Interpreting routine feline haematology: What does a five-part differential really mean?

Dennis B. DeNicola, DVM, PhD, DACVP | Medical Affairs Fellow, Chief Veterinary Educator

In this webinar we will:

• Refresh on the haematopoiesis of white cells.
• Discuss feline white cell morphology and purpose.
• Review absolute cells counts vs percentage differentials; tips on interpreting the white cell profile.
• Identify common feline leukogram patterns and how to interpret.
• Put all this information together using clinical case studies.

Haematopoiesis

‘Leuko’ (white) ‘poiesis’ (to make) – Granulocyte/Monocyte production
‘Lympho’ (lymphocyte) ‘poiesis’ (to make) – Lymphocyte production

Leukopoiesis

[Diagram showing the process of leukopoiesis]
**Neutrophil – Proliferation, Maturation, Storage**

Storage pool - approximately 5 days worth of mature neutrophils

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**Leukopoiesis**

Bone marrow

Lymphoid stem cell

- B lymphocyte
- T lymphocyte
- Thymus

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**Lymphopoiesis – recirculation of lymphocytes**

Bone marrow (B cells)

Thymus (T cells)

Blood

Tissues

Lymphoid tissues
Feline white cell morphology and purpose

Neutrophil Identification

- Most common leukocyte in most animals
- 10-12 micrometers in diameter
- Nucleus divided into multiple lobes
- Condensed chromatin pattern
- Faint blue to light pink cytoplasm
- May see poorly distinct granules

Neutrophil function

**CHEMOTAXIS**

Neutrophils (white blood cells) are attracted to bacterial chemical products like the peptide fMLP (f-Met-Leu-Phe)
Neutrophil function

**NECROSIS**
A white blood cell dies after a meal of "leukotoxic" *Streptococcus pyogenes*

*Speed = x3*

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**BACTERIAL CAPSULE**
The slippery capsule of *Streptococcus pneumoniae* helps these bacteria avoid being eaten by neutrophils

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Lymphocyte Identification

- Second most common leukocyte in most animals
- 10µm in diameter
- Round in shape
- Round to oval, sometimes indented nucleus
- Chromatin smooth areas intermixed with more clumped chromatin
- Cytoplasm scant and blue
Lymphocyte – Cytotoxic T cells

CYTOTOXIC T-LYMPHOCYTE

A specialized white blood cell responsible for eliminating unwanted body cells (e.g., cancer) kills a cell infected with the influenza virus.

Monocyte Identification

- Largest leukocyte in peripheral blood in health
- Round to angular in shape
- 15-20μm in diameter
- Nucleus is variable in shape
- Chromatin is lacy
- Cytoplasm is blue-grey and often contains vacuoles
- Looks similar in common domestic species

Monocyte function

MACROPHAGE

Another white blood cell responsible for killing microbes is ingesting the yeast Candida albicans.
Eosinophil Identification
- Absent or present in low numbers
- Slightly larger than neutrophil
- Nucleus similar to neutrophil
  - Slightly less densely clumped
- Cytoplasm faint blue
- Multiple reddish to reddish-orange granules
- Granules different shapes for most species

Basophil Identification
- Larger than neutrophils
  - Nucleus less segmented
  - Chromatin less clumped
- Granules round and stain purple
- In cat, mature basophil granules do not stain well
- High numbers of granules in horse and cow
- Dog has only few granules

Leukocyte cell counts
Absolute (#) or Relative (%)

Keys to interpretation of the leukogram
‘Pattern recognition’

Leukogram components
- WBC: white blood cells
- % NEU: % of leukocytes that are neutrophils
- % LYM: % of leukocytes that are lymphocytes
- % MONO: % of leukocytes that are monocytes
- % EOS: % of leukocytes that are eosinophils
- % BASO: % of leukocytes that are basophils
- NEU: absolute number of neutrophils
- LYM: absolute number of lymphocytes
- MONO: absolute number of monocytes
- EOS: absolute number of eosinophils
- BASO: absolute number of basophils

Use the relative (%) values to assist in rapidly verifying analyzer results:
- If the analyzer reports 10% LYM, approximately 1 in 10 leukocytes should be LYM
- If the analyzer reports 75% NEU, approximately 3 in 4 leukocytes should be NEU
### Leukogram components

