PLT	1	
	Large PLT	1	
	Smudge cell	18	9.0
	Sediment	46	
	PLT		
	PLT estimate	**Estimated esult**	**Estimation ethod**
	PLT concentration	64*10^9/L	Automated
	PLT concentration	80*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	0.4
!	Microcyte	3+	0.1
	Color	**Degree**	**%**
!	Hypochromic RBC	2+	11.2
	Polychromatic RBC	0	0.1
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	0.2
	Echinocyte	0	7.1
	Elliptocyte	0	1.2
	Ovalocyte	0	10.5
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	0.5
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Abnormal lymphocytes



Manual microscopic result

The re-differentiation showed presence of lymphocytes (25%) and abnormal lymphocytes (59%).
These abnormal lymphocytes had small cell bodies and irregular shape. The chromatins were more fine compared with the normal lymphocytes, and nucleoli were visible in some cells. Scant cytoplasm appeared blue.

Other examinations

Item	Result
Bone marrow morphology	Active nucleated cell hyperplasia in bone marrow; myeloid hyperplasia was poor, mainly metamyelocytes; presence of immature lymphocytes (28.5%) and mature lymphocytes (41.5%), where abnormal lymphocytes were common.
Flow cytometry	Abnormal shape of B lymphocytes were observed, FSC and SSC were not strong, compliant with the signs of CD5-CD10-B cells, and not compliant with HCL phenotype.
Pathological diagnosis	CD5-CD10- small B-cell lymphoma

Case analysis

The patient had enlarged spleen and multiple enlarged retroperitoneal lymph nodes. In combination with the peripheral blood morphology results, the primary diagnosis was small B-cell lymphoma. The diagnosis of CD5-CD10- small B-cell lymphoma was confirmed by flow cytometry. Further genetic detections, lymph node biopsy, and other relevant examinations are required for immunophenotyping.

Case 10
T-lymphoblastic lymphoma

10

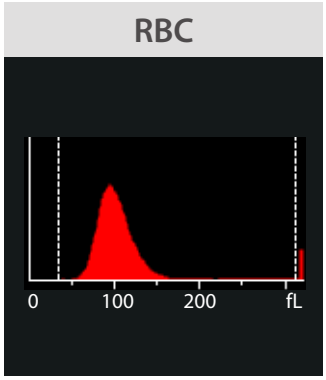
Clinical information

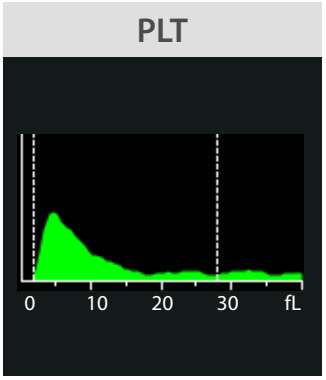
A 9-year-old female patient was admitted to the hospital due to "asthenia for 10 days, WBC increased for 1 day".

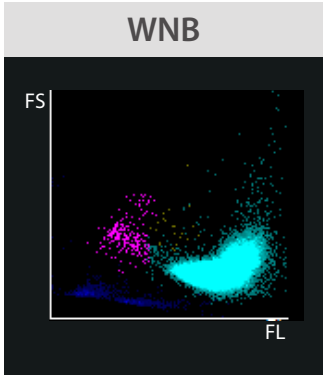
CBC results

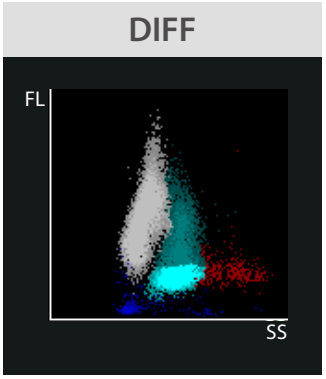
CBC results on Aug. 4

Parameter	Flags			Result	Unit
WBC	&		H	114.76	10^9/L
Neu#	&	R	H	34.00	10^9/L
Lym#				****	10^9/L
Mon#				****	10^9/L
Eos#		R	H	0.55	10^9/L
Bas#		R		0.03	10^9/L
IMG#		R		11.17	10^9/L
Neu%	&	R	L	29.6	%
Lym%				****	%
Mon%				****	%
Eos%		R		0.5	%
Bas%		R		0.0	%
IMG%		R		9.7	%
RBC			L	1.41	10^12/L
HGB			L	49	g/L
HCT			L	14.6	%
MCV			H	103.6	fL
MCH			H	34.8	pg
MCHC				336	g/L
RDW-CV			H	18.6	%
RDW-SD			H	67.5	fL
PLT			L	29	10^9/L
MPV				9.9	fL
PDW			H	18.0	
PCT			L	0.029	%
P-LCC			L	8	10^9/L
P-LCR				27.2	%
NRBC#				0.347	10^9/L
NRBC%				0.30	/100WBC









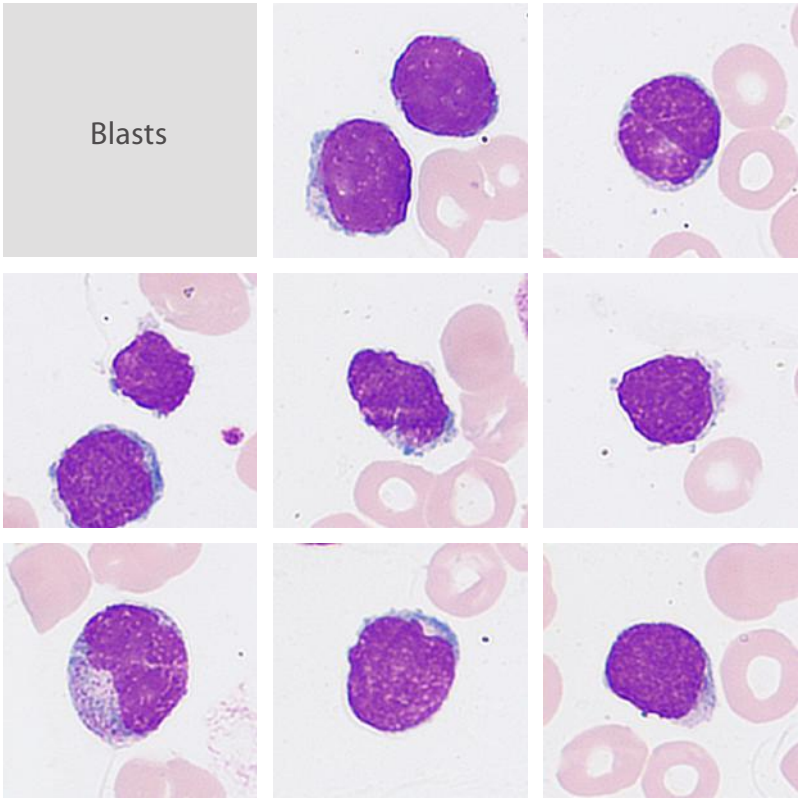
Flags

-WBC Abn Scattergram
-Blasts?
-Abn Lymph/blast?
-Immature Gran?
-Left Shift?
-Neutrophilia
-Leukocytosis
-Dimporphic Population
-Anemia
-Thrombocytopenia

- WBC markedly increased; RBC and PLT decreased.
- In the WNB scattergram, nucleated red blood cells were observed; in the DIFF scattergram, the number of particles markedly increased, the Lym group extended towards the highly fluorescent region and covered the Mon group, so that the Lym and Mon groups were indistinguishable, indicating a large amount of myeloblasts, possibly lymphocytes; the Neu group also extended upward, indicating the presence of immature granulocytes.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	46	23.0
	Band neutrophil	2	1.0
L	Lymphocyte	29	14.5
	Monocyte	14	7.0
	Eosinophil	1	0.5
	Basophil	1	0.5
!	Metamyelocyte	5	2.5
!	Myelocyte	5	2.5
!	Myeloblast	95	47.5
	Reactive lymphocyte	2	1.0
	Non-WBC	**93**	**%**
	Nucleated RBC	1	0.5
	Smudge cell	52	26.0
	Sediment	40	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	19*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	3+	
!	Macrocyte	2+	13.2
	Microcyte	0	3.4
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	27.2
	Polychromatic RBC	0	0.0
	Shape	**Degree**	**%**
!	Poikilocytosis	3+	
!	Schistocyte	3+	9.2
	Echinocyte	0	0.6
	Elliptocyte	0	0.9
	Ovalocyte	0	14.6
	Stomatocyte	0	0.3
	Leptocyte	0	0.0
	Dacryocyte	0	1.7
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0



Manual microscopic result

Presence of myeloblasts (47.5%). The cell bodies were small in round or oval shapes. The nuclei were large, round or oval. The chromatins were fine and granule-like with clear boundaries, slightly coarser than those in the myelomonocytes. Nucleoli were visible in some cells. Extremely scant cytoplasm appeared pale blue, the boundaries were clear, and a very small amount of azurophilic granules were observed.

Other examinations

Item	Result
Flow cytometry	The abnormal cells accounted for 53.1% of the nucleated cells, expressing HLA-DR, CD2, CD7, CD38, CD99, CD117, and cCD3; partially expressing CD13, CD34, and TdT; and not expressing CD1a, CD4, CD5, and CD8. These cells were immature T-lymphocytes, where a group of HLA- DRpart+CD64part+MPOpart+CD13+CD33+CD38+ myeloid cells accounted for 0.6% of the nucleated cells; and the granulocytes showed abnormal differentiation in the CD15-CD11b, CD16-CD13, and CD11b-CD13 scattergrams. Conclusion: Suggested diagnosis: T-cell acute lymphoblastic leukemia (ETP-ALL possible), the involvement of myeloid cells is to be excluded.

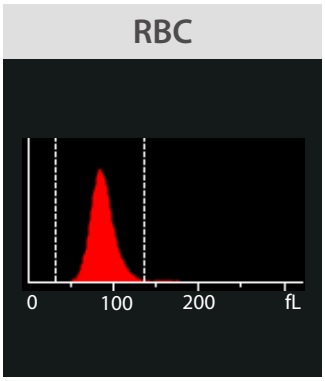
Case analysis

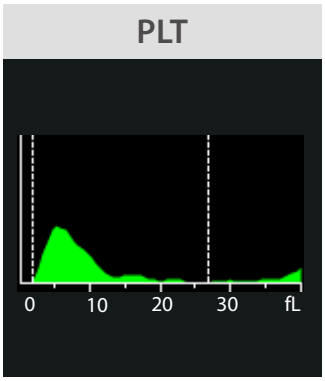
T-cell acute lymphoblastic leukemia is a heterogeneous diseases characterized by the proliferation of malignant immature T lymphocytes, accounting for 10%–15% of childhood ALL. Although the current high-intensity chemotherapy has led to an induction response rate of more than 95% in children with T-ALL, it is prone to early relapse and difficult to response after relapse, so the long-term prognosis is still worse than that of pediatric precursor B-cell ALL. Early T-cell precursor-acute lymphoblastic leukemia (ETP-ALL) was first noted by Coustan-Smith et al. from St Jude Children's Hospital in 2009. The investigators screened out samples of patients with T-ALL with similar gene expression profiles to normal early T-precursor cells, and found that they had characteristic immunophenotypes. These patients had low response rates and short survival.

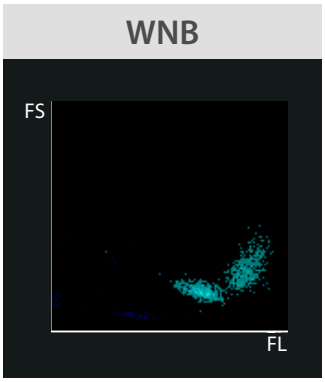
ETP-ALL was classified as an independent subtype by the WHO Classification of Tumors of Haematopoietic and Lymphoid Tissues in 2016. It has a unique immunophenotype and gene composition, and retains some characteristics of bone marrow stem cells at the immunophenotype and gene level. It is clinically highly aggressive and has a poor long-term prognosis. Once a patient is diagnosed, induction chemotherapy should be administered in clinical practice and the CBC should be monitored regularly.

