We've Got Bad Blood: Canine and Feline Leukemias

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Lecture Goals

Differentiate between leukemia and leukemic lymphoma

Classify major types of leukemia

Confidently perform diagnostics and/or know when to refer

ID what to monitor/when to treat CLL

Implement immediate action in clinically critical patients

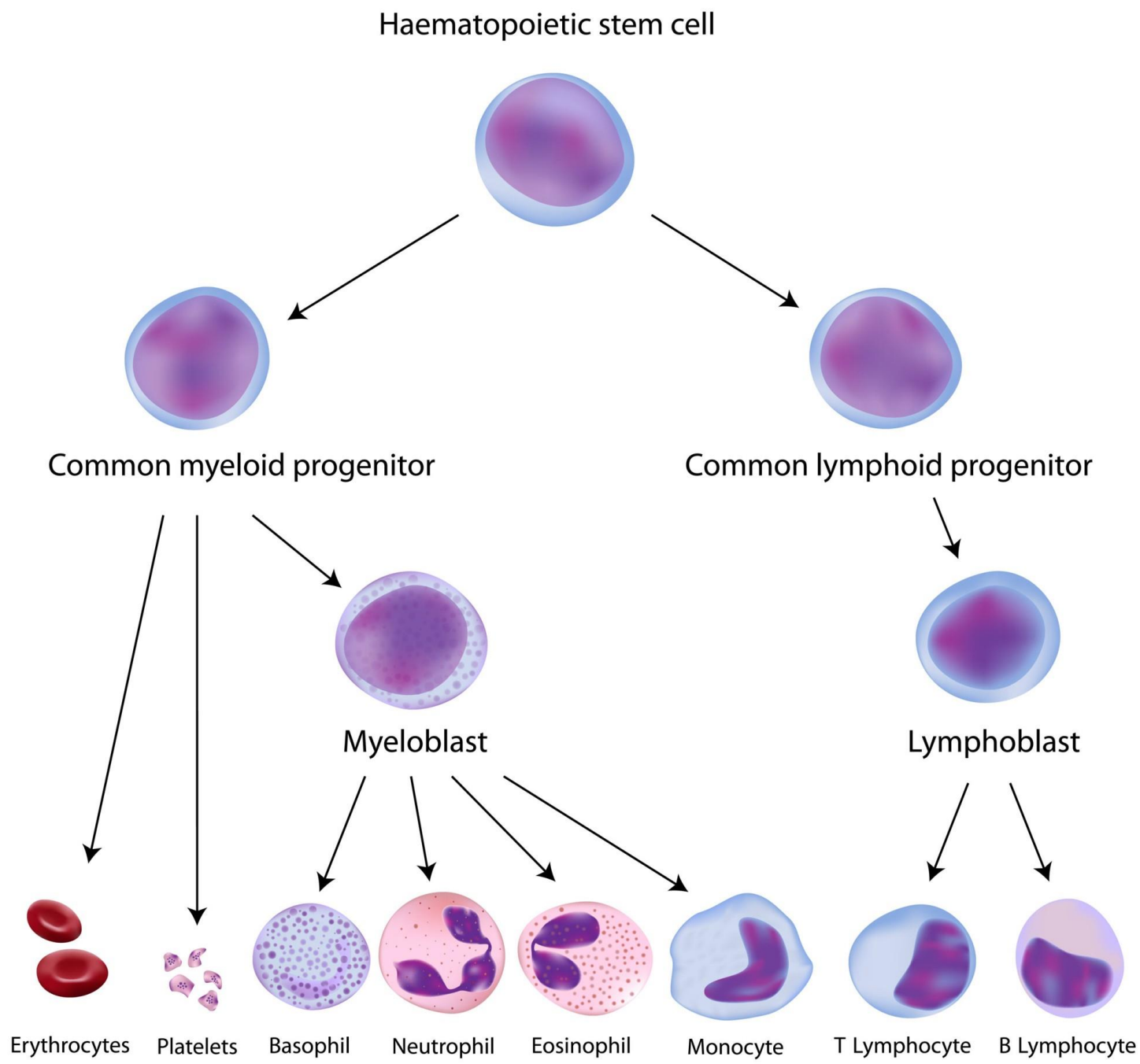
What is leukemia?

= Malignancy arising from the bone marrow (which produces all blood cells)

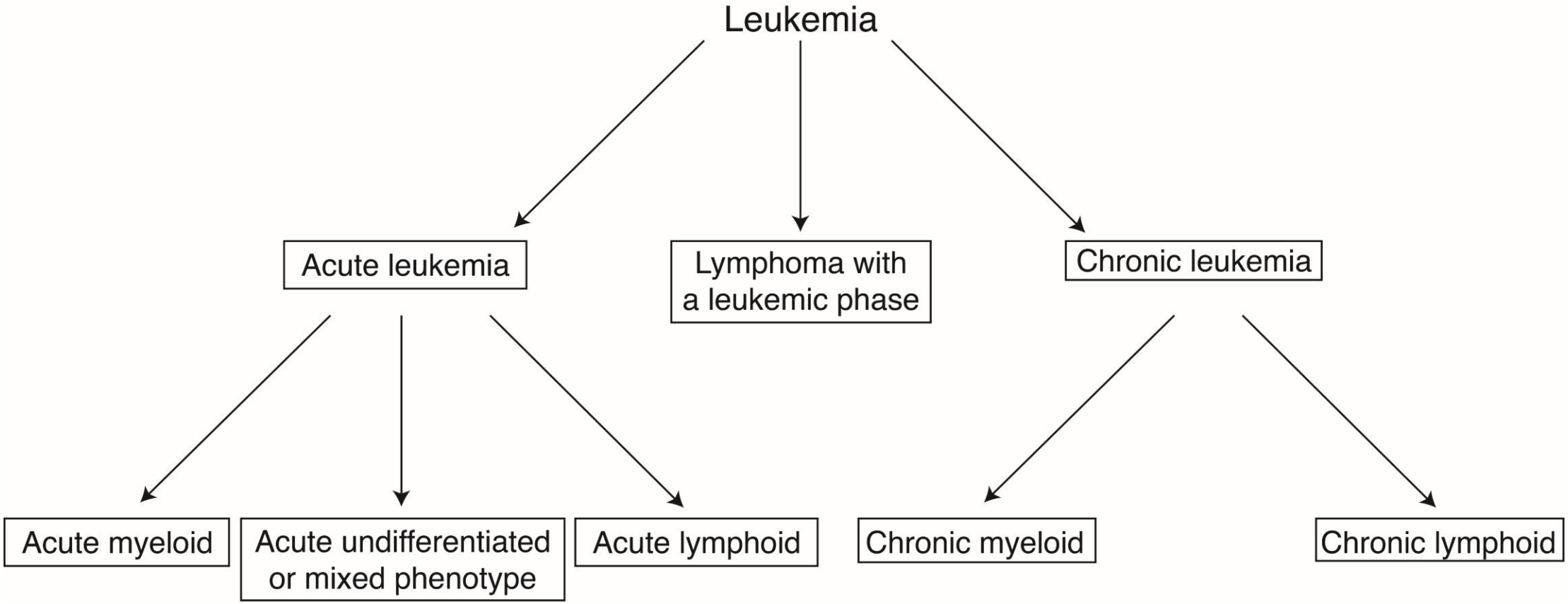
→ Detectable abnormalities in circulation

Distinguish from: malignancy of lymphocytes originating outside of the bone marrow (in other lymphoid tissues like the lymph nodes), then invading the bone marrow +/- peripheral blood = lymphoma (leukemic/stage V)

Hematopoiesis



Leukemia types



Diagnostics: Complete blood count (CBC)

Simple, daily in-house

Often only sign of disease

Will not detect: aleukemic

Machine may misclassify cells!