- **WBC**: white blood cells
- % **NEU**: % of leukocytes that are neutrophils
- % **LYM**: % of leukocytes that are lymphocytes
- % **MONO**: % of leukocytes that are monocytes
- % **EOS**: % of leukocytes that are eosinophils
- % **BASO**: % of leukocytes that are basophils
- **NEU**: absolute number of neutrophils
- **LYM**: absolute number of lymphocytes
- **MONO**: absolute number of monocytes
- **EOS**: absolute number of eosinophils
- **BASO**: absolute number of basophils

**Interpretation of leukogram is based on absolute numbers**

### Leukogram components

<table>
<thead>
<tr>
<th>Test</th>
<th>Results</th>
<th>Reference interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>5.84 x10⁹/L</td>
<td>2.87 - 17.02</td>
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<tr>
<td>NEU</td>
<td>3.32 x10⁹/L</td>
<td>1.48 - 10.29</td>
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<tr>
<td>LYM</td>
<td>1.73 x10⁹/L</td>
<td>0.92 - 6.88</td>
</tr>
<tr>
<td>MONO</td>
<td>0.19 x10⁹/L</td>
<td>0.05 - 0.67</td>
</tr>
<tr>
<td>EOS</td>
<td>0.58 x10⁹/L</td>
<td>0.17 - 1.57</td>
</tr>
<tr>
<td>BASO</td>
<td>0.02 x10⁹/L</td>
<td>0.01 - 0.26</td>
</tr>
</tbody>
</table>

**White blood cell count:**
- **WBC** is used to help characterize the severity of a change within the leukogram.
- Should not be used to differentiate between various disease conditions, including:
  - Inflammation
  - Stress (glucocorticoid influence)
  - Excitement (epinephrine influence)
  - Neoplasia

**Leukocyte differential:**
- Absolute values (not relative or % values) for different leukocytes must be used for interpretation.
- Patterns of leukocyte quantitative changes are used for differentiating various disease conditions, including:
  - Inflammation
  - Stress (glucocorticoid influence)
  - Excitement (epinephrine influence)
  - Neoplasia
Leukogram: Pattern recognition

- Three common leukocyte disorder patterns
- Inflammation difficult to identify without recognition of immature and/or toxic neutrophils:

<table>
<thead>
<tr>
<th>Leukocyte</th>
<th>Moderate inflammation</th>
<th>Stress</th>
<th>Excitement</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEU</td>
<td>↑ - ↑↑</td>
<td>↑ - ↑↑</td>
<td>High N - ↑</td>
</tr>
<tr>
<td>BAND</td>
<td>↑ - ↑↑</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>LYM</td>
<td>↓ - ↓↓</td>
<td>↓↓</td>
<td>High N - ↑</td>
</tr>
<tr>
<td>MONO</td>
<td>N - ↑↑</td>
<td>N - ↑</td>
<td>N</td>
</tr>
<tr>
<td>EOS</td>
<td>↓</td>
<td>↓</td>
<td>N</td>
</tr>
<tr>
<td>BASO</td>
<td>N - ↑</td>
<td>N</td>
<td>N</td>
</tr>
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</table>

Leukogram: Pattern recognition

- Three common leukocyte disorder patterns
- Inflammation difficult to identify without recognition of immature and/or toxic neutrophils:

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<td>↓</td>
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<td>N</td>
</tr>
<tr>
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<td>N - ↑</td>
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</table>

In reality – identification of either or both immature and toxic neutrophils supports the presence of inflammation

Leukogram - Identification of Band Neutrophils

- Three common leukocyte disorder patterns
- Inflammation difficult to identify without recognition of immature and/or toxic neutrophils:
  - Blood film microscopic examination
  - Cytogram review with advanced hematology analyzers

Definitions
- A neutrophil with a “horseshoe-shaped” nucleus with parallel-sided nuclear membranes
- “Slight” nuclear indentations are acceptable

Band neutrophil

Mature neutrophil
Leukogram - Identification of Band Neutrophils

- Definitions
  - A neutrophil with a “horseshoe-shaped” nucleus with parallel-sided nuclear membranes
    - “Slight” nuclear indentations are acceptable
  - A neutrophil where the thinnest portion of the nucleus is more than one third the thickest portion of the nucleus
    - Problem when nucleus is folded on itself

Importance in identifying immaturity and toxicity

- Immature neutrophil
  - Same as with other species
- Toxic neutrophil
  - Slightly different than other species … ‘no big surprise’

Toxic Neutrophil Identification

- Morphologic changes seen in neutrophil forms with severe or overwhelming inflammation
  - Rapid maturation in response to demand – skipping normal maturation steps
  - Potential direct effect of bacterial endotoxins
- Potentially present in mature and immature neutrophil forms
- Indicative of inflammatory disease