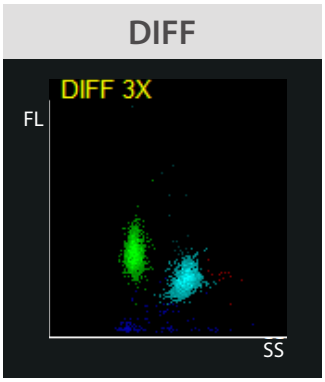
CBC results on Aug. 21

Parameter	Flags	Result	Delta#	8-14	8-13	Unit
WBC	L	1.52	-9.670	11.19	46.15	10^9/L
Neu#	L	0.70	-7.980	8.68	19.71	10^9/L
Lym#		0.81	-1.240	2.05	****	10^9/L
Mon#	L	0.00	-0.460	0.46	****	10^9/L
Eos#	L	0.01	0.010	0.00	0.07	10^9/L
Bas#		0.00	0.000	0.00	0.01	10^9/L
IMG#		0.01	-0.980	0.99	3.97	10^9/L
Neu%	L	46.6	-31.00	77.6	42.7	%
Lym%	H	53.0	34.70	18.3	****	%
Mon%	L	0.0	-4.10	4.1	****	%
Eos%	L	0.4	0.40	0.0	0.2	%
Bas%		0.0	0.00	0.0	0.0	%
IMG%		0.6	-8.20	8.8	8.6	%
RBC	L	1.76	-0.480	2.24	2.15	10^12/L
HGB	L	55	-15.0	70	69	g/L
HCT	L	15.7	-5.70	21.4	20.6	%
MCV		89.3	-6.10	95.4	95.7	fL
MCH		31.2	-0.10	31.3	31.9	pg
MCHC		350	22.0	328	334	g/L
RDW-CV		14.7	-3.60	18.3	18.3	%
RDW-SD		46.5	-14.80	61.3	61.8	fL
PLT	L	24	11.0	13	16	10^9/L
MPV		9.1	-1.20	10.3	9.6	fL
PDW		16.1	-1.20	17.3	17.2	
PCT	L	0.022	0.0090	0.013	0.015	%
P-LCC	L	4	0.0	4	5	10^9/L
P-LCR		16.3	-15.60	31.9	28.8	%
NRBC#		0.000	0.0000	0.000	0.000	10^9/L
NRBC%		0.00	0.000	0.00	0.00	/100WBC









Flags

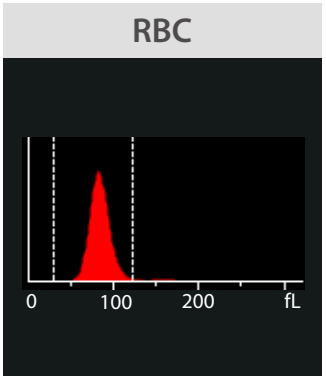
-Pancytopenia
-Neutropenia
-Leukopenia
-Anemia
-Thrombocytopenia

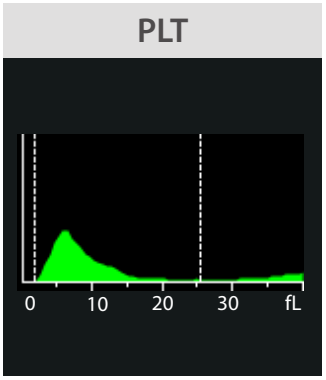
- The CBC results on Aug. 21 showed significant WBC decrease. In the DIFF scattergram, the particle groups distributed normally, indicating no abnormal cells.
- The flow cytometry also indicated no leukemia residual cells with significantly abnormal immunophenotype.

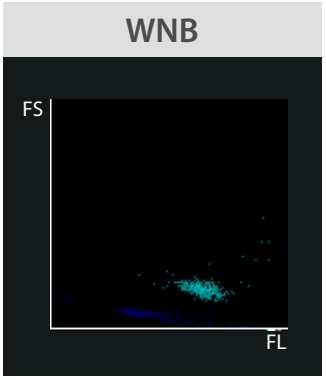
Case analysis

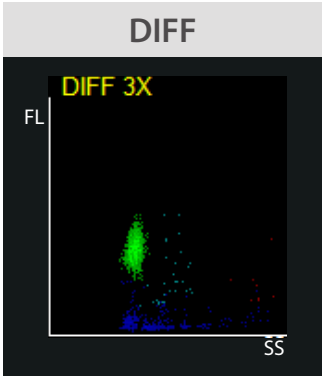
CBC results on Aug. 28

Parameter	Flags	Result	Delta#	8-21	8-14	Unit
WBC	L	0.63	-0.890	1.52	11.19	10^9/L
Neu#	R L	0.01	-0.690	0.70	8.68	10^9/L
Lym#	R L	0.62	-0.190	0.81	2.05	10^9/L
Mon#	R L	0.00	0.000	0.00	0.46	10^9/L
Eos#	R L	0.00	-0.010	0.01	0.00	10^9/L
Bas#		0.00	0.000	0.00	0.00	10^9/L
IMG#	R	0.00	-0.010	0.01	0.99	10^9/L
Neu%	R L	2.3	-44.30	46.6	77.6	%
Lym%	R H	97.1	44.10	53.0	18.3	%
Mon%	R L	0.0	0.00	0.0	4.1	%
Eos%	R	0.6	0.20	0.4	0.0	%
Bas%		0.0	0.00	0.0	0.0	%
IMG%	R	0.0	-0.60	0.6	8.8	%
RBC	L	1.73	-0.030	1.76	2.24	10^12/L
HGB	L	52	-3.0	55	70	g/L
HCT	L	14.9	-0.80	15.7	21.4	%
MCV		86.3	-3.00	89.3	95.4	fL
MCH		29.9	-1.30	31.2	31.3	pg
MCHC		347	-3.0	350	328	g/L
RDW-CV		12.8	-1.90	14.7	18.3	%
RDW-SD		39.4	-7.10	46.5	61.3	fL
PLT	L	22	-2.0	24	13	10^9/L
MPV		9.5	0.40	9.1	10.3	fL
PDW		15.8	-0.30	16.1	17.3	
PCT	L	0.020	-0.0020	0.022	0.013	%
P-LCC	L	4	0.0	4	4	10^9/L
P-LCR		20.8	4.50	16.3	31.9	%
NRBC#		0.000	0.0000	0.000	0.000	10^9/L
NRBC%		0.00	0.000	0.00	0.00	/100WBC







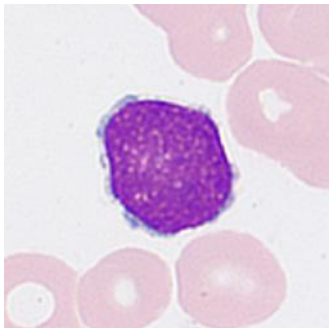


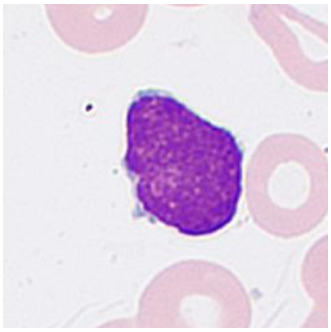
Flags

-WBC Abn Scattergram
-Abn Lymph/blast?
-Lymphopenia
-Neutropenia
-Pancytopenia
-Anemia
-Thrombocytopenia

The CBC results on Aug. 28 showed progressive WBC decrease, and the differentiation results showed a flag of "suspected". In the DIFF scattergram, the Neu group extended toward the highly fluorescent region, indicating presence of immature granulocytes. No other marked abnormalities were observed, but the analyzer raised an alarm of abnormal cells. A small amount of myeloblasts were observed in microscopic examination.

The flow cytometry showed that the cCD3+ cells accounted for approx. 1.99% of the nucleated cells; no leukemia residual cells with significantly abnormal immunophenotype were observed (leukemia residual cells < 10^{-4}) (Note: when pro-T, pre-T, cortical T, and medullary T are observed, the cCD3 expression is regarded as +).

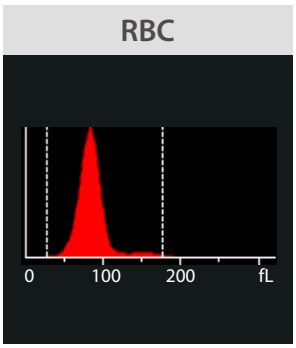


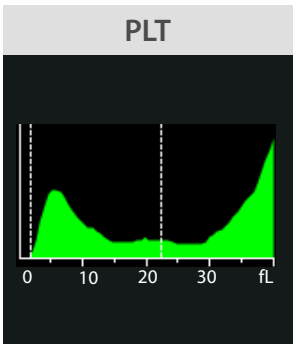


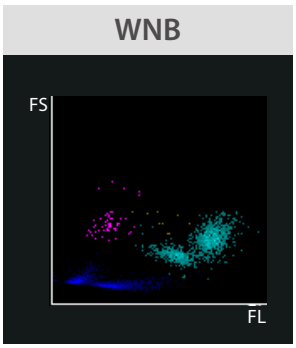
Case analysis

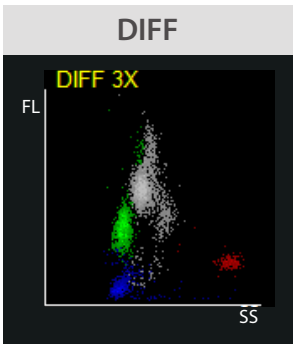
CBC results on Oct. 23

Parameter	Flags	Result	Delta#	9-11	09-04	Unit
WBC	& L	1.78	-0.610	2.39	0.74	10^9/L
Neu#		****		1.31	0.38	10^9/L
Lym#	& R L	0.53	-0.540	1.07	0.36	10^9/L
Mon#		****		0.01	0.00	10^9/L
Eos#	R	0.08	0.080	0.00	0.00	10^9/L
Bas#	R	0.01	0.010	0.00	0.00	10^9/L
IMG#		****		0.01	0.02	10^9/L
Neu%		****		54.3	51.5	%
Lym%	& R	29.8	-15.10	44.9	48.2	%
Mon%		****		0.6	0.2	%
Eos%	R	4.6	4.50	0.1	0.1	%
Bas%	R	0.6	0.50	0.1	0.1	%
IMG%		****		0.2	2.9	%
RBC		3.55	1.360	2.19	2.08	10^12/L
HGB	L	101	41.0	60	56	g/L
HCT	L	30.2	12.30	17.9	16.8	%
MCV		84.9	3.50	81.4	80.8	fL
MCH		28.3	1.10	27.2	27.0	pg
MCHC		333	-1.0	334	334	g/L
RDW-CV		15.1	-0.70	15.8	16.3	%
RDW-SD		46.1	-0.20	46.3	47.4	fL
PLT	L	54	-19.0	73	32	10^9/L
MPV		10.1	1.80	8.3	8.9	fL
PDW		16.7	0.90	15.8	15.7	
PCT	L	0.054	-0.0070	0.061	0.029	%
P-LCC	L	17	5.0	12	7	10^9/L
P-LCR		31.1	15.00	16.1	21.3	%
NRBC#		0.085	0.0850	0.000	0.000	10^9/L
NRBC%		4.77	4.770	0.00	0.00	/100WBC









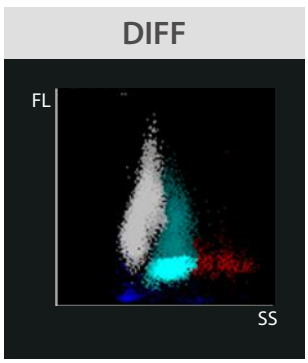
Flags

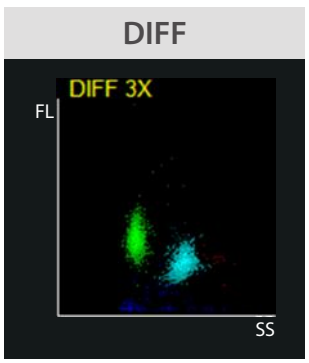
-WBC Abn Scattergram
-Blasts?
-Abn Lymph/blast?
-Immature Gran?
-Left Shift?
-NRBC
-Lymphopenia
-Leukopenia
-Thrombocytopenia

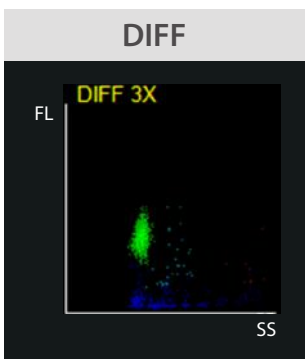
The results after 2 months still showed WBC decreased, but the DIFF scattergram was significantly different. The Mon and Neu groups markedly extended toward the highly fluorescent region and fused together, showing grayish-white color, and the analyzer raised the alarm of myeloblasts and abnormal lymphocytes; in the WNB scattergram, the presence of nucleated red blood cells was observed, indicating condition aggravated.