Is it leukemia?

Lymphocytosis (>6000 µ/L), persistent

Cytopenias:
Thrombocytopenia,
Neutropenia, Anemia

Large, unclassified cells

Monocytosis

Abnormal CBC?

Don’t panic!

Diagnostics: Blood smear

Ideally both in-house and sent to a clinical pathologist to review

- An easy add-on at big reference labs (IDEXX, Antech)
- Or send to clin path dept. at local academic hospitals (ISU)

Look for infectious organisms

Compare lymphocyte size to that of a normal neutrophil

- “Large”/BLASTS = 1.5-2+ x
- “Intermediate” = ~same
- “Small” = smaller

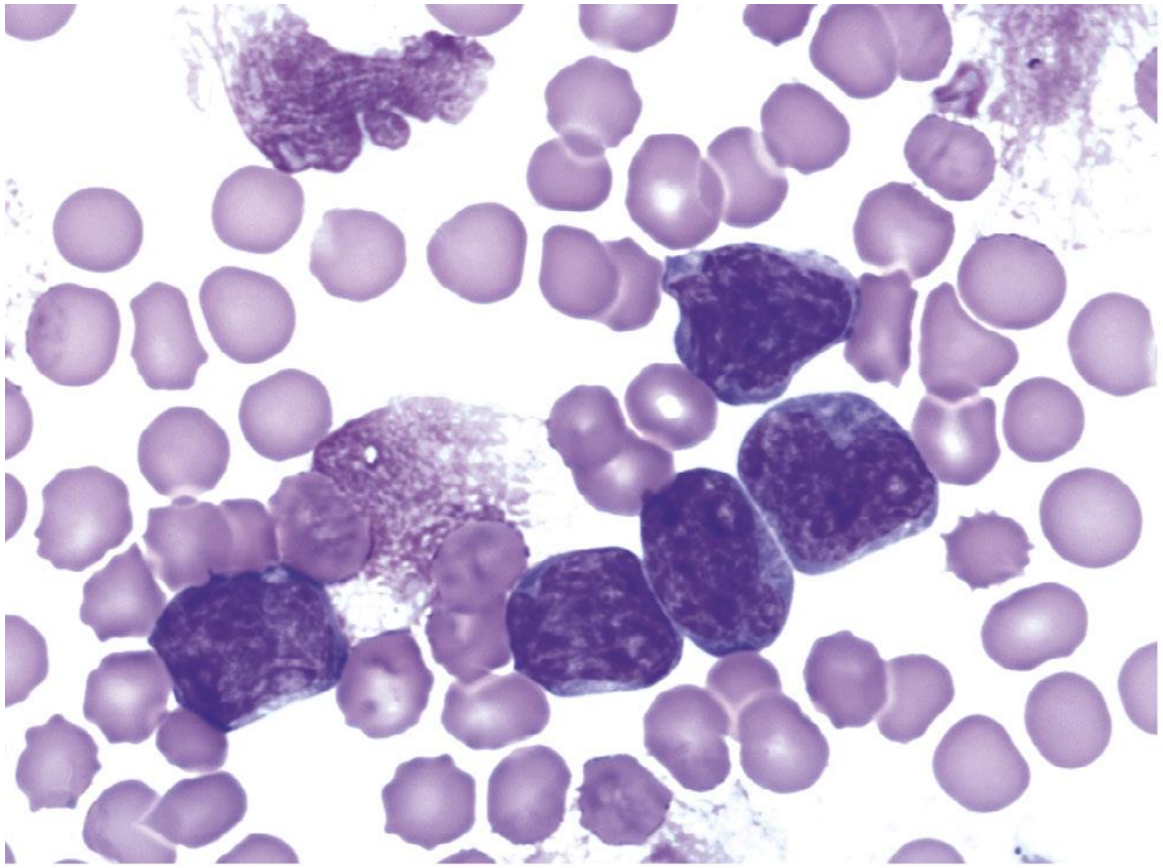
Blasts: Cytology Characteristics

BIG

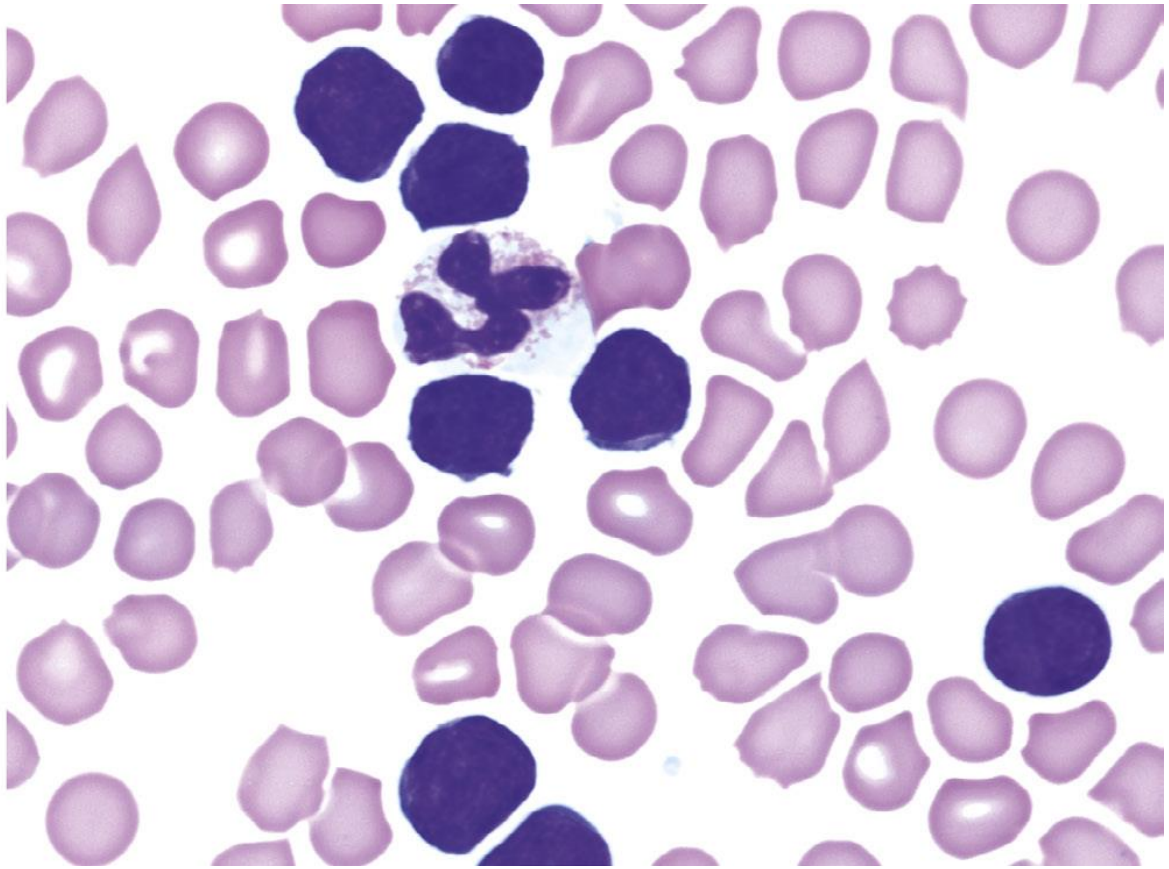
BLUE

BAD

Diagnostics: Blood Smear



Acute lymphocytic leukemia (canine)



