Learning Objectives:
At the completion of this presentation and with some study, the participant will be able to:
- follow a systematic approach for interpreting CBC information
- correlate CBC instrument information with microscopic morphology and probable clinical pathology
- given CBC information, keep looking at the “bigger picture” to help narrow down a probably cause for these blood pictures—compare and contrast—look for patterns.
- and make sure we are not late for lunch!

Organizing CBC Results
- Summarizing WBC parameters
  - Total WBC count: leukopenia, leukocytosis
  - Differential expressed as % and as absolutes: absolute numbers mean much more than relative percentages
  - Examine scatter plots—Great information!
  - WBC morphology: immature cells, truly aberrant morphology
  - Funnel the information down from general to specific!

- Summarizing Platelet Parameters
  - Examine platelet count correlate w/ slide
  - Examine MPV (used in certain situations)
  - Examine platelet morphology and arrangement
  - Platelet histogram may be helpful as well

Reference Ranges used today
- WBC: 4.5-11.0
- RBC: 4.60-5.40 / 4.00-4.80
- NE: 50-70 (2.3-7.7)
- HGB: 16+/2 / 14+/2
- LY: 20-40 (0.9-4.4)
- HCT: 46+/4.4 / 42+/2
- MO: 2-10 (0.1-1.1)
- MCV: 80-99
- EO: 1-4 (0-0.5)
- MCH: 26-32
- BA: 0-2 (0-0.1)
- MCHC: 32-36
- RDW CV: 11-14.5%
- PLT: 140-440
- MPV: 7-10
Case #1: 64 yo male with fever

What can we say about this information?

- He has an absolute neutrophilia
  - ANC of 27.8
- He is not anemic, polycythemic, t’osis or t’penic
- What do you want to see next?

Most likely we can deduce that this is a reactive leukocytosis…. a neutrophilia with a mild left shift due to infection.

Probably RO: a myelocytic leukemia

But remember: all lab test results must be interpreted in the context of the patient’s clinical presentation, other tests and his/her medical hx.
### Case #2: 59 yo male with fever

<table>
<thead>
<tr>
<th>WBC: 34.2</th>
<th>RBC: 4.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE%: 85.8</td>
<td>HGB: 11.4</td>
</tr>
<tr>
<td>LY%: 1.9</td>
<td>HCT: 33.2</td>
</tr>
<tr>
<td>MO%: 1.9</td>
<td>MCV: 82.9</td>
</tr>
<tr>
<td>EO%: 4.4</td>
<td>MCH: 28.4</td>
</tr>
<tr>
<td>BA%: 6.0</td>
<td>MCHC: 34.3</td>
</tr>
<tr>
<td>NRBC: 2/100WBC</td>
<td>RDW: 15.9</td>
</tr>
<tr>
<td>Immature NE</td>
<td>PLT: 587</td>
</tr>
</tbody>
</table>

**What can we say about this information?**

- He has an absolute neutrophilia, again ANC of 29.3, w/ immature cells
- He is anemic, and has a thrombocytosis

**How is this different from the previous case?**

- Want to look at the slide?

### On his manual differential:

- Segs: 31% RBCs: Normo-Normo
- Bands: 27% Platelets: Inc.
- Metas: 13% Occ: Giant platelets
- Myelos: 15%
- Lymphs: 6%
- Monos: 1%
- Eos: 3%
- Basos: 4% NRBC: 1/100 WBCs

This information is consistent with__________
Case #2: 59 yo male with fever

- On his manual differential:
  - Segs: 31%
  - Bands: 27%
  - Metas: 13%
  - Myelos: 15%
  - Lymphs: 6%
  - Monos: 1%
  - Eos: 3%
  - Basos: 4%
  - RBCs: Normo-Normo
  - Platelets: Inc.
  - Occ: Giant platelets
  - Metas: 13%
  - Lymphs: 6%
  - Monos: 1%
  - Eos: 3%
  - Basos: 4%
  - NRBC: 1/100 WBCs

This information is consistent with CML.

Summarize Key Points to Case #1 and #2

- Similar total WBCs, different differentials
- Case 1 had slight LS. Case 2 had moderate left shift.
- Case 1 neutrophils had toxic granulation, Case 2 had none, but had basos (key!)
- Case 2 demonstrated anemia and thrombocytosis, Case 1 had neither
- LOOK AT THE BIGGER PICTURE!
  - Case 1: Normal response to bact. infection
  - Case 2: RO chronic myelogenous leukemia

Case #3 - 16 yo female

- WBC: 7.7
- NE%: 58
- LY%: 36
- MO%: 3
- EO%: 2
- BA%: 1
- NRBC:

- RBC: 5.38
- NE#: 4.5
- LY#: 2.8
- MO#: 0.2
- EO#: 0.15
- BA#: 0.07
- NRBC:

- HGB: 11.2
- HCT: 36.4
- MCV: 67.7
- MCH: 20.8
- MCHC: 30.7
- RDW: 14.8
- MPV: 8.4

What is abnormal and what are you looking for on the smear?
Case #3 - 16 yo female: 
So what are you thinking on this one if you saw this morphology too?