1+ Basophilia &/or Döhle bodies
2+ Foamy cytoplasm
3+ Marked basophilia & foamy cytoplasm
4+ Nuclear degeneration
What's unique to feline immature and toxic neutrophils

- Immature neutrophil
  - Same as with other species
- Toxic neutrophil
  - Slightly different than other species … ‘no big surprise’
  - Döhle bodies can be seen in normal cat blood neutrophils
  - Döhle bodies only significant in the cat when the cytoplasmic features of toxicity are observed

- ‘When immature out number the mature neutrophils’
- Cats with degenerative left shifts are 1.57 times more likely to die or be euthanized in hospital than cats without degenerative left shifts

Which one of the following is your interpretation of how cell #6 should be classified?

A. Segmented neutrophil
B. Band
C. Segmented neutrophil but between neutrophil and band
D. Band but between neutrophil and band

Neutrophil – Proliferation, Maturation, Storage

- Storage pool
  - Most species – approximately 5 days worth of neutrophils
Neutrophil – Proliferation, Maturation, Storage

Mild, Moderate and Marked Inflammation

What is included in a complete blood count

1. Verify/Confirm the CBC data

Analyzer data

Blood film microscopic review

Evolution of in-house hematology analyzers and their cytograms

Check the IDEXX Hematology page under the Resources tab on the right for more IDEXX innovation.
What is included in a complete blood count

1. Verify/Confirm the CBC data
2. Identify cell morphologic abnormalities

Evolution of in-house hematology analyzers and their cytograms

Check the IDEXX Hematology page under the Resources tab on the right for more IDEXX innovation.

Relative unique feature of leukocyte changes with the feline patient
Leukogram: Pattern recognition

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<th>Moderate inflammation</th>
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<th>Excitement</th>
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<tr>
<td>NEU</td>
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<td>BAND</td>
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<td>↓ - ↓↓</td>
<td>↓↓</td>
<td>High N - ↑</td>
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<td>MONO</td>
<td>N - ↑↑</td>
<td>N - ↑</td>
<td>N</td>
</tr>
<tr>
<td>EOS</td>
<td>↓</td>
<td>↓</td>
<td>N</td>
</tr>
<tr>
<td>BASO</td>
<td>N - ↑</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

- Difference between ‘stress’ (glucocorticoid) and ‘excitement’ (epinephrine)
- Stress - Same in cat as dog (takes up to 4 hours for effect)
- Excitement – Potential marked lymphocytosis in the cat

Clinical Case Studies

Arthur

Signalment
- Domestic Shorthair cat
- Male neutered
- 10-year-old

Presentation
- Presented for dental with planned:
  - Extraction of several teeth
- No previous significant clinical problems

Physical examination
- Good body condition
- No discernable weight loss
- Temp – 37.7°C, Pulse - 240, Resp Rate - 32, CRT < 2sec

Arthur – 10-year-old, MN, Domestic Shorthair

- Diagnostic work-up
  - Minimum DataBase
    - Hematology – to be discussed
    - Chemistry panel with IDEXX SDMA – no significant abnormalities
    - Urinalysis – not collected
- Anesthesia for dental
  - Induction went well
  - Under anesthesia for just over one hour
  - Extracted 4 teeth without complications
1. Good separation between cell populations = verified numbers reported
2. Potential increased density of reticulocyte population = reticulocytosis
3. Decreased density of platelet population = thrombocytopaenia

1. Reported thrombocytopenia
2. Qualified (**) results
   - Confirm with dot plot and/or blood film review

1. Slight difficulty in separation between unlysed RBCs, NEU, BASO and EOS
   - Continuum of digitized events
2. Differential looks relatively good with exception for BASO
   - Results should be qualified
Arthur – 10-year-old, MN, Domestic Shorthair

1. Qualified (*) results
   - Confirm with dot plot and/or blood film review
2. No BASO count is reported – most questionable result
3. Remaining portion of differential looks solid

Arthur – 10-year-old, MN, Domestic Shorthair

- Case outcome
  - No complications during dental
  - Recovery from anesthesia was uneventful
  - Sent home and scheduled a follow-up check-up in 2 weeks

Howie

Signalment
- Domestic Shorthair cat
- Male neutered
- 5-year, 6-month-old

Presentation
- Referred because of suspect pneumonia
- Sudden onset difficulty breathing
- Periodically seemed to improve on her own

Physical examination
- Temp – 39.9°C, Pulse - 170, Resp Rate - 52, CRT < 2sec
- Dark pink mucous membranes
- Mildly harsh bilateral lung sounds
Howie – 5-year, 6-month-old, MN, Domestic Shorthair