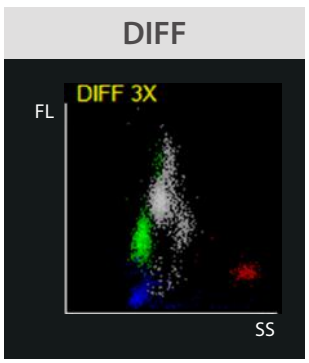
The flow cytometry showed that the CD45dimCD7st cells accounted for approx. 4.75% of the nucleated cells, also expressing CD117 and cCD3, and partially expressing CD99. Suggested diagnosis was abnormal immature T lymphocytes.

In this case, multiple CBC tests and flow cytometry examinations were conducted from diagnosis to treatment. The CBC results were consistent with the flow cytometry results. The progression of disease can be seen from the changes in the DIFF scattergrams below.









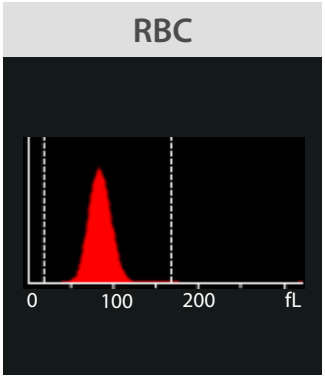
Case 11
Plasma cell leukemia (PCL)

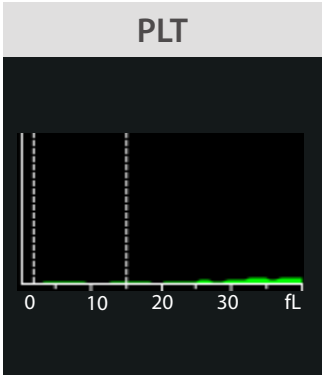
Clinical information

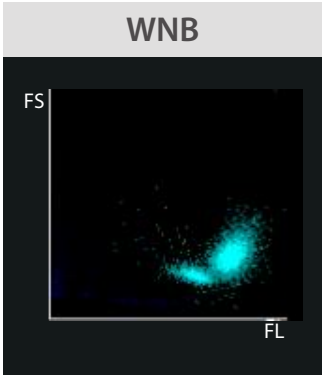
A 51-year-old male patient was admitted to the hospital on Nov. 29, 2022 due to "palpitations for more than 3 years, definite diagnosis of multiple myeloma for 3 years, recurrence 3 months after transplantation".

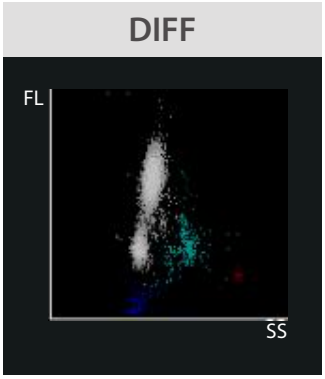
CBC results

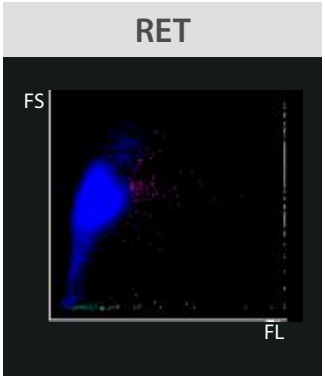
Parameter	Flags		Result	Unit
WBC			7.66	10^9/L
Neu#	R	L	0.67	10^9/L
Lym#			****	10^9/L
Mon#			****	10^9/L
Eos#			0.02	10^9/L
Bas#			0.01	10^9/L
IMG#	R		0.02	10^9/L
Neu%	R	L	8.8	%
Lym%			****	%
Mon%			****	%
Eos%		L	0.3	%
Bas%			0.1	%
IMG%	R		0.3	%
RBC		L	1.76	10^12/L
HGB		L	50	g/L
HCT		L	14.8	%
MCV			84.1	fL
MCH			28.7	pg
MCHC			341	g/L
RDW-CV			15.4	%
RDW-SD			47.7	fL
PLT	&	L	3	10^9/L
MPV			****	fL
PDW			****	
PCT			****	%
P-LCC			****	10^9/L
P-LCR			****	%
IPF			6.7	%
RET#		L	0.0024	10^12/L
RET%		L	0.14	%
IRF			6.7	%
LFR			93.3	%
MFR			6.7	%
HFR			0.0	%
RHE			28.6	Pg
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC











Flags

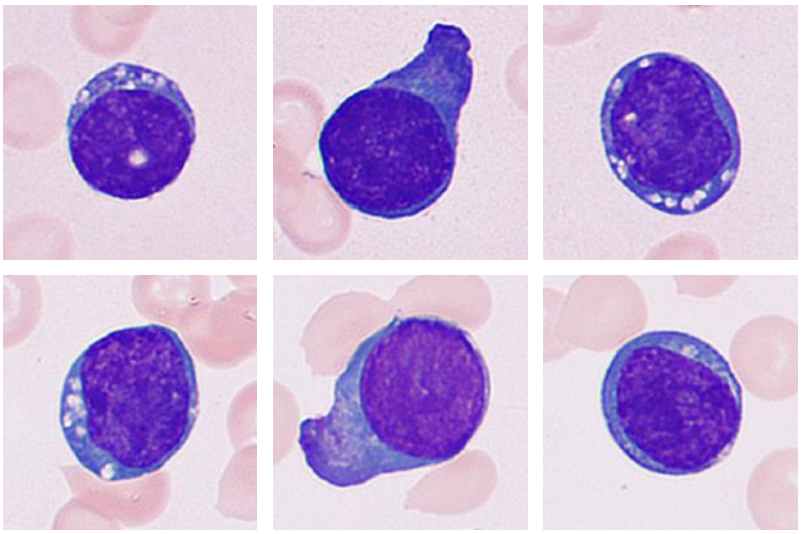
-WBC Abn Scattergram
-Blasts?
-Abn Lymph/blast?
-Atypical Lymph?
-Neutropenia
-Fragments?
-Anemia
-PLT Histogram Abn.
-Thrombocytopenia

- WBC normal, but the differentiation results were of poor reliability and were blocked; RBC decreased; severe anemia; extremely low PLT count.
- In the DIFF scattergram, the Mon particles were completely elevated to above the Lym particles and were tilting to the right, indicating the presence of a large amount of abnormal cells.

Peripheral blood morphology examination

	WBC		
	WBC	**190**	**100%**
L	Segmented neutrophil	3	1.6
	Band neutrophil	6	3.2
	Lymphocyte	40	21.1
L	Monocyte	5	2.6
	Eosinophil	2	1.1
!	Metamyelocyte	5	2.6
!	Plasma cell	129	67.8
	Non-WBC	**45**	**%**
	Giant PLT	2	
	Smudge cell	40	21.1
	Sediment	3	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	8*10^9/L	Automated
	PLT concentration	8*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
!	Macrocyte	2+	11.2
	Microcyte	0	2.2
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	25.1
	Polychromatic RBC	0	0.5
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	0.2
	Echinocyte	0	0.0
	Elliptocyte	0	0.2
	Ovalocyte	0	5.6
	Stomatocyte	0	0.0
	Leptocyte	0	1.3
	Dacryocyte	0	0.4
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Abnormal lymphocytes



Manual microscopic result

The microscopic examination showed a large amount of plasma cells/ lymphoma cells. The cells were large, most of them were round shaped. The nuclei were large and round, not centrally-located. The chromatins aggregated to lumps. Nucleoli were observed in some cells. The cytoplasm was abundant and appeared in dark blue, foamy. Rouleux red blood cells were observed.

Other examinations

Item		Result	Reference range
Urinalysis	Urobilinogen	1+	Normal
	Urine bilirubin	1+	Negative
	Urine protein	1+	Negative
Hepatic function	ALT	162.7	9.0-50.0U/L
	AST	192.0	15.0-40.0U/L
	ALP	165.4	45.0-125.0U/L
	γ-GGT	137.2	10.0-60.0U/L
	TP	98.0	65.0-85.0g/L
	GLO	71.7	20.0-40.0g/L
	ALB	26.3	40.0-55.0g/L
	A/G	0.4	1.2-2.4
	TBil	80.8	0.0-26.0μmol/L
	inDBil	22.5	0.0-18.0μmol/L
	DBil	58.3	0.0-8.0μmol/L
	Prealbumin	0.10	0.17-0.42g/L
	GA	39.46	0.0-10.0mg/L
Serum light chain panel	Light chain κ	9450.00	598-1329mg/dL
	Light chain λ	124.00	298-665 mg/dL
	κ/λ	76.21	1.35-2.65
Immunoglobulin	IgG	9150.00	751.00-1560.00 mg/dL
	IgA	54.20	82.00-453.00 mg/dL
	IgM	39.50	30.00-220.00 mg/dL
	Total IgE	19.90	0.00-165.00IU/mL

Case analysis

This patient was diagnosed with refractory/recurrent multiple myeloma, with secondary plasma cell leukemia, accompanied with infections, organ function abnormal (liver, lung, hear, GI tract, etc.), severe anemia, and platelets decreased.

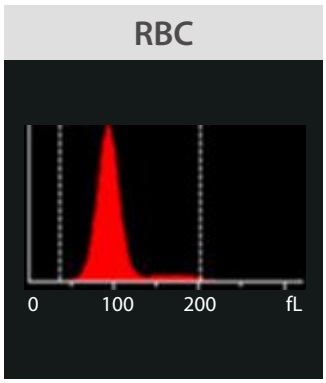
Case 12
Hairy cell leukemia (HCL)

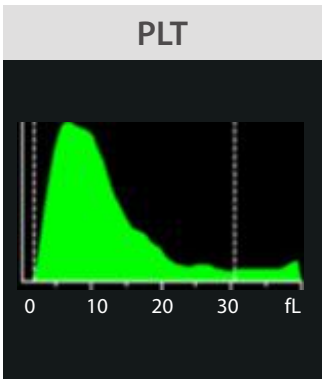
Clinical information

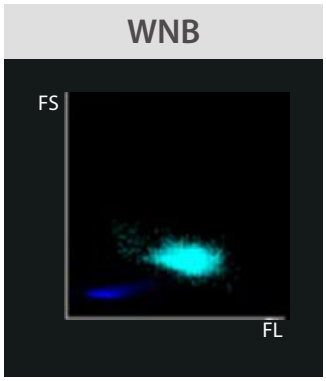
The patient was a 65-year-old female.

