MEDLAB BASICS · STUDY SHEET

CBC, Analyzers and Spurious Results

CBC parameters and indices with the ASCP ranges, how analyzers count cells, flags and histograms, spurious results and their fixes, reticulocytes, ESR, manual counts and body fluids

21 sources + more detail

medlabbasics.com/sheets/lab-cbc-analyzers.html
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1 CBC parameters and the ASCP ranges

Ranges are the ASCP BOC composite ranges (June 2026), for exam use only. Units ×10³/µL equal ×10⁹/L.

PARAMETER	MEASURED OR CALCULATED	ASCP RANGE, CONVENTIONAL (SI)
WBC	Measured (counted)	3.6–10.6 ×10³/µL (×10⁹/L)
RBC	Measured (counted)	4.00–6.00 ×10⁶/µL (×10¹²/L)
Hemoglobin	Measured (photometry after lysis)	12.0–18.0 g/dL (120–180 g/L)
Hematocrit	Calculated on most analyzers: RBC × MCV ÷ 10	35–50% (0.35–0.50 L/L)
MCV	Measured (mean cell size); by hand: Hct × 10 ÷ RBC	76–100 fL
MCH	Calculated: Hgb × 10 ÷ RBC	26–34 pg
MCHC	Calculated: Hgb × 100 ÷ Hct	32–36 g/dL (320–360 g/L)
RDW	Calculated from the RBC size curve	11.5–14.5% (0.115–0.145)
Platelets	Measured (counted)	150–450 ×10³/µL (×10⁹/L)
Reticulocytes	Measured (fluorescence or supravital stain)	0.5–2.5%; absolute 20–115 ×10³/µL
nRBCs	Counted per 100 WBCs	0 per 100 WBCs

Absolute count = WBC × percentage. Judge a differential on absolute numbers: a 'high' percentage can be a normal absolute count.

CELL	RELATIVE	ABSOLUTE, ×10³/ML (×10⁹/L)
Neutrophils	50–70%	1.7–7.5
Lymphocytes	18–42%	1.0–3.2
Monocytes	2–11%	0.1–1.3
Eosinophils	1–3%	0–0.3
Basophils	0–2%	0–0.2

2 Indices, RDW and the rule of three

- MCV (fL) = Hct (%) × 10 ÷ RBC (×10⁶/µL). Under 76 fL is microcytic and over 100 fL macrocytic on the ASCP range (many laboratories use 80 fL as the lower limit).
- MCH (pg) = Hgb (g/dL) × 10 ÷ RBC (×10⁶/µL).
- MCHC (g/dL) = Hgb (g/dL) × 100 ÷ Hct (%).
- RDW is the spread of red cell sizes. RDW-CV = SD of the size curve ÷ MCV × 100, so it moves with MCV; RDW-SD (in fL) does not.
- A high RDW with a normal MCV can be the only sign of two populations (one small, one large) whose average looks normal.
- Rule of three: RBC × 3 ≈ Hgb, and Hgb × 3 ≈ Hct ± 3. It holds only for normocytic, normochromic cells; a failure in such a patient means a result needs checking.

EXAM TIP An MCHC above 36 g/dL is the classic flag of a spurious CBC: think cold agglutinin, lipemia, hemolysis or icterus first. Only marked spherocytosis or sickle cells (possibly acanthocytes) raise it for real, and a smear tells you which. An MCHC under 28 g/dL is the other alarm.

3 How analyzers count

PRINCIPLE	WHAT IT MEASURES	WEAK POINT
Electrical impedance (Coulter principle)	Each cell in an electrolyte passes through a small aperture between two electrodes; the pulse is proportional to cell volume. Particles in a set size window are counted as that cell.	Anything of the right size is counted: microcytes, fragments, lipid particles and bacteria in the platelet window; giant platelets and clumps fall outside it.
Light scatter (flow cell)	Low-angle (forward) scatter tracks size; high-angle (side) scatter tracks internal complexity and granularity. Two-dimensional plots separate cell types.	Cells with unusual size or granules can land in the wrong cluster; the analyzer flags rather than identifies.
Fluorescence flow cytometry	A nucleic acid dye stains RNA and DNA, so reticulocytes and platelets (separated from red cell fragments) are counted by fluorescence plus scatter; some analyzers run the whole WBC differential this way.	Fewer interferences, but still needs smear review for flagged samples.
VCS (volume, conductivity, scatter)	Impedance gives volume, radiofrequency conductivity gives internal composition (nucleus, N:C ratio), laser scatter gives granularity.	Same limits as other flow methods: abnormal cells are flagged, not named.
Immunological platelet count (CD41/CD61 flow)	Labeled antibodies to GPIIb-IIIa; the ICSH/ISLH reference method for platelets.	A reference method, not a routine one.

EXAM TIP When impedance gives a falsely high platelet count from microcytes or fragments, an optical or fluorescent platelet count, or a smear estimate, is the fix. When it gives a falsely low count from giant platelets, use a smear estimate or a phase-microscopy manual count.