Chronic lymphocytic leukemia (canine)

Rule Outs

Infectious disease

- neutrophilic leukocytosis
- lymphocytosis <20,000/µL
- *Ehrlichia*, *Babesia* (canine)
- *Cytauxzoon felis, Toxoplasma gondii, Aelurostrongylus abstrusus, Leishmania infantum, Mycoplasma haemofelis, Bartonella henselae,* FeLV/FIV (feline)

Persistent, nonneoplastic/polyclonal lymphocytosis (English Bulldogs)

Addison's disease (mild lymphocytosis)

Not the good kind of “viral”

Include retroviral testing in your minimum database!

- FeLV
  - 20% of lymphoma cases (mediastinal, renal, spinal, ocular)
    - 62x greater risk of developing lymphoma
    - 70-90% of myeloproliferative disorders (MDS)

- FeLV + FIV
  - 70% greater chance of leukemia or lymphoma
  - 5.6x greater risk than if only FeLV or only FIV

Lymphocytosis in Cats

JVIM, 2019, Rout et al

- Lymphocytosis defined as >6000/µL
- Most common phenotype: neoplastic T-cell (CD4+)
- MST for this type: 752 days (~2 years)
- Flow cytometry best

Diagnostics: Flow Cytometry

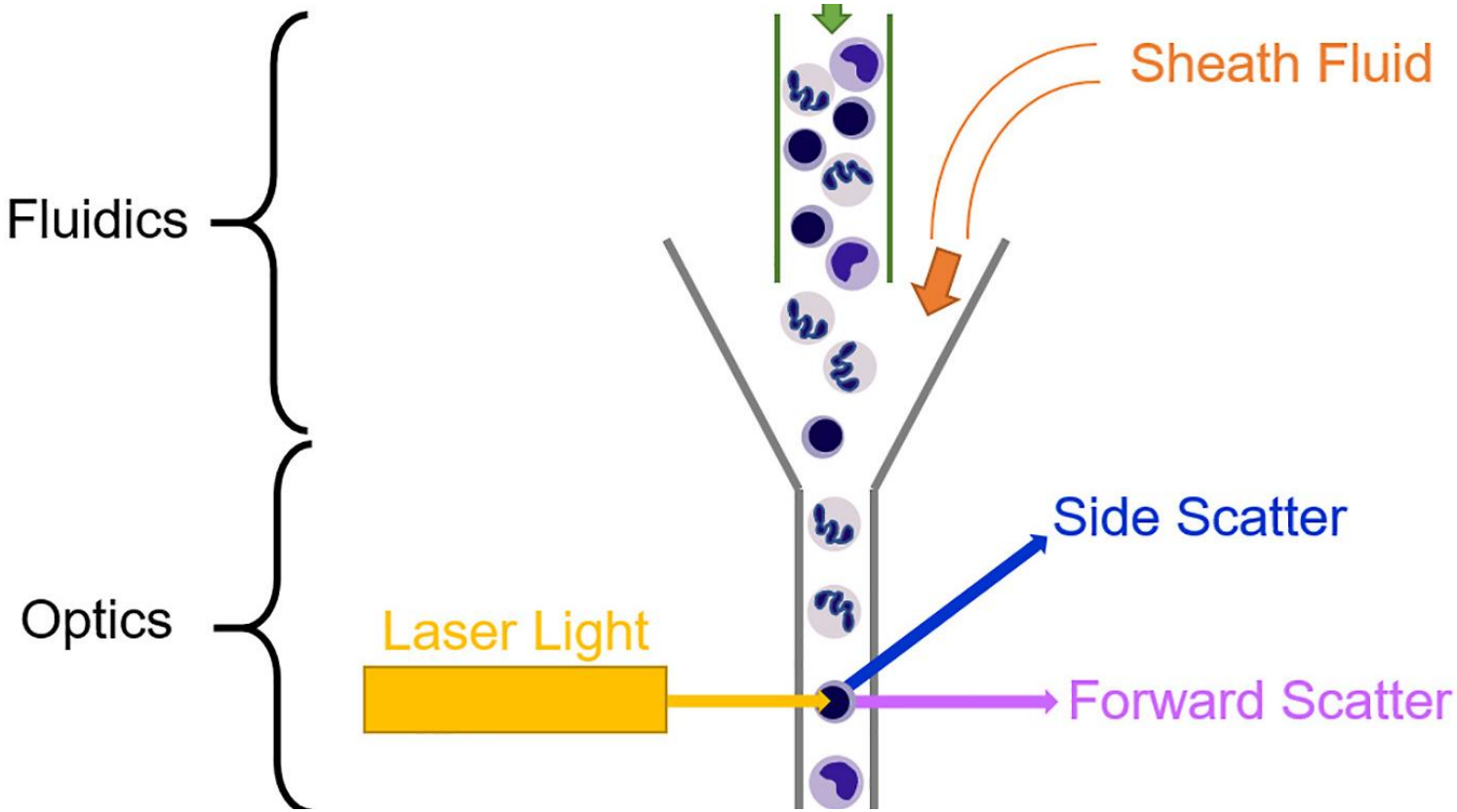
Emerging as the gold-standard test for diagnosis and classification canine and feline leukemias

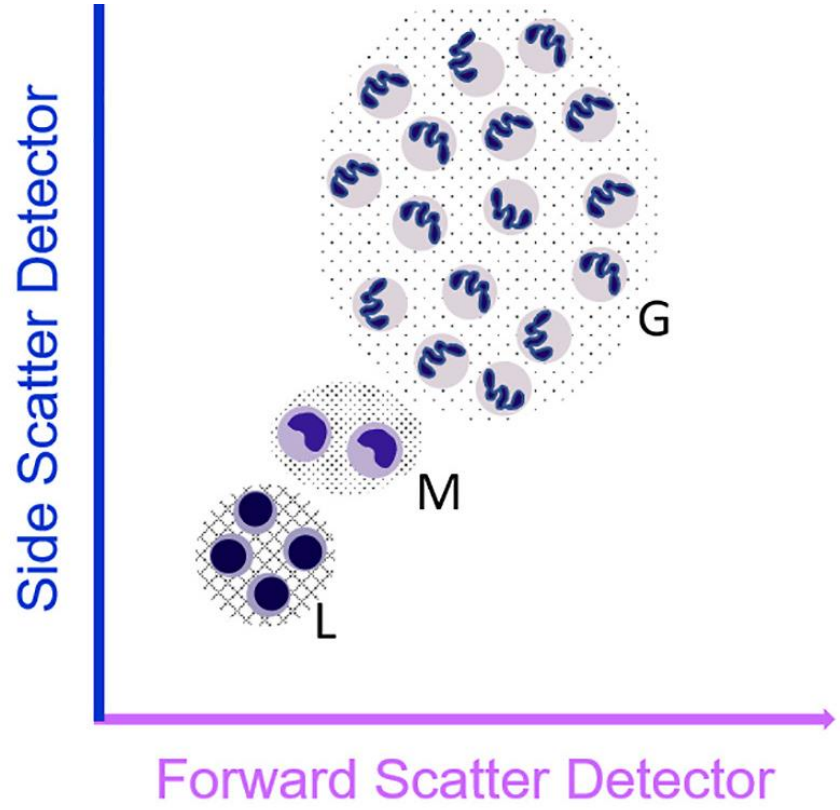
Easy to acquire in-house and use on fresh blood (same as for CBC)