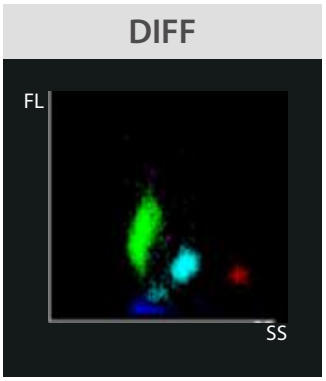
CBC results

Parameter	Flags		Result	Unit
WBC		H	14.65	10^9/L
Neu#	R		3.84	10^9/L
Lym#	R	H	10.58	10^9/L
Mon#	R	L	0.02	10^9/L
Eos#			0.20	10^9/L
Bas#			0.01	10^9/L
IMG#	R		0.02	10^9/L
Neu%	R	L	26.2	%
Lym%	R	H	72.4	%
Mon%	R	L	0.1	%
Eos%			1.3	%
Bas%			0.0	%
IMG%	R		0.1	%
RBC			4.33	10^12/L
HGB			135	g/L
HCT			39.6	%
MCV			91.3	fL
MCH			31.3	pg
MCHC			342	g/L
RDW-CV			13.5	%
RDW-SD			46.7	fL
PLT			145	10^9/L
MPV			11.3	fL
PDW			16.6	
PCT			0.163	%
P-LCC			51	10^9/L
P-LCR			34.9	%
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC









Flags

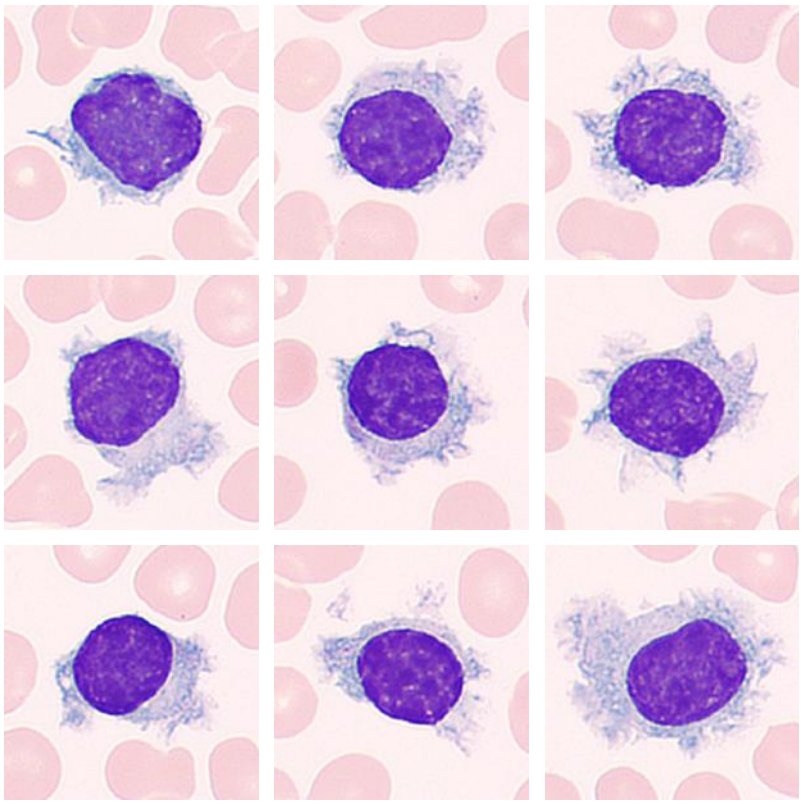
-Blasts?
-Abn Lymph/blast?
-Lymphocytosis

- High WBC count, Lym increased; erythroids and platelets normal.
- In the DIFF scattergram, the number of Lym particles markedly increased in the highly fluorescent region, indicating the potential presence of abnormal lymphocytes.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	54	27.0
	Band neutrophil	1	0.5
L	Lymphocyte	36	18.0
L	Monocyte	2	1.0
	Eosinophil	1	0.5
	Basophil	1	0.5
!	Abnormal lymphocyte	105	52.5
	Non-WBC	**46**	**%**
	Large PLT	6	
	Smudge cell	38	19.0
	Sediment	2	

Abnormal lymphocytes



Manual microscopic result

The microscopic examination showed abnormal lymphocytes (52.5%). The cells were large, about 1–2 times the volume of mature lymphocytes. The nuclei were oval, not centrally located. Some nuclei were round, elliptical, kidney-shaped, or horseshoe-like. The cytoplasm was abundant, appeared in pale blue to dusty blue, fluffy. Hair-like protrusions were observed at the periphery of cell membrane.

Case analysis

Based on the peripheral blood morphology examination, the patient was likely to have hairy cell leukemia (HCL). MICM related examinations are required.

For HCL, the median age of onset is 63 years old, few cases are observed in adolescence and more are observed in males. Typical HCL is easy to identify but atypical HCL is usually misdiagnosed as CLL. HCL often manifests clinically as pancytopenia or cytopenia of one lineage. The disease is often observed in the middle-aged and the elderly, with a chronic disease course, repeated infections, no enlargement of lymph nodes, but enlarged spleen. Monocytes are significantly decreased or even missing.

Case 13
Chronic lymphocytic leukemia (CLL)

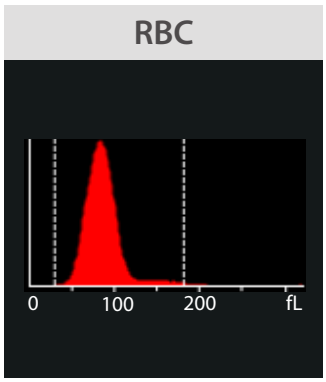
13

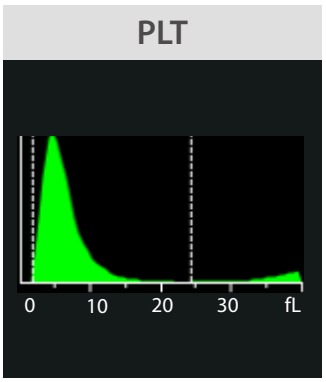
Clinical information

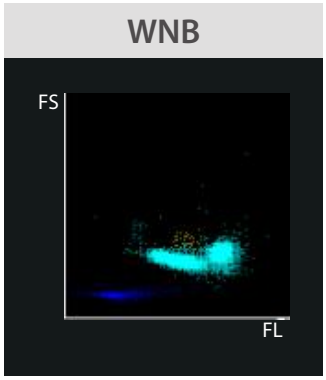
This patient was a 67-year-old male, with WBC increased of unknown reasons.

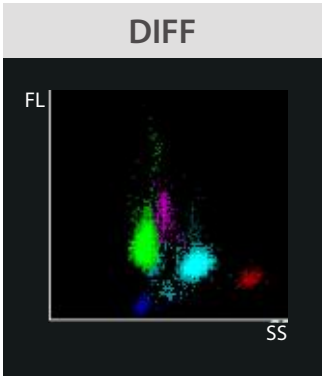
CBC results

Parameter	Flags		Result	Unit
WBC		H	19.97	10^9/L
Neu#	R		6.59	10^9/L
Lym#	R	H	12.82	10^9/L
Mon#	R		0.32	10^9/L
Eos#			0.20	10^9/L
Bas#			0.04	10^9/L
IMG#	R		0.08	10^9/L
Neu%	R	L	33.0	%
Lym%	R	H	64.2	%
Mon%	R	L	1.6	%
Eos%			1.0	%
Bas%			0.2	%
IMG%	R		0.4	%
RBC		L	3.00	10^12/L
HGB		L	82	g/L
HCT		L	25.6	%
MCV			85.2	fL
MCH			27.5	pg
MCHC			320	g/L
RDW-CV		H	19.8	%
RDW-SD		H	60.6	fL
PLT	&	H	591	10^9/L
MPV		L	6.3	fL
PDW			15.0	
PCT		H	0.357	%
P-LCC			30	10^9/L
P-LCR		L	5.0	%
IPF		L	0.8	%
RET#			0.0753	10^12/L
RET%			2.51	%
IRF			19.5	%
LFR			80.5	%
MFR			15.7	%
HFR			3.8	%
RHE			25.7	pg
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC









Flags

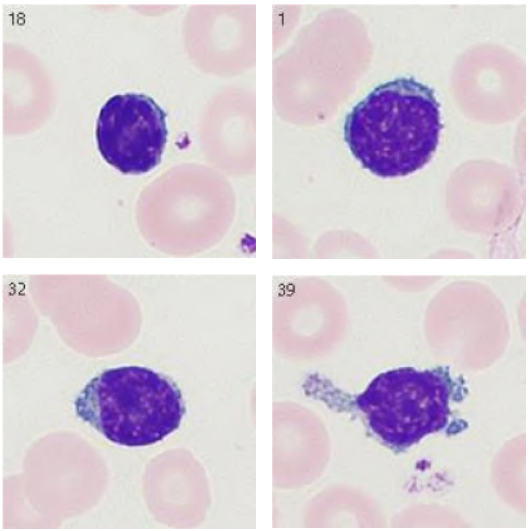
-Abn Lymph/blast?
-Lymphocytosis
-Leukocytosis
-Anemia

- WBC increased, predominantly Lym; RBC decreased, moderate anemia; PLT increased.
- In the DIFF scattergram, some Lym particles extended to the highly fluorescent region, indicating the potential existence of abnormal cells or abnormal shape of lymphocytes.

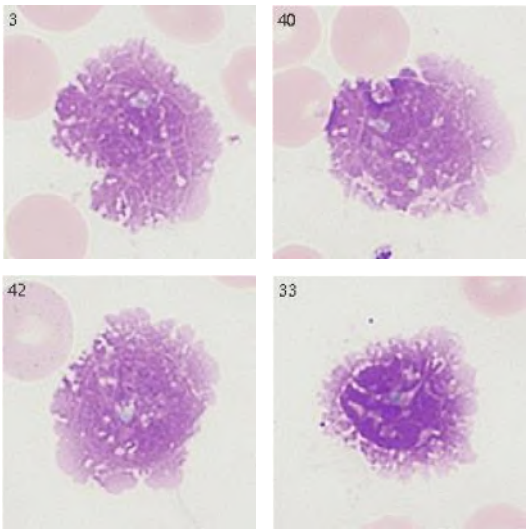
Peripheral blood morphology examination

	WBC		
	WBC	**100**	**100%**
H	Segmented neutrophil	78	78.0
	Band neutrophil	5	5.0
L	Lymphocyte	16	16.0
	Eosinophil	1	1.0
	Non-WBC	**172**	**%**
	Nucleated RBC	1	1.0
	Large PLT	1	
	PLT aggregation	1	
	Smudge cell	153	153.0
	Sediment	16	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	611*10^9/L	Automated
	PLT concentration	665*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	1.2
	Microcyte	0	5.8
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	60.0
	Polychromatic RBC	0	0.0
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	0.3
	Echinocyte	0	2.6
	Elliptocyte	0	0.5
	Ovalocyte	0	7.8
	Stomatocyte	0	0.0
	Leptocyte	0	0.7
	Dacryocyte	0	0.2
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.3

Lymphocytes



Smudge cells



Manual microscopic result

The microscopic examination showed that the lymphocytes had scant cytoplasm, with dense and regular-shaped nuclei, the chromatins were aggregated, with a shape similar to the normal mature lymphocytes or with a slightly larger nucleus or cell body. A small number of lymphocytes had moderate cytoplasm, loose chromatins, and irregular nuclei, and the shape of these cells was similar to that of the "abnormal shape of lymphocytes". Smudge cells markedly increased.

Other examinations

Item	Result
Flow cytometry immunofluorescence analysis	The flow cytometry showed that in the samples, there were approx. 63.4% of abnormal mature B lymphocytes, expressing CD5, CD19, CD23, and CD200; partially expressing CD22, CD20, and IgM; and not expressing CD10, CD34, CD38, CD79b, PMC7, sKappa, and sLambda. The flow cytometry results indicated CLL immunophenotyping (CLL score: 5).
Pathology examination report	(Posterior superior iliac spine): The HE and PAS staining showed uneven marrow hyperplasia. Most part showed extremely low hyperplasia (< 10%), a small part showed normal hyperplasia (approx. 40%). The lymphocytes increased in number, were scattered or focal, with small cell body, scant cytoplasm, round or slightly irregular nuclei, and coarse chromatins; myeloid and erythroid cells at various stages were visible, mainly myelocytes or at earlier stages. There was quite an amount of megakaryocytes, mainly segmented; reticulocyte staining was observed (MF-2, focal). The immunohistochemistry results are as follows: lymphocyte CD3 (-), CD5 (partial weak +), CD20 (+), PAX-5 (-), CD10 (-), CD23 (+), Cyclin D1 (-), SOX-11 (-), CD43 (-), CD38 (-), CD138 (-), MPO (-), TdT (-). Conclusion: Suggested diagnosis: CLL/small B-cell lymphocytic lymphoma. Further diagnosis is to be made in combination with clinical manifestations and other examinations.
Chromosome karyotyping	No clonal structure and number abnormalities were observed.