- **Diagnostic work-up**
  - Minimum DataBase
    - Hematology – to be discussed
    - Chemistry panel with IDEXX SDMA – mild hyperglobulinemia
    - Urinalysis – no significant abnormalities
    - Thoracic radiographs
      - Imaging down – service coming in the morning
  - **Main differentials**
    - Inflammatory
    - Infectious
    - Neoplasia

- **Hematology**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>RBC</td>
<td>7.82</td>
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<tr>
<td>Hematocrit</td>
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<td>Hemoglobin</td>
<td>112</td>
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<td>MCV</td>
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<td>MCH</td>
<td>14.3</td>
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<tr>
<td>MCHC</td>
<td>27.0</td>
</tr>
<tr>
<td>RDW</td>
<td>23.0</td>
</tr>
<tr>
<td>Reticulocyte</td>
<td>0.1%</td>
</tr>
<tr>
<td>Reticulocytes</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

  **Chemistry panel with IDEXX SDMA**

  - Mild hyperglobulinemia

- **Urinalysis**

  - No significant abnormalities

- **Thoracic radiographs**

  - Imaging down – service coming in the morning

Remember – suggestion of small pathologic RBCs

1. Good separation between cell populations = verified numbers reported
2. Low reticulocyte count
3. Suggestion of small pathologic RBCs – requires blood film review
Howie – 5-year, 6-month-old, MN, Domestic Shorthair

Hematology

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>WBC</td>
<td>16.14</td>
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<tr>
<td>Neutrophils</td>
<td>8.71</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>1.33</td>
</tr>
<tr>
<td>Monocytes</td>
<td>1.00</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>5.06</td>
</tr>
<tr>
<td>Basophils</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Normal mature and immature (‘band’) eosinophils

Howie – 5-year, 6-month-old, MN, Domestic Shorthair

Slightly toxic neutrophils
  - Increased blue staining of cytoplasm
  - Döhle bodies
Howie – 5-year, 6-month-old, MN, Domestic Shorthair

- **Signalment**
  - Domestic Shorthair cat
  - Female spayed
  - 10-year, 8-month-old

- **Presentation**
  - Sudden onset clinical signs
  - Severely depressed

- **Physical examination**
  - Temp – 33°C, Pulse - 105, Resp Rate - 35, CRT 3 sec
  - Pale pink mucous membranes
  - Mildly harsh bilateral lung sounds

- **Case Outcome**
  - Radiographs on day 2
    - Consistent with chronic bronchitis or asthma
    - Potential alternative diagnoses
    - Eosinophilic bronchopneumonia
    - Parasitic disease
  - Management
    - Corticosteroids
    - Bronchodilators
  - Referred again 2-years later
    - Life threatening respiratory distress – died during examination

July

- **Signalment**
  - Domestic Shorthair cat
  - Female spayed
  - 10-year, 8-month-old

- **Presentation**
  - Sudden onset clinical signs
  - Severely depressed

- **Physical examination**
  - Temp – 33°C, Pulse - 105, Resp Rate - 35, CRT 3 sec
  - Pale pink mucous membranes
  - Mildly harsh bilateral lung sounds

- **Diagnostic work-up**
  - Minimum database
    - Hematology – to be discussed
    - Chemistry panel with IDEXX SDMA – mild hyperglobulinemia and azotemia
    - Urinalysis – 1.032 USG, 1+ protein, >1 nonhyaline cast / LPF, suspect cocci, no pyuria
  - Main differentials
    - Overwhelming inflammation
    - Bacterial translocation
    - Septicemia
July – 10-year, 8-month-old, FN, Domestic Shorthair

1. Analyzer challenged to separate different cell populations – verification of numbers not possible
   - Apparent single population of leukocytes representing the vast majority of leukocytes present (continuum of digitized events)

2. Remember – suggestion of small pathologic RBCs
   - Increased cytoplasmic RNA compared to mature neutrophils

July – 10-year, 8-month-old, FN, Domestic Shorthair

1. Compare locations for normal leukocyte populations
2. Consider where immature and toxic neutrophils will be located
   - Increased cytoplasmic RNA compared to mature neutrophils

Good separation between cell populations = verified numbers reported
- Low reticulocyte count
- Suggestion of small pathologic RBCs – requires blood film review
- Larger than normal platelets of questionable significance in the cat

Remember – suggestion of small pathologic RBCs

July 1.