Individual cell counting, sorting, labeling (used to classify multiple disorders) –does NOT directly determine clonality but can be inferred

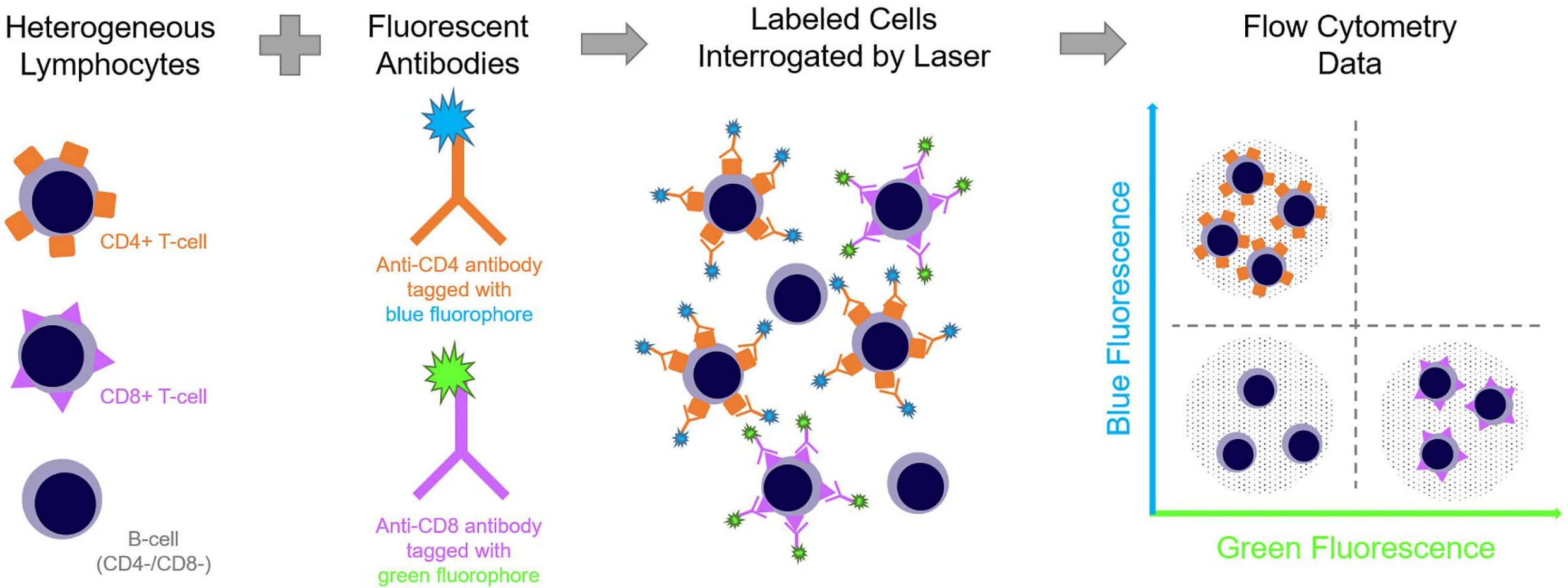
May not “match” cell morphology on blood smear

Flow Cytometry: How it works





Flow Cytometry: How it works



Flow Cytometry: How-to

Collect blood (peripheral or jugular vein, depending on thrombocytopenia risk)

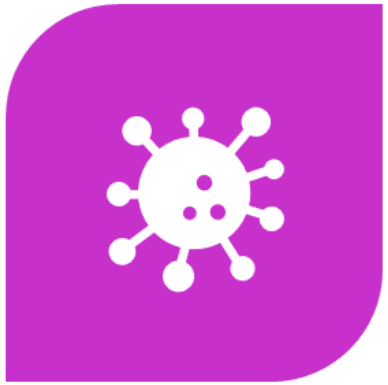
Send to lab of choice ASAP

Send a copy of the CBC too! Or request to have it run by lab

Flow Cytometry: Labs

- Colorado State Clinical Hematopathology Laboratory: *https://vetmedbiosci.colostate.edu/chl/choose-a-test/*
- Other veterinary schools: Minnesota, Penn, Auburn, NC State
- IDEXX and Antech

Flow Cytometry: Sample requirements



ALIVE

LIQUID

CHILLED

FLOW CYTOMETRY RESULTS

Date of Assay: 2/8/2024 %Dead cells: 3 Accession: **F240012250**

	Total count per ul		Reference interval per ul
T cell subset: CD4	718		306 - 2063
T cell subset: CD8	275		157 - 965
Pan T cell: CD3	1373		594 - 3383
Pan T cell: CD5	2260		593 - 3375
B cell: CD21	11785	H	0 - 724
B cell/Plasma cell: CD21-CD22+	0		0
Monocytes: CD14	444		33 - 839
Neutrophils: CD4+CD5-	5914		2379 - 12544
Precursor/Acute leukemia: CD34+MHCII-	0		0
T zone cells: CD5+CD45-	0		0
Aberrant T cell: CD4+CD8+	0		0
B cell size:	SMALL		

Flow Cytometry: Interpretation

TEST RESULTS

Flow cytometry

CD21 LYMPHOCYTOSIS

INTERPRETATION

The flow cytometry study revealed a homogeneous expansion of small CD21+ B cells. The flow cytometry features are most consistent with a diagnosis of B cell chronic lymphocytic leukemia, but rarely other subtypes of small B cell lymphoma have lymphocytosis (Hughes et al, Vet Path 2021). Approximately 45% of canine B cell CLL cases have peripheral lymphadenopathy, 50% have splenomegaly and 25% have hyperglobulinemia. A study from our laboratory found that most cases of B cell lymphocytosis involving small cells have a good long-term survival, but a subset have more aggressive disease (Rout et al, JVIM 2021). Cases with lymphocyte counts greater than 60,000/uL had poorer prognosis (median survival 173 days) than cases with less than 60,000/uL (median survival 526 days). If the clinical picture is not consistent with the suggested prognosis, additional prognostic information may be available by enumerating Ki67 expression, which is a measure of proliferation. The Ki67 prognostic information was determined in untreated cases and we do not know how treatment affects Ki67 expression. Testing is recommended prior to starting treatment and samples must be taken no more than one day before submission. This test is only performed Tuesdays and Wednesdays.