Case analysis

The patient's final diagnosis was CLL.

Case 14
Plasmodium malariae infection

14

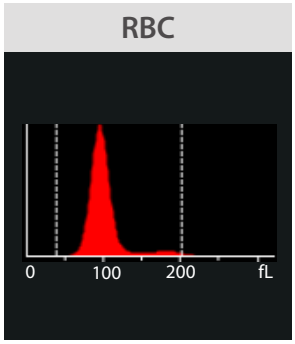
Clinical information

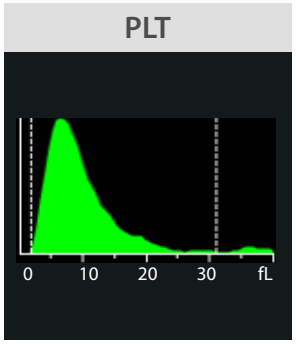
A 52-year-old male patient visited the hospital due to intermittent pyrexia (pyrexia onset every 72 hours) and pain for 1 week. This patient had a history of visiting Guinea a month before.

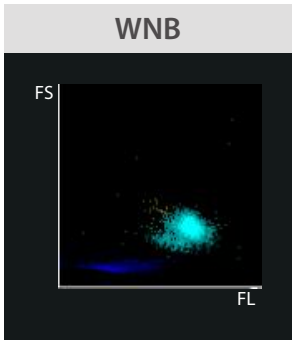
Physical examination: T 36.4 °C, P 86 bpm, R 20 times/min, BP 128/90 mmHg. The patient was conscious. He had no rash on the skin and mucous membranes, his superficial lymph nodes were not palpable or enlarged. The auscultation showed clear breath sounds in both lungs, with no dry or moist rales heard. HR: 86 bpm. The heart rhythm was normal and auscultation of each valve showed no pathological murmur. The abdomen was flat and soft, with no abdominal vein varices, gastrointestinal movement, or abdominal effusion. There was no tenderness or rebound tenderness. The liver and spleen were not palpable. The Murphy's sign was negative. The percussion test showed tympanic sound. There was no percussion pain in the liver region or kidney region. The shifting dullness was negative. The bowel sounds were normal with no gas and water sounds. Physiological reflexes were all normal and pathological reflexes were all negative.

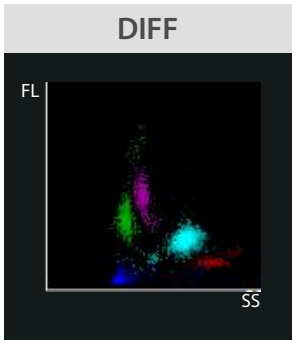
CBC results

Parameter	Flags	Result	Unit
WBC		4.95	10^9/L
Neu#		3.65	10^9/L
Lym#	L	0.67	10^9/L
Mon#		0.37	10^9/L
Eos#		0.24	10^9/L
Bas#		0.02	10^9/L
IMG#		0.01	10^9/L
Neu%	H	73.9	%
Lym%	L	13.5	%
Mon%		7.4	%
Eos%		4.7	%
Bas%		0.5	%
IMG%		0.3	%
RBC		4.26	10^12/L
HGB		139	g/L
HCT		40.6	%
MCV		95.4	fL
MCH		32.7	pg
MCHC		343	g/L
RDW-CV		11.9	%
RDW-SD		42.0	fL
*InR#		0.23	0^9/L
*InR‰		0.05	‰
PLT		137	10^9/L
MPV		9.9	fL
PDW		16.0	
PCT		0.136	%
P-LCC		33	10^9/L
P-LCR		24.2	%
NRBC#		0.000	10^9/L
NRBC%		0.00	/100WBC









Flags

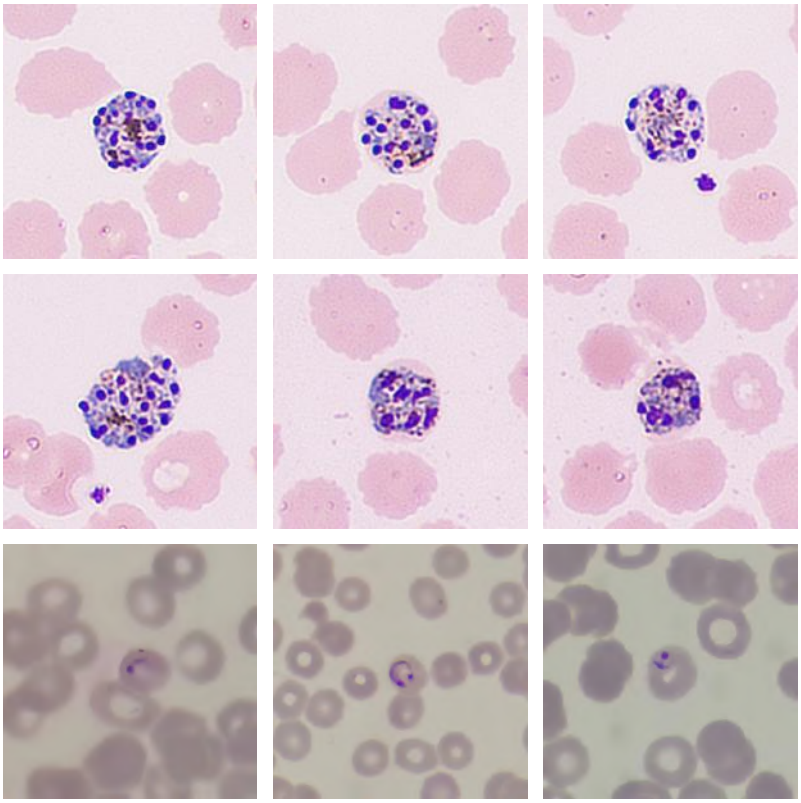
-Infected RBC
-Lymphopenia

- The blood cells were generally normal, high Neu%.
- In the DIFF scattergram, there was a small amount of green particles above the Mon group, indicating potential existence of abnormal cells or abnormal shape of lymphocytes. The Eos group was more inclined to the lower left distribution than the normal model, and was generally flat, located in the lowly fluorescent region. Microscopic examination is required.

Peripheral blood morphology examination

	WBC		
	WBC	**100**	**100%**
	Segmented neutrophil	70	70.0
!	Band neutrophil	11	11.0
L	Lymphocyte	11	11.0
	Monocyte	5	5.0
H	Basophil	2	2.0
!	Myelocyte	1	1.0
	Non-WBC	**34**	**%**
!	Nucleated RBC	1	1.0
	Large PLT	11	
	Smudge cell	13	13.0
	Sediment	9	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	183*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	0.1
!	Microcyte	2+	11.0
	Color	**Degree**	**%**
	Hypochromic RBC	0	0.2
	Polychromatic RBC	0	0.6
	Shape	**Degree**	**%**
!	Poikilocytosis	2+	
	Schistocyte	0	0.8
!	Echinocyte	2+	43.2
	Elliptocyte	0	0.3
	Ovalocyte	0	4.4
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	0.2
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.1

Plasmodium



Manual microscopic result

The microscopic examination showed red blood cells infected by *Plasmodium malariae*, mainly schizonts and trophozoites. Schizont almost occupied all red blood cells. The cytoplasm was dark blue and the merozoites were arranged in ring form. The malarial pigment was gathered at the center. The ring of trophozoites was thick, about 1/3 the diameter of the red blood cell. The parasite body had 1–2 red nuclei, dark blue cytoplasm, and was ring-like.

Other examinations

Item	Result
Plasmodium detection at CDC	*Plasmodium malariae*

Case analysis

Plasmodium malariae parasites in small red blood cells. There are usually 6–12 merozoites arranged in a chrysanthemum-like pattern, with central aggregation; The gametocytes are round with a dark red or pale red nucleus on one side or in the center, and dark brown malarial pigments scatter evenly. Data have shown that once infected, *Plasmodium malariae* may be carried lifelong. Its incubation period in humans may last from several years to even decades, and it can survive 20 to 30 years in human bone marrow before causing malaria episodes. Due to the long development duration in red blood cells and the small number of mature merozoites, the detection of *Plasmodium malariae* is easily missed in the peripheral blood smear examination at the early stage of onset.

Case 15

Plasmodium falciparum infection

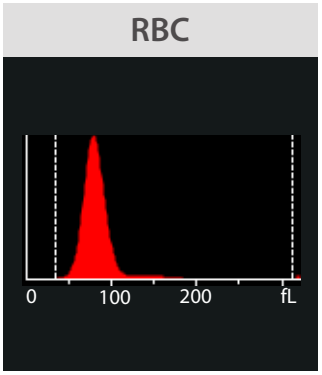
15

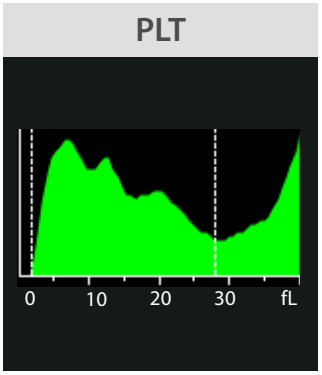
Clinical information

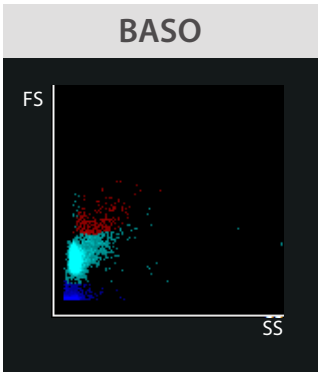
This patient was a 48-year-old male.

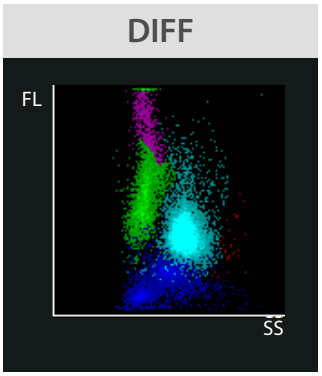
CBC results

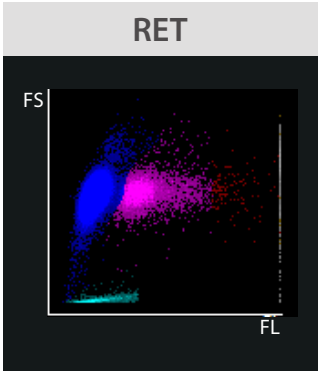
Parameter	Flags	Result	Unit
WBC	H	17.17	10^9/L
Neu#	R H	12.20	10^9/L
Lym#	R H	4.08	10^9/L
Mon#	R	0.56	10^9/L
Eos#	R	0.05	10^9/L
Bas#	R H	0.28	10^9/L
IMG#	R	1.02	10^9/L
Neu%	R	70.9	%
Lym%	R	23.8	%
Mon%	R	3.3	%
Eos%	R L	0.3	%
Bas%	R H	1.7	%
IMG%	R	5.9	%
RBC	L	2.14	10^12/L
HGB	L	62	g/L
HCT	L	18.1	%
MCV		84.6	fL
MCH		28.9	pg
MCHC		342	g/L
RDW-CV		14.8	%
RDW-SD		43.4	fL
*InR#		0.04	0^9/L
*InR‰		0.02	‰
PLT	& L	61	10^9/L
MPV		****	fL
PDW		****	
PCT		****	%
P-LCC		****	10^9/L
P-LCR		****	%
RET#	H	0.2499	10^12/L
RET%	H	11.68	%
IRF		2.4	%
LFR		97.6	%
MFR		2.3	%
HFR		0.1	%