- Classic Thalassemia Trait/Minor blood picture! (decreased globin chain synthesis)
- Slightly dec H & H, very low MCV (60s)
- Normal RDW-CV or even a low RDW-SD
- High RBC, often greater than 5.00 in females, and 5.50 in males
- Classic morph: micro, no aniso to speak of, red cell potpourri (targets, spheres, ellipsoids, schistos) and basophilic stippling. Confirm with electrophoresis.

Here’s what a thal intermedia looks like – target shooting!

Case Study #4: 14 yo female

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC: 4.9</td>
<td>RBC: 4.37</td>
</tr>
<tr>
<td>NE%: 53</td>
<td>NE#: 2.6</td>
</tr>
<tr>
<td>LY%: 39</td>
<td>LY#: 1.9</td>
</tr>
<tr>
<td>MO%: 4</td>
<td>MO#: 0.2</td>
</tr>
<tr>
<td>EO%: 1</td>
<td>EO#: 0.04</td>
</tr>
<tr>
<td>BA%: 1</td>
<td>BA#: 0.04</td>
</tr>
<tr>
<td>NRBC:</td>
<td></td>
</tr>
<tr>
<td>PLT: 436</td>
<td></td>
</tr>
<tr>
<td>MPV: 9.3</td>
<td></td>
</tr>
</tbody>
</table>

What is abnormal and what are you looking for on the smear?
Summary Comparison and Contrast of Cases #3 and #4

- Both females are mildly anemic
- Both have microcytosis (low MCVs)
- But Case #3 has normal RDW and high RBC
- And Case #4 has inc. RDW and lower RBC
- THIS ALONE IS GREAT INFORMATION!
- Case #3 peripheral smear demonstrates typical thal minor morphology to include, microcytosis w/o aniso, but classic sl poik, base, stippling, and Case #4 has the micro, sl hyp, aniso and little poik.

They're similar but distinctly different!

Another more progressed, more severe IDA case with low MCV, MCH and MCHC

Approach to anemia- using red cell indices-esp. MCV

<table>
<thead>
<tr>
<th>Anemia (dec. HGB)</th>
<th>Microcytic</th>
<th>Normocytic</th>
<th>Macrocytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Deficiency</td>
<td>Aci</td>
<td>B12/Folate</td>
<td>ETOH/Smoking</td>
</tr>
<tr>
<td>Thal/HGBopathy</td>
<td>Acute Blood Loss</td>
<td>Marrow disorders</td>
<td>MDS</td>
</tr>
<tr>
<td>Aci</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sideroblastic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Relatively new RET-He

Can be a sensitive monitor of iron availability

Sort of like the MCH of Retics

Do the retics have enough hemoglobin in pg?
One more to challenge you!
58 yo female

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>11.9</td>
</tr>
<tr>
<td>NE%</td>
<td>68</td>
</tr>
<tr>
<td>LY%</td>
<td>23</td>
</tr>
<tr>
<td>MO%</td>
<td>6</td>
</tr>
<tr>
<td>EO%</td>
<td>1</td>
</tr>
<tr>
<td>BA%</td>
<td>2</td>
</tr>
<tr>
<td>NRBC:</td>
<td></td>
</tr>
</tbody>
</table>

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Case Study #5: 18 yo male with lethargy and low grade fever

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>18.2</td>
</tr>
<tr>
<td>NE%</td>
<td>27.3</td>
</tr>
<tr>
<td>LY%</td>
<td>68.4</td>
</tr>
<tr>
<td>MO%</td>
<td>2.1</td>
</tr>
<tr>
<td>EO%</td>
<td>1.2</td>
</tr>
<tr>
<td>BA%</td>
<td>1.0</td>
</tr>
<tr>
<td>NRBC:</td>
<td></td>
</tr>
<tr>
<td>PLT:</td>
<td>536</td>
</tr>
</tbody>
</table>

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Case Study #5: 18 yo male with lethargy and low grade fever

- Absolute lymphocytosis is only abnormality hematologically. Appears reactive – heterogeneous morphology - WBC < 20.0
- No cytopenias present - that is key!
- Clinical assessment and medical hx essential
- Need to RO Infectious Mono through serologic tests
- May need to RO any risk factors for HIV