Diagnostics: Bone Marrow Aspirate

Needle aspiration of the bone marrow and cytologic examination of the cells obtained

Only way to compare cells in the circulation to those in the bone marrow

Largely being replaced by Flow cytometry of blood (Flow easier to obtain and has many markers)

Indications

Aleukemic/subleukemic (not enough cells for Flow of peripheral blood to be diagnostic)

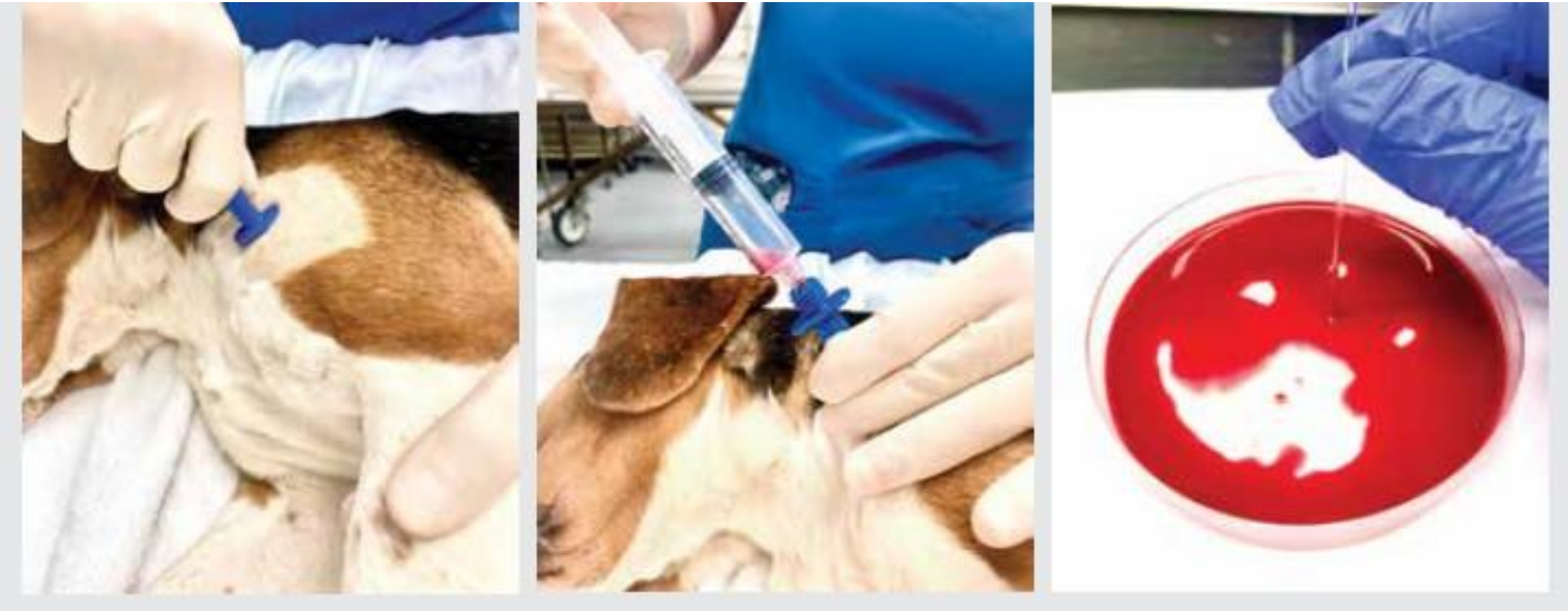
Cytopenias (bi-or pan especially)

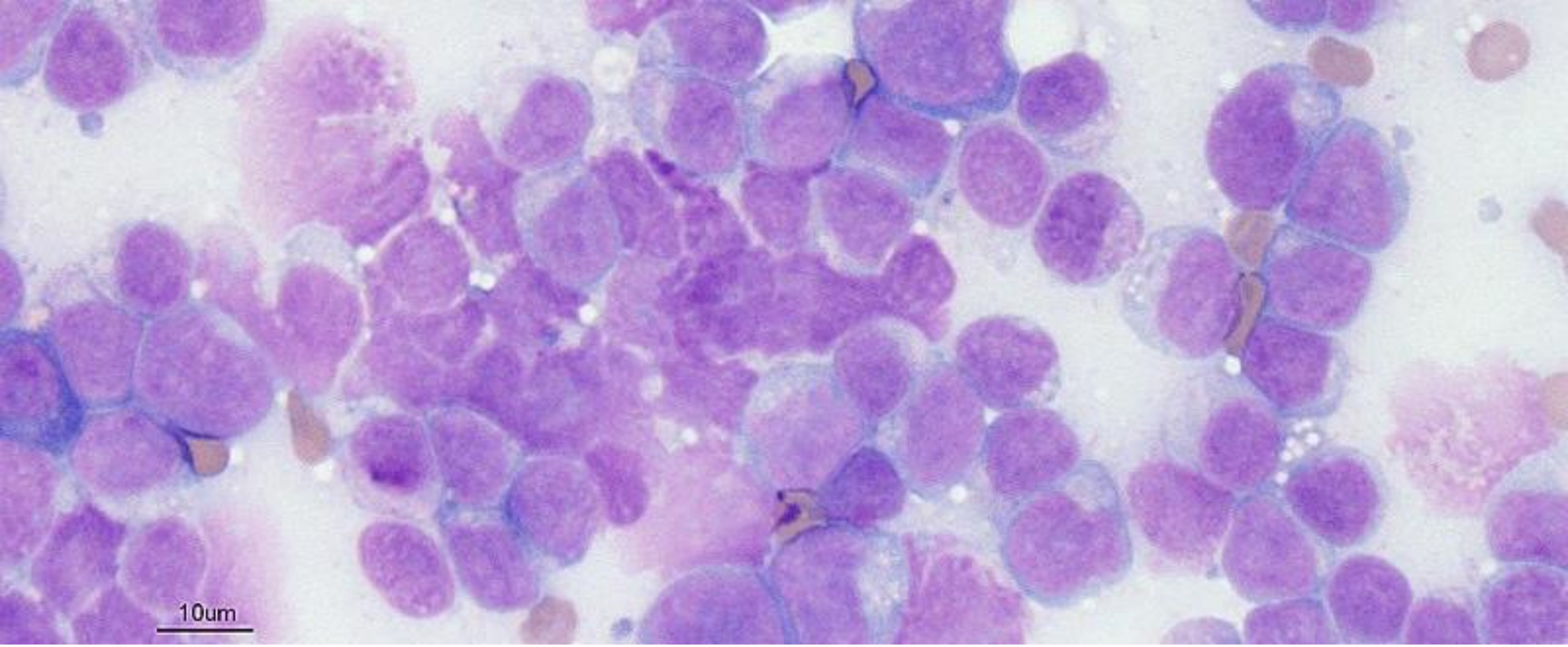
Stable patient

Bone Marrow Aspiration: How-to

- Perform under heavy sedation or general anesthesia
- Supplies: Sterile gloves, clippers and scrub solution, local anesthetic (optional), petri dish with 2.5% to 3% EDTA solution (approx 2 mL), glass microscope slides, microhematocrit capillary tubes, No. 11 surgical blade, sterile gauze, 10- or 12-mL syringe, and 14- to 18-gauge 1- to 2-inch bone marrow needles with stylet (Rosenthal, Illinois sternal, Jamshidi)
- Clip fur and sterilely prep site
  - proximal humerus, ilium, proximal femur, sternum (if sternal, use 20-22 g hypodermic needle)
- Prime collection syringe and needle with EDTA
- Make stab incision over area to sample (avoid joints), then pop needle in