Flags

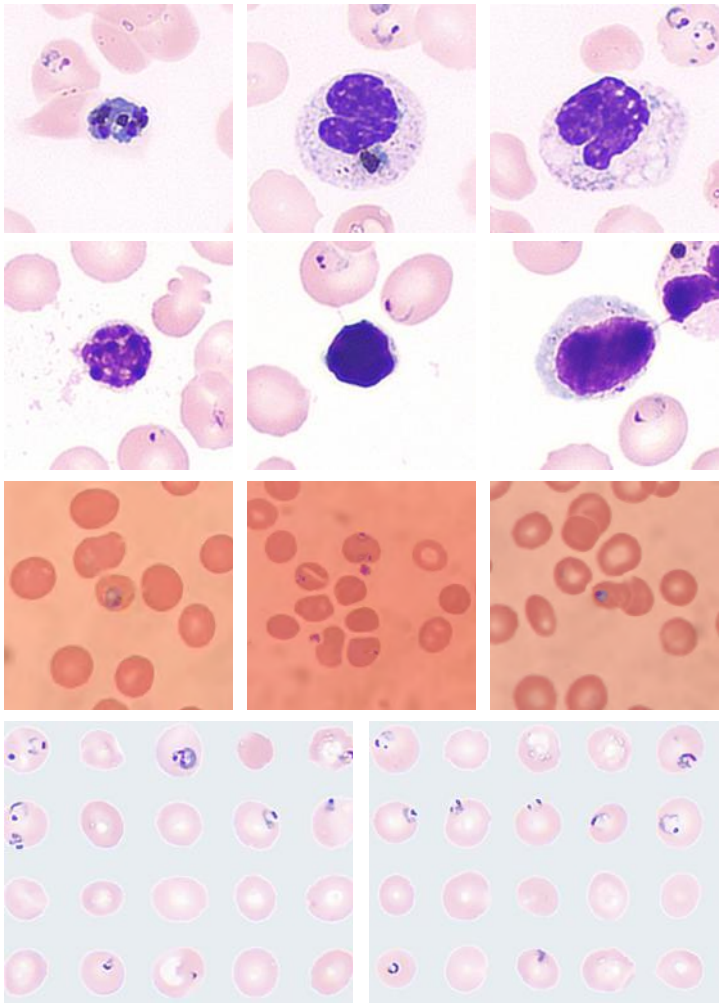
-Abn Lymph/blast?
-Immature Gran?
-Left Shift?
-Basophilia
-Lymphocytosis
-Neutrophilia
-Anemia
-Reticulocytosis

- WBC increased; RBC and PLT both decreased.
- In the DIFF scattergram, the particle groups all diffused toward the highly fluorescent region; in the RET scattergram, there was a group of highlighted particles in the LFR region.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
L	Segmented neutrophil	91	45.5
!	Band neutrophil	38	19.0
L	Lymphocyte	17	8.5
	Monocyte	11	5.5
	Basophil	1	0.5
!	Metamyelocyte	26	13.0
	Promyelocyte	1	0.5
!	Myeloblast	3	1.5
!	Reactive lymphocyte	12	6.0
	Non-WBC	**161**	**%**
!	Nucleated RBC	11	5.5
	Giant PLT	1	
	Large PLT	30	
	PLT aggregation	2	
	Smudge cell	97	48.5
	Sediment	11	
	Plasmodium - trophozoite	8	
	Plasmodium - schizont	1	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	139*10^9/L	Automated
	PLT concentration	100*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	2+	
	Macrocyte	0	1.2
!	Microcyte	2+	13.0
	Color	**Degree**	**%**
	Hypochromic RBC	0	1.6
	Polychromatic RBC	0	0.3
	Shape	**Degree**	**%**
!	Poikilocytosis	1+	
!	Schistocyte	1+	1.7
	Echinocyte	0	4.2
	Elliptocyte	0	1.7
	Ovalocyte	0	16.7
	Stomatocyte	0	0.0
	Leptocyte	0	0.2
	Dacryocyte	0	0.4
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.3

疟原虫



Manual microscopic result

The microscopic examination showed red blood cells infected by *Plasmodium falciparum*, mainly trophozoites. The ring was thin, taking up about 1/5 the red blood cell. There were 1–2 nuclei. Two or more protozoons were inside each red blood cell. The parasite body was usually located at the edge of the red blood cell. A small amount of schizonts were visible, irregularly arranged, and the malarial pigments were gathered. Neutrophils ingesting the *Plasmodium* were visible.

Case analysis

In recent years, due to the increasing mobility of the population, malaria is mainly caused by *Plasmodium falciparum* and *Plasmodium vivax*, while cases of *Plasmodium malariae* are less common. Once a patient is infected, the *Plasmodium* in the red blood cells lyses and proliferates, damaging the red blood cells and leading to anemia. The schizonts released and the other metabolic products are engulfed by phagocytic cells, resulting in abnormal monocyte and neutrophil contents. This is shown in the scattergram as the Neu and Mon groups extending toward the highly fluorescent and high lateral scattered light regions. Sometimes, the Neu particles in the high lateral scattered light region are counted as Eos by the analyzer. For real eosinophils, their eosinophilic granules specifically bind to the reagents in the analyzer so that the lateral scattered light is markedly enhanced. This can be used for the differentiation from the neutrophils engulfing the *Plasmodium*.

In addition, the infected red blood cells carry the nucleic materials of the *Plasmodium*, so the infected red blood cells showed certain fluorescent signals in the RET scattergram, leading to false RET increase.

Case 16

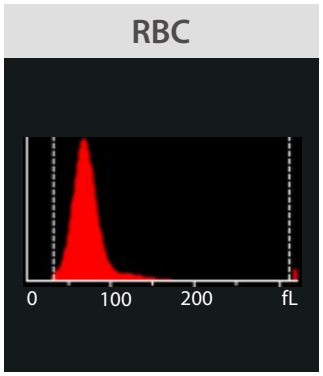
Essential thrombocythemia (ET)

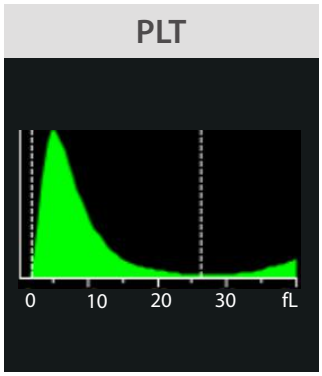
Clinical information

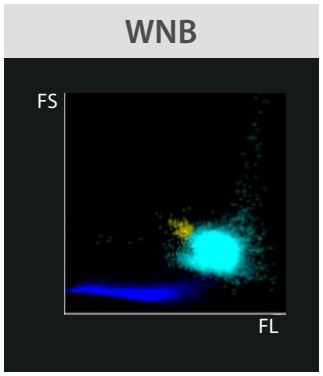
This patient was a 48-year-old male.

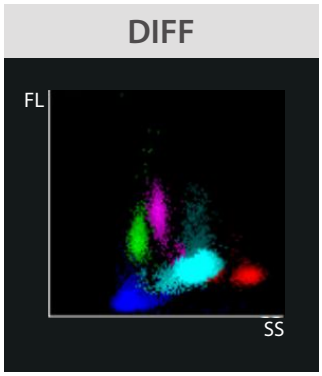
CBC results

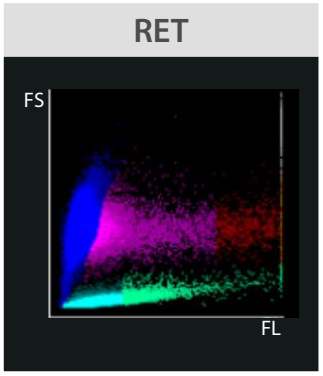
Parameter	Flags			Result	Unit
WBC			H	59.17	10^9/L
Neu#		R	H	54.22	10^9/L
Lym#				1.68	10^9/L
Mon#			H	1.41	10^9/L
Eos#		R	H	1.62	10^9/L
Bas#		R	H	0.24	10^9/L
IMG#				1.75	10^9/L
Neu%		R	H	91.7	%
Lym%			L	2.8	%
Mon%			L	2.4	%
Eos%		R		2.7	%
Bas%		R		0.4	%
IMG%				2.9	%
RBC		R	L	3.72	10^12/L
HGB			L	75	g/L
HCT		R	L	25.9	%
MCV		R	L	69.6	fL
MCH		R	L	20.1	pg
MCHC		R	L	288	g/L
RDW-CV		R	H	19.5	%
RDW-SD		R		49.5	fL
PLT	&	@	H	5126	10^9/L
MPV		R		8.1	fL
PDW		R		16.1	
PCT		R	H	3.129	%
P-LCC		R	H	832	10^9/L
P-LCR		R		16.2	%
IPF		R		3.8	%
RET#		R	H	0.3437	10^12/L
RET%			H	9.24	%
IRF				23.7	%
LFR			L	76.3	%
MFR				13.7	%
HFR			H	10.0	%
RHE			L	19.1	pg
NRBC#				0.000	10^9/L
NRBC%				0.00	/100WBC











Flags

-Immature Gran?
-Left Shift?
-Basophilia
-Eosinophilia
-Neutrophilia
-Leukocytosis
-RBC Agglutination
-Fragments
-Hypochromia
-Iron Deficiency?
-Microcytosis
-Reticulocytosis
-PLT Clump

- WBC increased, predominantly Neu; RBC decreased, microcytic hypochromic anemia; PLT extremely increased.
- Histograms and scattergrams were basically normal.

Peripheral blood morphology examination

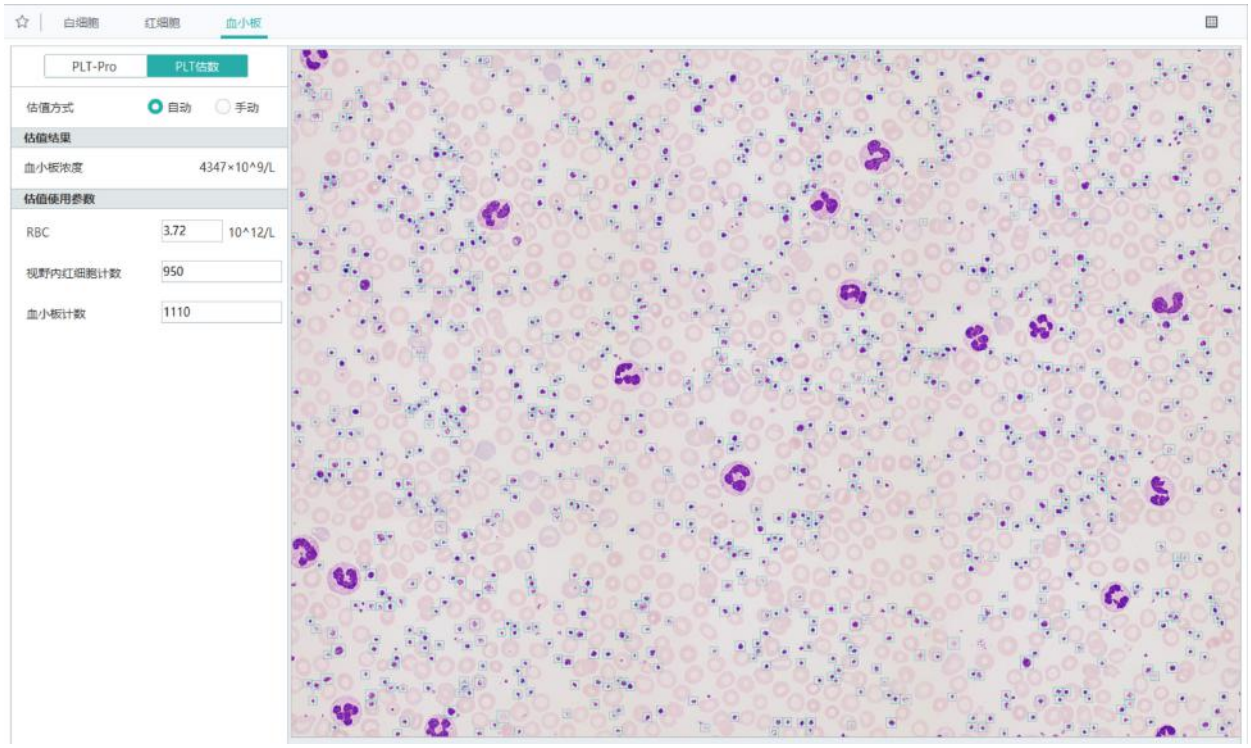
	WBC		
	WBC	**100**	**100%**
H	Segmented neutrophil	86	86.0
	Band neutrophil	4	4.0
L	Lymphocyte	1	1.0
L	Monocyte	1	1.0
	Eosinophil	4	4.0
H	Basophil	3	3.0
	Metamyelocyte	1	1.0
	Non-WBC	**10**	**%**
	Large PLT	4	
	PLT aggregation	1	
	Smudge cell	4	4.0
	Sediment	1	