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Characteristics of Reactive (variant, atypical) Lymphocytes

- Pleomorphic, heterogeneous within the same blood smear ****
- Irregular shapes with irregular shaped nuclei
- Large cells with abundant, often flowing bright blue cytoplasm
- Indented by surrounding RBCs with peripheral basophilia
- Blasty appearing “immunoblasts” and plasmacytoid cells

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More reactive lymphocytes of IM
Case Study #6: 21 yo male with fever, lethary and lymphadenopathy

WBC: 27.6  RBC: 4.32
NE%: 22.3  NE#: 6.2  HGB: 12.3
LY%: 73.4  LY#: 20.3  HCT: 38.1
MO%: 2.0  MO#: 0.6  MCV: 88.2
EO%: 2.2  EO#: 0.6  MCH: 28.5
BA%: 0.1  BA#: 0.0  MCHC: 32.3
NRBC:
PLT: 101  MPV: 7.3
RDW: 15.2

What is abnormal here?

Case Study #6: 21 yo male with fever, lethary and lymphadenopathy

WBC: 27.6  RBC: 4.32
NE%: 22.3  NE#: 6.2  HGB: 12.3
LY%: 73.4  LY#: 20.3  HCT: 38.1
MO%: 2.0  MO#: 0.6  MCV: 88.2
EO%: 2.2  EO#: 0.6  MCH: 28.5
BA%: 0.1  BA#: 0.0  MCHC: 32.3
NRBC:
PLT: 101  MPV: 7.3
RDW: 15.2

What is abnormal here?

Case Study #6: 21 yo male with fever, lethary and lymphadenopathy

WBC: 27.6  RBC: 4.32
NE%: 22.3  NE#: 6.2  HGB: 12.3
LY%: 73.4  LY#: 20.3  HCT: 38.1
MO%: 2.0  MO#: 0.6  MCV: 88.2
EO%: 2.2  EO#: 0.6  MCH: 28.5
BA%: 0.1  BA#: 0.0  MCHC: 32.3
NRBC:
PLT: 101  MPV: 7.3
RDW: 15.2

What is abnormal here?

Case Study #6: 21 yo male with fever, lethary and lymphadenopathy

WBC: 27.6  RBC: 4.32
NE%: 22.3  NE#: 6.2  HGB: 12.3
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MO%: 2.0  MO#: 0.6  MCV: 88.2
EO%: 2.2  EO#: 0.6  MCH: 28.5
BA%: 0.1  BA#: 0.0  MCHC: 32.3
NRBC:
PLT: 101  MPV: 7.3
RDW: 15.2

What is abnormal here?

Summary Comparison of Case #5 and Case #6-Key Points

- Both have relative and absolute lymphocytosis
- Case #5 has no anemia or t’penia, Case # 6 has both
- Lymphoid cells in Case #5 are heterogeneous/pleomorphic in morphology, Case #6 cells are very homogeneous. Cells have higher N:C ratio.

Further studies including bmix, flow cytometry, and possible cytogenetics to RO leukemia/lymphoma in the 21 year old.
Case Study #7: 58 yo female with SOB and extreme fatigue

WBC: 3.9
NE%: 38.1
LY%: 53.6
MO%: 5.2
EO%: 2.4
BA%: 0.7
NRBC:

RBC: 1.56
HGB: 6.4
HCT: 19.1
MO%: 4.1
EO%: 0.1
BA%: 0.0
PLT: 87
MPV: 7.8

What is abnormal here?

Summary Case Study #7: 58 yo female with SOB and extreme fatigue

- Severe anemia: marked decrease HGB, HCT and RBC
- Morph classification: macrocytic (MCV=122)
- Leukopenic...absolute neutropenia (1.5)
- Thrombocytopenic (87) therefore...pancytopenic
- Microscopic morph: macro-ovalocytes and hypersegmented neutrophils
- ALL THESE ARE KEY FEATURES!

Case Study #8: 63 yo woman with night sweats, fatigue, bruises easily

WBC: 3.4
NE%: 30.6
LY%: 59.8
MO%: 8.1
EO%: 0.6
BA%: 0.9
NRBC: 1

RBC: 2.98
HGB: 8.7
HCT: 25.4
MCV: 85.2
MCH: 29.2
MCHC: 34.3
RDW: 16.9
PLT: 45
MPV: 8.2

What is abnormal here?
And further...

Case Study #8: 63 yo woman with night sweats, fatigue, bruises easily

- With pancytopenia and abnormal cells looking like blasts, follow up studies are necessary to RO an acute leukemia.

- Here we have seen 2 cases with pancytopenia...
  how are they different?