Bone Marrow Aspiration: How-to





Bone Marrow Aspirate: Cytology

Leukemia types

- Chronic Lymphocytic leukemia (CLL)
- Chronic Myeloid Leukemia (CML)
- Acute Lymphoid Leukemia (ALL)
- Acute Myeloid Leukemia (AML)

Not so bad blood: Chronic leukemias

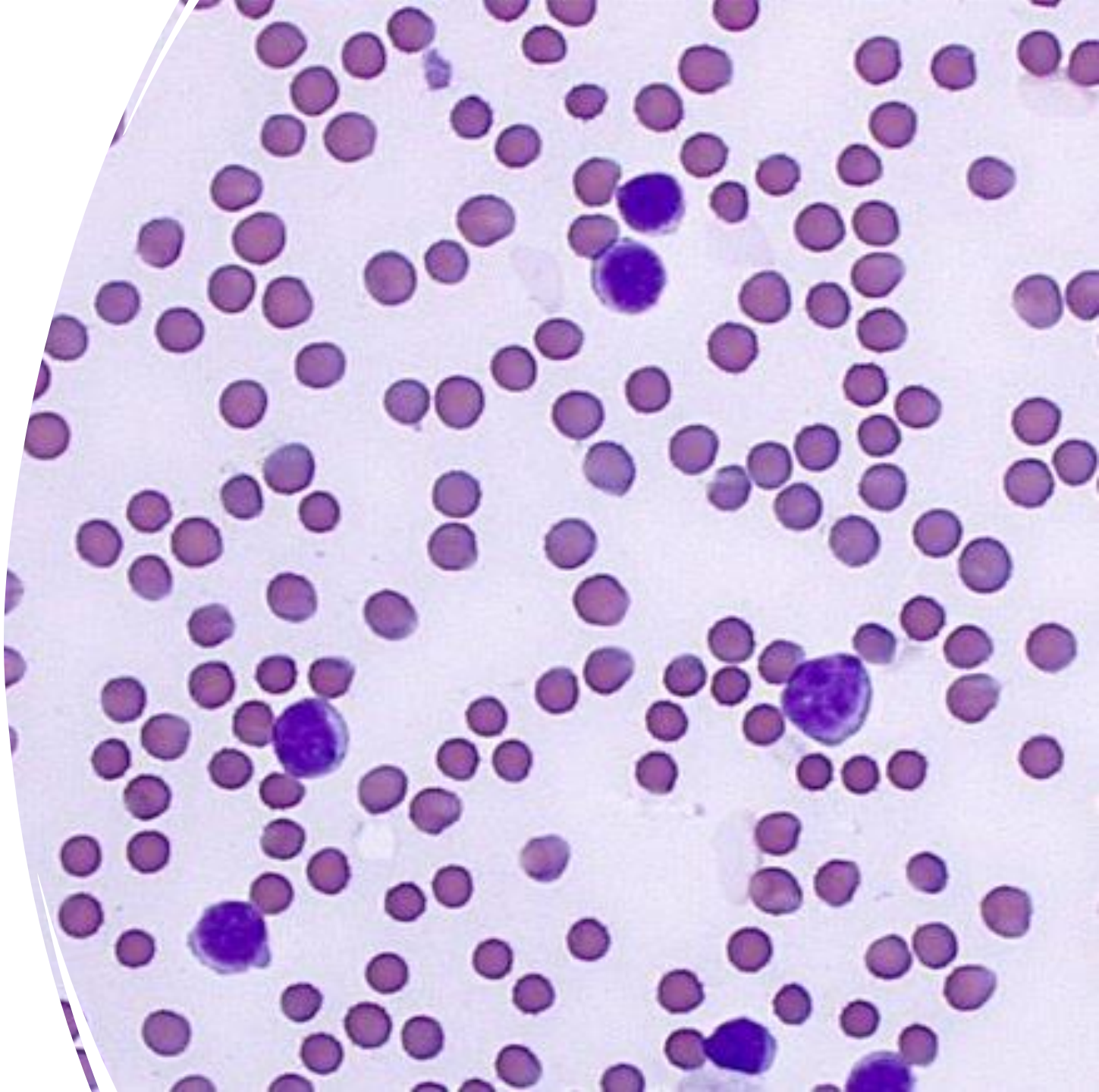
Clinical Presentation

- Older (10-11 yrs), small-breed
- Incidental – MOST COMMON
- +/- mild peripheral lymphadenopathy, splenomegaly/hepatomegaly

Diagnostic findings

- CBC/blood smear:
  - Moderate to severe lymphocytosis
  - Lymphocytes small to medium sized, mature/differentiated*
  - Cats: 50% anemic
- Chemistry:
  - Hyperglobulinemia (25%)

Chronic Lymphocytic Leukemia (CLL)



When to treat

Clinically signs (nonspecific)

Severe lymphocytosis (≥ 60,000/µL*)

Cytopenias: Thrombocytopenia, Neutropenia, Anemia

Hepatomegaly/Splenomegaly/other organ involvement

Severe lymphadenopathy

CLL: Treatment and Prognosis

Treatment

- Delay until one or more criteria met
- Oral chemotherapy and steroids
  - Chlorambucil: 0.2 mg/kg or 6-8 mg/m^2 EOD or 20 mg/m^2 PO q2 wks
  - Prednisone/prednisolone: 1 mg/kg/day for 2 weeks, 0.5 mg/kg/day after
- +/- vincristine, cyclophosphamide
- No consensus on when to stop

Prognosis is GOOD

- 70% normalize lymphocyte count
- MSTs 1-3 years with good QOL
  - But will eventually progress