	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	4347*10^9/L	Automated
	PLT concentration	4953*10^9/L	Manual

	RBC		
	Size	**Degree**	**%**
!	Uneven erythrocyte sizes	3+	
	Macrocyte	0	2.0
!	Microcyte	2+	17.1
	Color	**Degree**	**%**
!	Hypochromic RBC	3+	42.6
!	Polychromatic RBC	2+	2.0
	Shape	**Degree**	**%**
	Poikilocytosis	0	
	Schistocyte	0	1.1
	Echinocyte	0	0.0
	Elliptocyte	0	0.5
	Ovalocyte	0	7.7
	Stomatocyte	0	2.3
	Leptocyte	0	1.4
	Dacryocyte	0	0.4
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0

Manual microscopic result

The microscopic examination showed WBCs increased, mainly mature neutrophils. The platelets were abnormally increased, scattered, and distributed in small clusters. The cell sizes were uneven, microplatelets, large platelets, and giant platelets were visible. A small amount of platelets were lack of granules.



Other examinations

Item	Result
Bone marrow morphology examination	Active bone marrow hyperplasia; active myeloid hyperplasia, the ratio of cells at each stage was normal; active erythroid hyperplasia; a total of 51 megakaryocytes were observed; the platelets were scattered and visible in clusters; no other pathological cells or parasites were observed. Suggested diagnosis: thrombocytosis.
Gene detection	JAK2 14exon: JAK2 V617F 40% mutation.

Case analysis

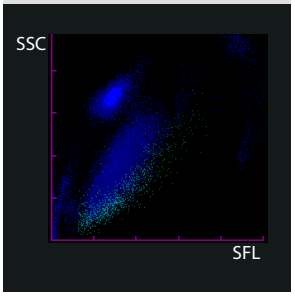
Essential thrombocythemia (ET) adds to the risk of embolism and hemorrhage. About 1/3 of the ET patients have gene mutations, where JAK2 V617F mutations account for 60%. In 2008, WHO listed JAK2 V617F gene mutation as one of the primary diagnostic indicator for myeloproliferative neoplasms (MPN). In the WHO MPN classification guideline of 2016, JAK2 analysis becomes the main evaluation criteria for all MPN diagnoses.

Case 17
Hypogranular platelet

Clinical information

A 59-year-old male patient visited the hospital due to chronic colitis, gastroenteritis, etc. Subsequent pathological diagnosis showed benign colon neoplasm. The initial CBC results showed: PLT-I: 220*10^9/L, PLT-F: 29*10^9/L. The difference was significant, the scattergrams are shown as follows, so retesting was conducted using another analyzer.

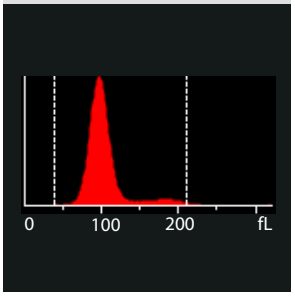
PLT-F(SFL-SSC)



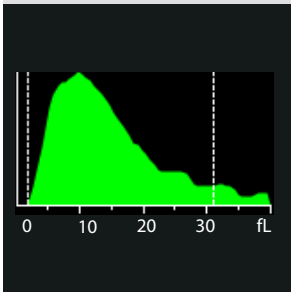
CBC results

Parameter	Flags	Result	Unit
WBC		6.64	10^9/L
Neu#		4.14	10^9/L
Lym#		1.83	10^9/L
Mon#		0.49	10^9/L
Eos#		0.15	10^9/L
Bas#		0.03	10^9/L
IMG#		0.02	10^9/L
Neu%		62.5	%
Lym%		27.5	%
Mon%		7.3	%
Eos%		2.3	%
Bas%		0.4	%
IMG%		0.3	%
RBC		4.75	10^12/L
HGB		155	g/L
HCT		47.2	%
MCV		99.3	fL
MCH		32.6	pg
MCHC		328	g/L
RDW-CV		12.4	%
RDW-SD		44.3	fL
PLT	R	219	10^9/L
MPV	R H	13.6	fL
PDW	R	16.3	
PCT	R H	0.297	%
P-LCC	R H	114	10^9/L
P-LCR	R H	52.1	%
NRBC#		0.000	10^9/L
NRBC%		0.00	/100WBC

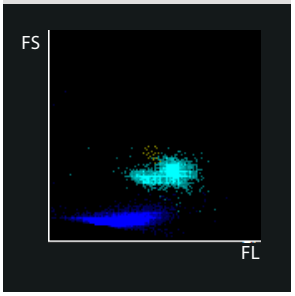
RBC



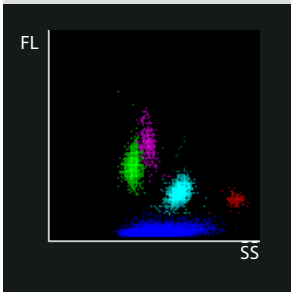
PLT



WNB



DIFF



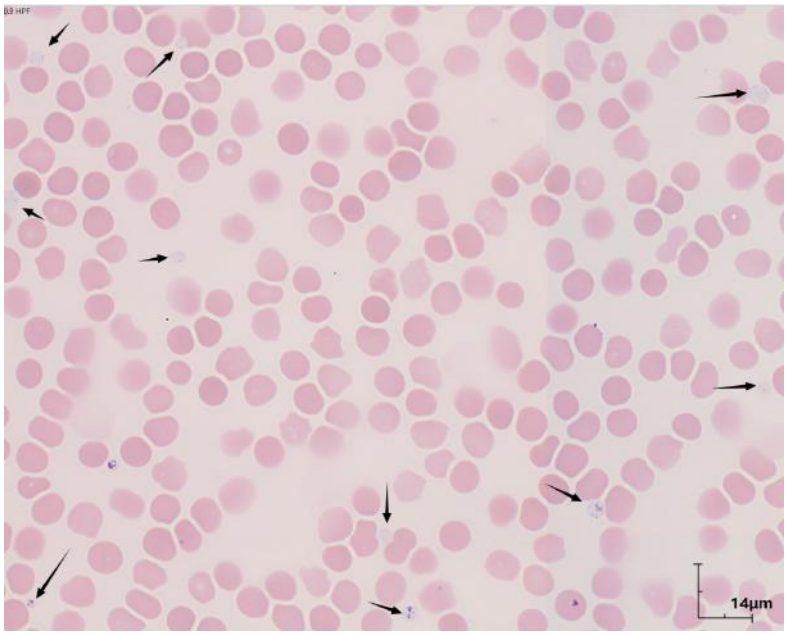
Flags

- PLT Clump?

- The blood cells were generally normal.
- The PLT histogram had a zigzag tail, the alarm of platelet aggregation was raised. Since the PLT results from different tests varied, microscopic examination was required for retest.

Peripheral blood morphology examination

	WBC		
	WBC	**200**	**100%**
	Segmented neutrophil	131	65.5
	Band neutrophil	5	2.5
L	Lymphocyte	23	11.5
	Monocyte	12	6.0
H	Eosinophil	23	11.5
H	Basophil	6	3.0
	Non-WBC	**450**	**%**
	Giant PLT	6	
	Large PLT	6	
	Smudge cell	388	194.0
	Sediment	50	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	214*10^9/L	Automated
	PLT concentration	209*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	10.7
	Microcyte	0	0.8
	Color	**Degree**	**%**
	Hypochromic RBC	0	0.1
	Polychromatic RBC	0	0.1
	Shape	**Degree**	**%**
!	Poikilocytosis	2+	
!	Schistocyte	2+	1.7
	Echinocyte	0	0.2
	Elliptocyte	0	1.4
!	Ovalocyte	2+	15.0
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	1.5
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0



Manual microscopic result

The PLT estimate was consistent with the second CBC result. A large amount of grayish-white platelets scattered.

Case analysis

This is a case of fluorescence-based false PLT count decreased caused by platelet granule deficiency. Platelet granule deficiency is observed in congenital disorders, such as gray platelet syndrome. The platelets and megakaryocytes have abnormal shapes and the cellular granules markedly decrease. Since the PLT cellular granules carry a large amount of nucleic materials, the lack of these granules leads to the weakening of PLT fluorescence signal, which is a possible cause of PLT false decrease.

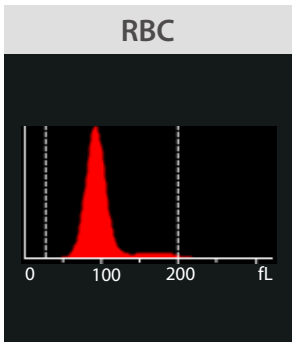
Case 18
EDTA-induced pseudothrombocytopenia (EDTA-PTCP)

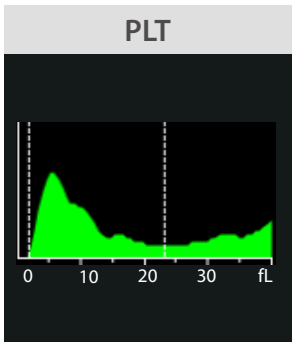
Clinical information

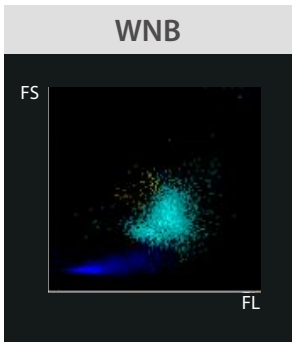
This patient was a 66-year-old male. The gastroscopic examination on Jul. 3, 2023 showed progressive gastric cancer and chronic atrophic gastritis. The patient was then admitted to the hospital due to "gastric malignancy". Since onset, the patient was in good general conditions, with normal urination and defecation, but weight loss.