4 Corrections and estimates to know by hand

- Corrected WBC = uncorrected WBC × 100 ÷ (100 + nRBCs per 100 WBCs). The ASCP lists it for more than 10 nRBCs. Example: 15.0 ×10³/µL with 25 nRBCs → 15.0 × 100 ÷ 125 = 12.0 ×10³/µL.
- Citrate (blue top) tube results: multiply WBC, RBC, Hgb, Hct and platelets by 1.1 (9 parts blood to 1 part citrate). Indices need no correction.

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4 Corrections and estimates to know by hand CONTINUED

- Diluted sample: multiply WBC, RBC, Hgb, Hct and platelets by the dilution factor; MCV, MCH, MCHC and RDW are unchanged.
- Platelet estimate: average platelets per 100× oil field (10 fields) × 15 = ×10³/µL (laboratories use factors of 10 to 20).
- Absolute count = WBC × percentage, or for retics, RBC × retic %. Example: 2.0% × 3.50 ×10⁶/µL × 10 = 70 ×10³/µL.

EXAM TIP The app's calculators do these: Red Cell Indices, WBC Corrected for nRBCs, Reticulocyte Count, Manual Cell Count, Dilution Factor and ANC.

5 Spurious results and the fix

From Gulati 2022 and Cattaneo 2025. Check the analyzer manufacturer's manual for model-specific behavior.

CAUSE	WHAT HAPPENS	HOW YOU SPOT IT	FIX
Cold agglutinin (IgM autoagglutination)	RBC and Hct falsely low; MCV, MCH and MCHC falsely high; WBC can be low if trapped in clumps	MCHC far above 36; Hgb × 3 far above Hct; grainy tube wall; red cell clumps on the smear	Warm the tube at 37 °C for 10–15 min and rerun at once; check a fresh smear. If it fails, recollect and keep at 37 °C
Lipemia	Hgb, MCH and MCHC falsely high (turbidity); impedance platelets can rise from lipid particles	Milky plasma; high MCHC; Hgb and Hct disagree	Replace plasma with an equal volume of diluent and rerun; report Hgb, MCH and MCHC from the rerun (and counts, Hct, MCV and RDW from the first run if the two runs disagree)
In vitro hemolysis	RBC and Hct falsely low; MCH and MCHC high; ghosts may raise the platelet count	Red plasma; mildly high MCHC; K, LD and AST up with a normal retic	Report with a 'specimen hemolyzed' comment, or report only WBC, Hgb, MCV, RDW and a smear-verified platelet count
Icterus (bilirubin above about 25 mg/dL)	Hgb, MCH and MCHC falsely high	Bright yellow plasma; Hgb interference flag	Dilute 1:2 to 1:5 with diluent, rerun and correct for the dilution
Platelet clumping (EDTA-dependent)	Platelets falsely low; large clumps counted as WBCs	Clump flag; clumps at the feather edge; no bleeding history	Vortex 1–2 min and rerun (works in about half), or recollect in citrate and multiply by 1.1
Platelet satellitism	Platelets can be falsely low, usually only slightly (platelets ringed around neutrophils)	Smear shows rosettes of platelets on neutrophils	Citrate tube (× 1.1) or vortex and rerun
Giant platelets	Platelets falsely low; WBC sometimes falsely high	Platelets as big as red cells on the smear; MPN, MDS, inherited macrothrombocytopenias	Smear estimate or phase-microscopy manual count
nRBCs	WBC falsely high (counted as WBCs) unless the analyzer corrects	nRBC flag; nRBCs on the differential	Corrected WBC = WBC × 100 ÷ (100 + nRBCs per 100 WBCs)
Cryoglobulins or cryofibrinogen	WBC and/or platelets falsely high (precipitate counted)	Turbid cold plasma; pale amorphous material on the smear; hepatitis C, myeloma	Warm to 37 °C for 10–20 min and rerun
Very high WBC (100 ×10³/µL or more)	Hgb, MCH, MCHC falsely high (turbidity); RBC, MCV and Hct can rise	Leukemia sample; high MCHC	Dilute, rerun and correct for the dilution
Microcytes (MCV under 60 fL) and schistocytes	Platelets falsely high on impedance; MPV may be high	Platelet histogram does not return to baseline; fragments on the smear	Optical or fluorescent platelet count, or smear estimate
Glucose 600 mg/dL (33 mmol/L) or more	MCV and Hct falsely high; MCHC falsely low	High MCV with low MCHC; often IV glucose contamination	Dilute, let stand 10 min, rerun and correct for the dilution; or spun hematocrit and recalculate MCV and MCHC
Clots or fibrin	Small clots: all counts and Hgb low; fibrin clumps can raise the WBC; either can block the aperture (no result)	Fibrin strands on the smear; delta failure	Recollect; do not report
IV fluid dilution	All counts, Hgb and Hct low	Delta failure; chemistry also diluted	Recollect away from the line

SAFETY Verify a new platelet count under 100 ×10³/µL, or a drop of 50% or more, on the smear before it is released. A falsely low count can lead to a platelet transfusion or a cancelled procedure, and a true fall may be heparin-induced thrombocytopenia.

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