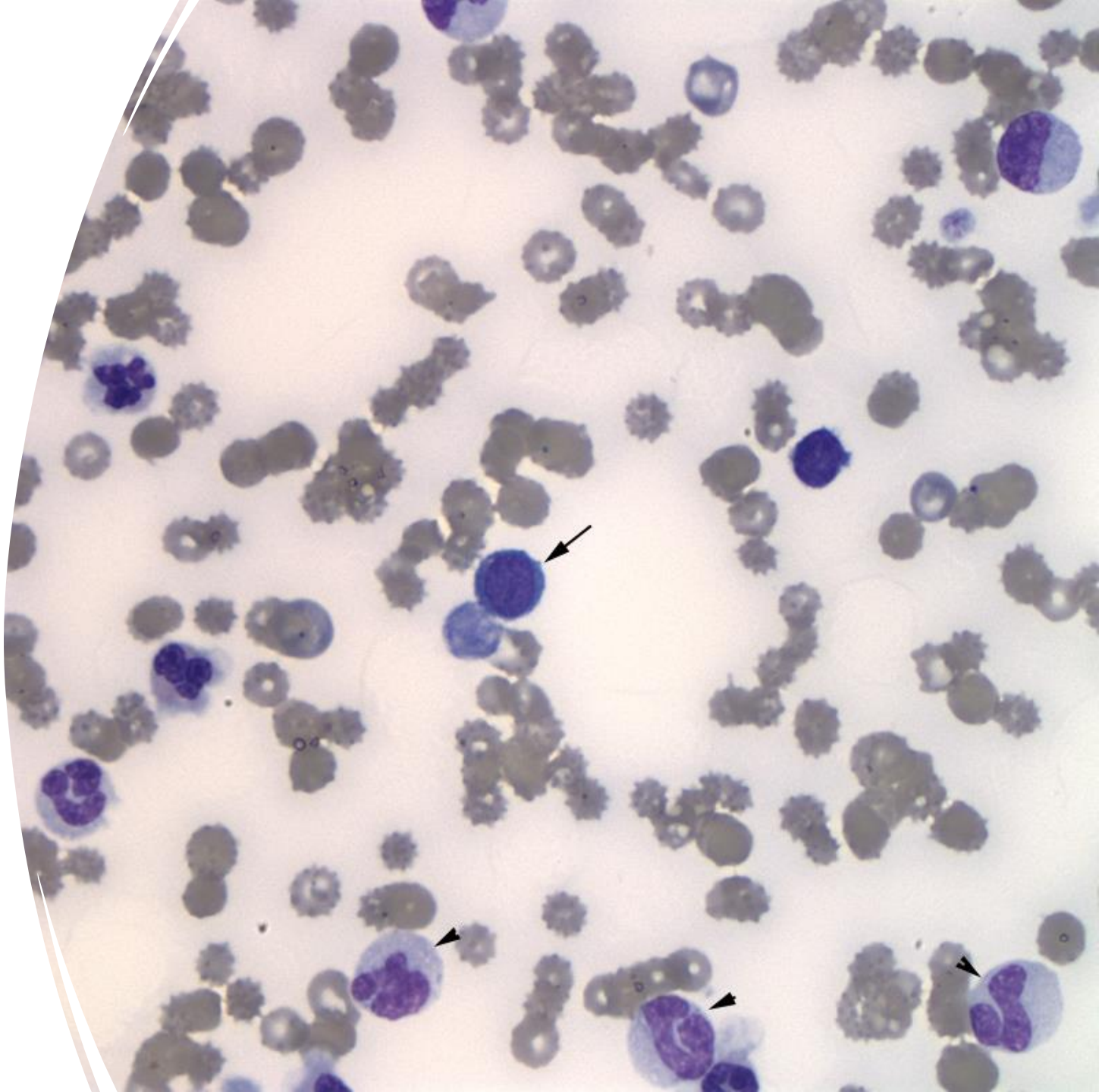
CLL prognostic considerations

Immunophenotype:
Atypical < B < T

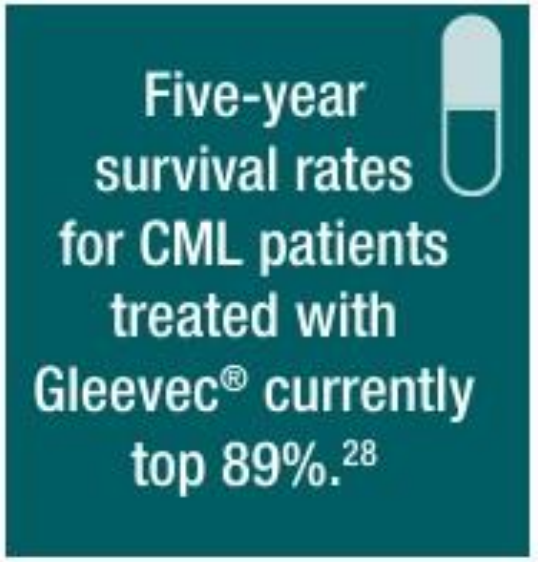
Breed: Boxer, English Bulldog (young, male)

Degree of lymphocytosis at diagnosis

Chronic Myeloid Leukemia (CML)



CML: Treatment and Prognosis



NOTE:
CML is much rarer than CLL! Less is known about treatments and outcomes

Treatment
- Oral chemotherapy and steroid: hydroxyurea +/- busulfan, and prednisone
- Anecdotal: tyrosine kinase inhibitors (Palladia, imatinib)
  - Gleevac/imatinib effective in human patients due to BCL-ABL mutation

Prognosis
- ~ 1 year; range 41 days - 4.5 years

“Richter’s Syndrome” and “Blast Crisis”

Severe progression of chronic leukemia

New immature cells/blasts in circulation

Rapid clinical decline + lymphadenopathy

5% overall; 2% T-CLL and 10% B-CLL

MST 41 days

Acute leukemias are *not* cute!

They’re aggressive and deadly!