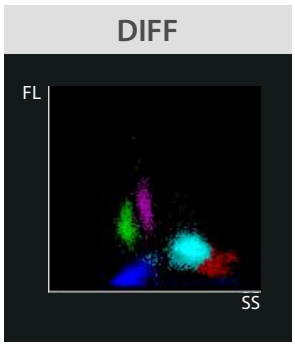
CBC results

Parameter	Flags		Result	Unit
WBC	R		8.14	10^9/L
Neu#	R		5.91	10^9/L
Lym#			1.02	10^9/L
Mon#			0.45	10^9/L
Eos#	R	H	0.69	10^9/L
Bas#			0.07	10^9/L
IMG#			0.05	10^9/L
Neu%	R	H	72.7	%
Lym%		L	12.5	%
Mon%			5.5	%
Eos%	R	H	8.4	%
Bas%			0.9	%
IMG%			0.6	%
RBC			4.86	10^12/L
HGB			153	g/L
HCT			46.7	%
MCV			96.1	fL
MCH			31.4	pg
MCHC			327	g/L
RDW-CV			13.5	%
RDW-SD			46.0	fL
PLT-O	R		175	10^9/L
PLT-I	R	L	38	
MPV	R		9.8	fL
PDW	R		16.6	
PCT	R	L	0.037	%
P-LCC	R		49	10^9/L
P-LCR	R		28.2	%
NRBC#			0.000	10^9/L
NRBC%			0.00	/100WBC









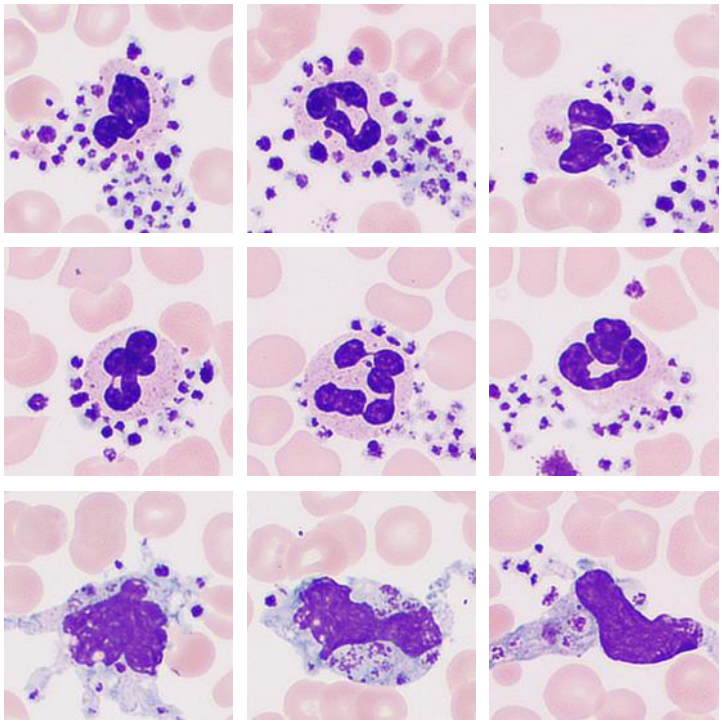
Flags

-WNB Abn Scattergram
-Left Shift?
-PLT Clump?

- The blood cells were generally normal. The difference between PLT-O and PLT-I was significant, possibly due to PLT aggregation.
- The PLT histogram had a zigzag tail, the alarm of platelet aggregation was raised. In the WNB scattergram, the blood cell particle group on the left bottom corner extended toward the right upper direction and even surpassed the WBC group, and the analyzer raised the alarm of abnormal scattergram. In the DIFF scattergram, the Neu group extended toward the high lateral scattered light region and invaded the Eos region, so some Neu particles were counted as Eos.

Peripheral blood morphology examination

	WBC		
	WBC	**201**	**100%**
L	Segmented neutrophil	67	33.3
	Lymphocyte	68	33.8
H	Monocyte	40	19.9
H	Eosinophil	20	10.0
H	Basophil	5	2.5
	Metamyelocyte	1	0.5
	Non-WBC	**252**	**%**
	Giant PLT	1	
	Large PLT	14	
	PLT aggregation	61	
	Smudge cell	63	31.3
	Sediment	113	
	PLT		
	PLT estimate	**Estimated result**	**Estimation method**
	PLT concentration	214*10^9/L	Automated
	PLT concentration	209*10^9/L	Manual
	RBC		
	Size	**Degree**	**%**
	Uneven erythrocyte sizes	0	
	Macrocyte	0	10.7
	Microcyte	0	0.8
	Color	**Degree**	**%**
	Hypochromic RBC	0	0.1
	Polychromatic RBC	0	0.1
	Shape	**Degree**	**%**
!	Poikilocytosis	2+	
!	Schistocyte	2+	1.7
	Echinocyte	0	0.2
	Elliptocyte	0	1.4
!	Ovalocyte	2+	15.0
	Stomatocyte	0	0.0
	Leptocyte	0	0.0
	Dacryocyte	0	1.5
	Contents	**Degree**	**%**
	Basophilic stippling	0	0.0



Manual microscopic result

Besides the aggregation of a large amount of PLTs, neutrophils were surrounded by a large amount of PLTs, and monocytes were ingesting PLTs.

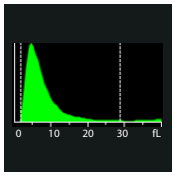
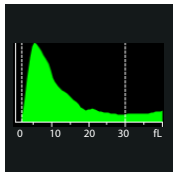
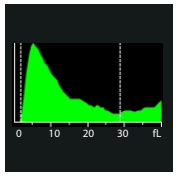
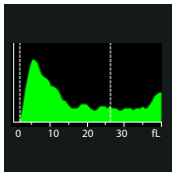
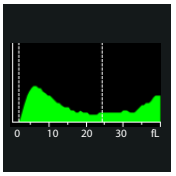
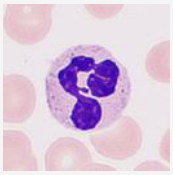
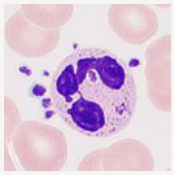
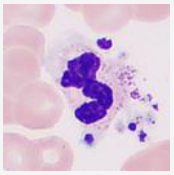
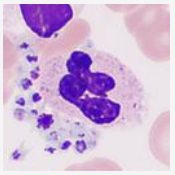
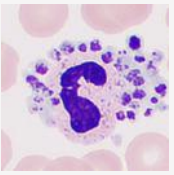
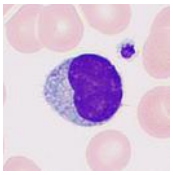
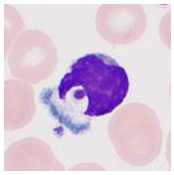
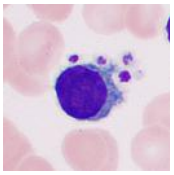
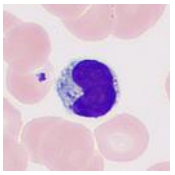
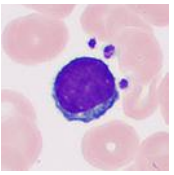
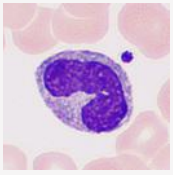
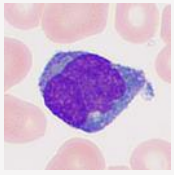
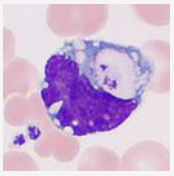
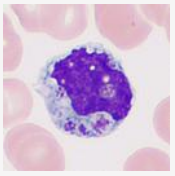
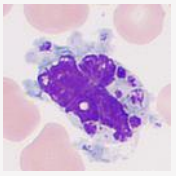
Case analysis

Platelet satellitism is commonly reported in samples from various cancer patients and are thought to be related to platelet activation induced by ethylenediaminetetraacetic acid anticoagulants (EDTA). This EDTA-induced pseudo-thrombocytopenia is known as EDTA-PTCP in clinical practice.

PTCP can be observed in patients with autoimmune disorders, inflammations, tumors, or pregnancy, and even in the healthy population. This indicated that these autoantibodies are not related to the onset of diseases.

To investigate this case for the relationship between PLT satellitism and the blood sampling time/ anticoagulants, blood samples were collected in EDTA-tubes and citrate tubes, respectively, and tested at 5 min, 30 min, 1 h, 2 h, and 3 h after blood sampling. The results are as follows:

Case analysis

EDTA sample					
Time after blood sampling	5min	30min	1h	2h	3h
PLT-O	240	220	197	162	99
PLT-I	224	157	83	47	27
WBC-O	5.26	5.34	5.18	5.62	4.42
WBC-D	6.12	6.05	6.95	7.59	8.29
WBC-N	6.01	6.17	6.14	7.70	8.13
PLT histogram					
Neu					
Lym					
Mon					

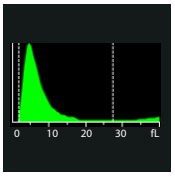
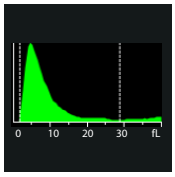
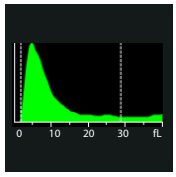
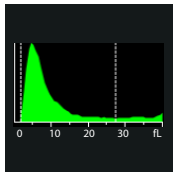
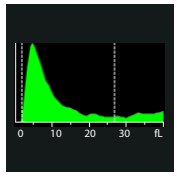
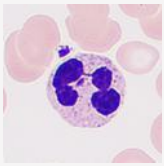
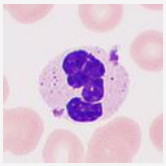
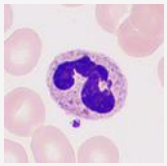
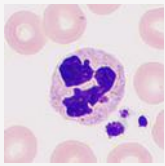
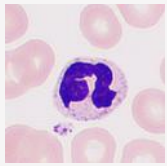
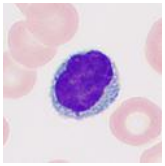
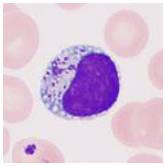
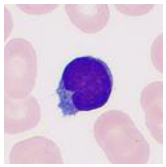
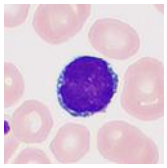
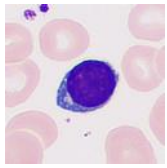
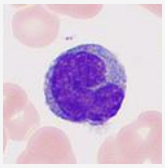
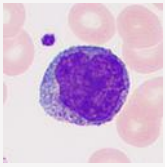
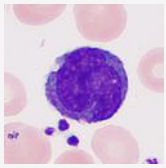
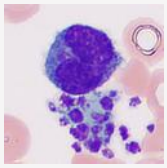
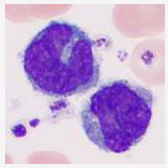
The histogram within 5 min after blood sampling showed that there was no pattern of platelet aggregation. However, with the prolongation of the test time, the histogram at 30 min after blood sampling already showed an elevating trend of the tail, together with zigzag patterns. The histogram at 3 h after blood sampling clearly indicated PLT aggregation.

The CDR test results showed that there was almost no difference in PLT-I and PLT-O results within 5 min after blood sampling. With the prolongation of the test time, the PLT-O results were much greater than PLT-I, indicating that the testing of EDTA-dependent platelet aggregation samples could be improved by RET channel; however, the PLT-O results also decreased with the increase of time, indicating that the ability of RET channel to depolymerize platelets continuously decreased with the increase of time.

The WBC results also increased over time, possibly because the PLT aggregation group had scattered light and fluorescence signals similar to WBC and were hence counted as WBCs.

According to the film reading results, satellitism and phagocytosis were also more pronounced over time.

Case analysis

Citrate sample					
Time after blood sampling	5min	30min	1h	2h	3h
PLT-O	225	185	170	140	116
PLT-I	189	174	129	115	93
WBC-O	5.54	4.22	4.70	4.02	3.94
WBC-D	5.60	5.35	5.25	5.92	6.30
WBC-N	5.62	5.36	5.26	5.42	5.41
PLT histogram					
Neu					
Lym					
Mon					

As shown in the histogram, PLT results, and cytogram, the PLT aggregation trend in the citrate tubes was significantly weaker than that in the EDTA tubes.

In this case, severe EDTA-dependent PLT satellitism was observed along with chronic gastric cancer. It is worth noting that PLT satellitism usually occurs around neutrophils, but it is rare to see satellitism and phagocytosis around lymphocytes and monocytes, such as in this case. A possible reason for PLT satellitism around lymphocytes may be platelet adsorption caused by the lymphocyte surface protein molecular abnormality.

PLT satellitism generally occurs under the following conditions.

1. EDTA-K2 can induce immune mediation in blood. Antiplatelet antibodies are then produced, leading to PLT satellitism and low PLT count.

2. The complement mediated cell lysis (C3) is activated and the major product, C3b, attaches onto the surface of the platelets and binds with the C3b receptors on the neutrophils, so platelets are engulfed, leading to low PLT count.

3. WBCs and PLTs interact through adhesion protein molecules.

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