Normal

Normal
# July – 10-year, 8-month-old, FN, Domestic Shorthair

<table>
<thead>
<tr>
<th>Hematology</th>
<th>5/9/20 11:29 AM</th>
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<tbody>
<tr>
<td>WBC</td>
<td>4.57 2.87 - 17.02 x10^9/L</td>
</tr>
<tr>
<td>Neutrophils</td>
<td>0.45 2.00 - 10.29 x10^9/L</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>1.44 0.30 - 6.88 x10^9/L</td>
</tr>
<tr>
<td>Monocytes</td>
<td>2.80 0.05 - 0.47 x10^9/L</td>
</tr>
<tr>
<td>Eosinophils</td>
<td>0.07 0.17 - 1.57 x10^9/L</td>
</tr>
<tr>
<td>Basophils</td>
<td>0.01 0.01 - 0.26 x10^9/L</td>
</tr>
</tbody>
</table>

- **Hematology** results showing WBC, Neutrophils, Lymphocytes, Monocytes, Eosinophils, and Basophils within normal ranges.

- **Micrographs** showing normal blood cell morphology.

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# July – 10-year, 8-month-old, FN, Domestic Shorthair

- **Micrographs** showing normal blood cell morphology.

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# July – 10-year, 8-month-old, FN, Domestic Shorthair

- **Micrographs** showing normal blood cell morphology.

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# July – 10-year, 8-month-old, FN, Domestic Shorthair

- **Micrographs** showing normal blood cell morphology.
Tom

**Signalment**
- Domestic Shorthair cat
- Male neutered
- 11-year-old

**Presentation**
- Referred several months previously with suspected inflammatory bowel disease
- Several months of intermittent office visits with weight loss, episodes of diarrhea, dehydration, mild anemia and inflammatory leukogram
- Management of IBD resulted in stabilization just one month prior to current hospitalization
- Current presentation - sudden onset depression and anorexia
- Dehydrated, severely depressed, labored breathing, no fever, pale mucous membranes

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**Case Outcome**
- Surgically placed feeding tube
- Supportive care – fluids / electrolytes
- July went home to watch for continued clinical improvement

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July – 10-year, 8-month-old, FN, Domestic Shorthair

- **Signalment**
  - Domestic Shorthair cat
  - Male neutered
  - 11-year-old

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July – 10-year, 8-month-old, FN, Domestic Shorthair

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July – 10-year, 8-month-old, FN, Domestic Shorthair
Tom – 11-year-old, MN, Domestic Shorthair

- **Diagnostic work-up**
  - Minimum DataBase
    - Hematology – to be discussed
    - Chemistry panel with IDEXX SDMA – increased CREA and SDMA
    - Urinalysis – isosthenuria, proteinuria
  - Diagnostic imaging
    - Thoracic radiographs pending laboratory findings interpretation

<table>
<thead>
<tr>
<th>Hematology</th>
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<tr>
<td>Neutrophils</td>
<td>3.7%</td>
<td>2.30 - 12.9 x 10^9/L</td>
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<td>Monocytes</td>
<td>05.79</td>
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<tr>
<td>Bands</td>
<td>Suspected</td>
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Bands – Suspect presence

* Qualified results – confirm with dot plot and/or blood film review

Tom – 11-year-old, MN, Domestic Shorthair

Normal

Bands – Suspect presence

* Qualified results – confirm with dot plot and/or blood film review
Tom – 11-year-old, MN, Domestic Shorthair

- Predominating mononuclear cells

Tom – 11-year-old, MN, Domestic Shorthair

- Blue staining cytoplasm in neutrophils
  - Few mononuclear cells representing either immature monocytes or lymphocytes
Tom – 11-year-old, MN, Domestic Shorthair

- Blue staining cytoplasm in neutrophils
- Few ‘giant’ and immature appearing neutrophils
- Few mononuclear cells representing either immature monocytes or lymphocytes

Tom – 11-year-old, MN, Domestic Shorthair

- Blue staining cytoplasm in neutrophils
- Prominent Döhle bodies
- Many mononuclear cells representing immature lymphocytes
  - Similar size to neutrophils
  - 2-3 times the diameter of an erythrocyte

Tom – 11-year-old, MN, Domestic Shorthair

○ Case Outcome
  - Because of grave prognosis, owners elected euthanasia
Questions?

Would you like more information about IDEXX Haematology innovation and solutions?

Visit the IDEXX haematology page that is available under the webinar resource tab or get in touch via the Contact Form.

If you submit the Contact form, we will make sure to provide the information you need about IDEXX products and solutions.