Really bad blood: Acute leukemias

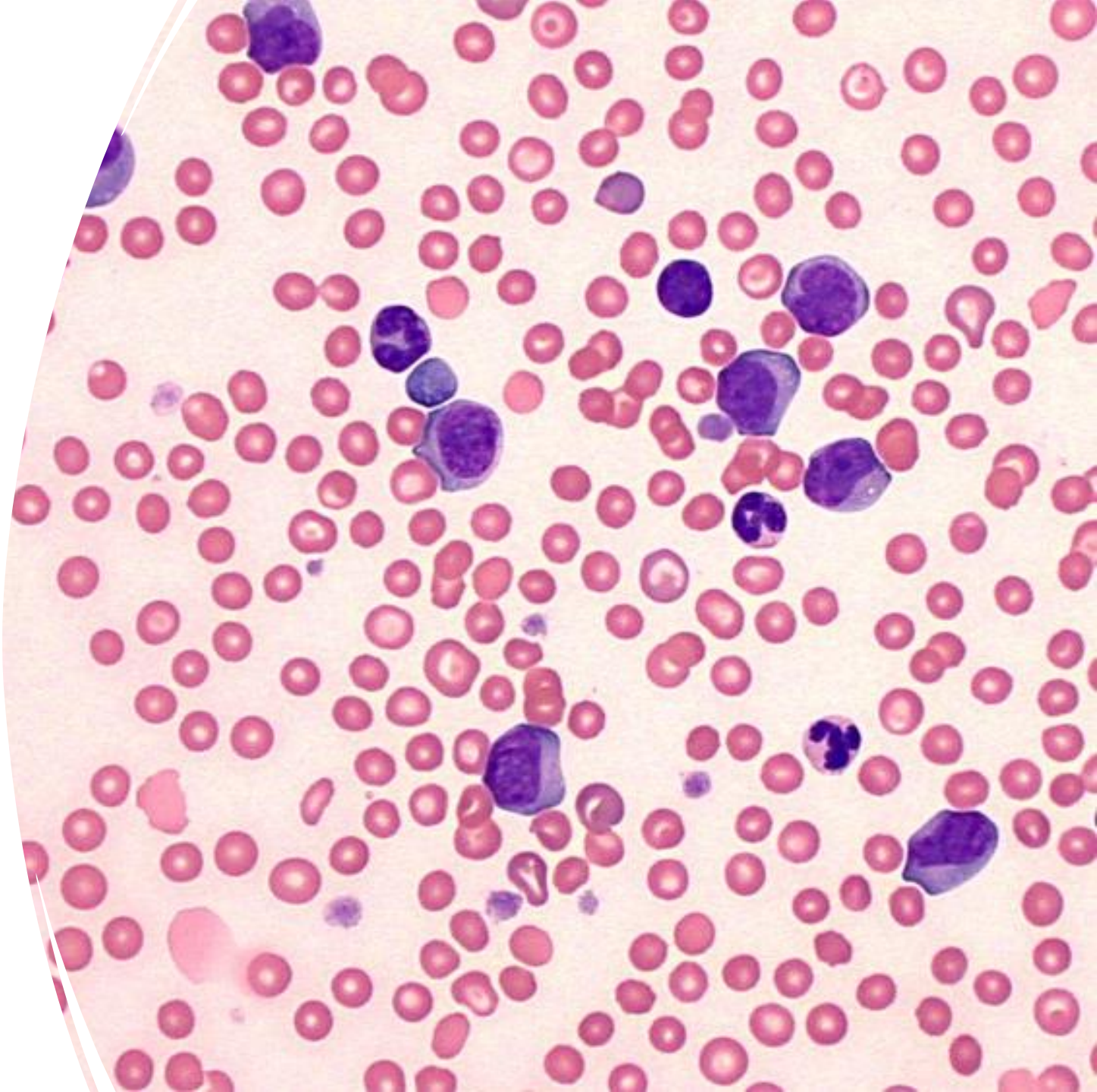
Clinical Presentation

- ACUTELY ILL (days to weeks)
- Vague constitutional
- pale MMs, epistaxis, petechiae
- Organomegaly
- Lymphadenopathy (mild to moderate)

Diagnostic findings

- CBC/blood smear/bone marrow aspirate/FLOW
  - Severe lymphocytosis or neutrophilia
  - Anemia, thrombocytopenia, neutropenia
  - AML: aleukemic or subleukemic
  - ≥20% blast cells
  - CD34+ (not always)

Acute Lymphoid Leukemia (ALL)



ALL: Treatment and Prognosis

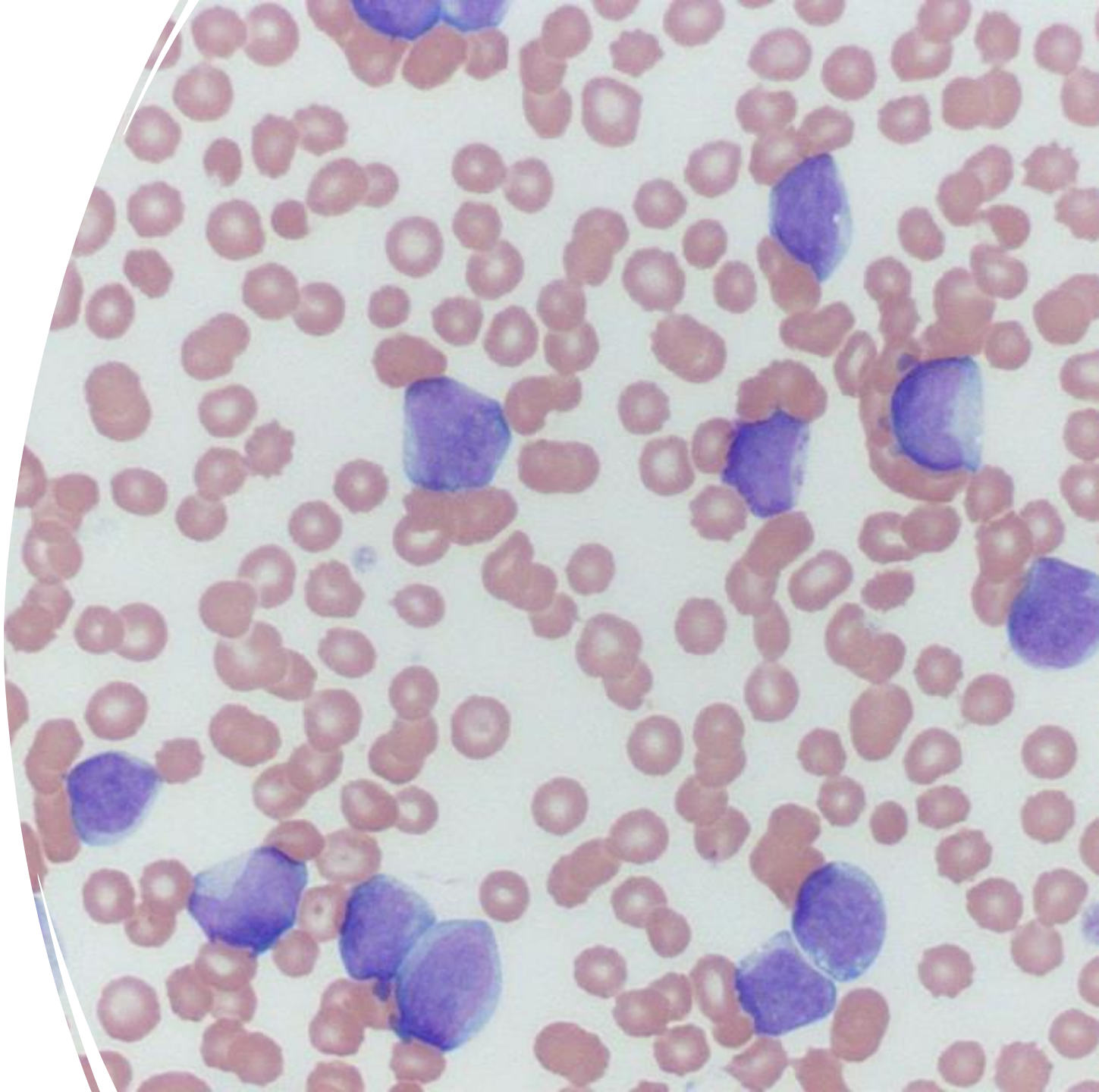
Treatment

- FIRST, STABILIZE PATIENT – fluids, transfusions, etc
- Intensive injectable chemotherapy and steroids
  - CHOP-based
- Possible acute tumor lysis syndrome (electrolyte abnormalities, AKI)
  - Diuresis 24-48 hours

Prognosis is BAD

- Risk for sepsis, hemorrhage, DIC
- Palliative (steroid) only: ~1 week
- Chemo + steroid: 16 – 129 days

Acute Myeloid Leukemia



AML: Treatment and Prognosis

Treatment

- FIRST, STABILIZE PATIENT – fluids, transfusions, etc
- Intensive injectable chemotherapy and steroids
  - CHOP-based +/- cytarabine
  - Doxorubicin + cytarabine
- Possible acute tumor lysis syndrome (electrolyte abnormalities, AKI)
  - Diuresis 24-48 hours

Prognosis is BAD

- Risk for sepsis, hemorrhage, DIC
- Palliative (steroid) only: ~1-14 days
- Chemo + steroid: 6 – 210 days

Myelodysplastic Syndrome (MDS)

Clonal/neoplastic disorder resulting in cytopenias

BM aspirate: Hyperplastic bone marrow with abnormal maturation

<20% blasts in circulation (dogs), <10% in cats but likely other organ (spleen/liver) involvement (lower than in AML)

MST ~ 1 yr; cause of death = cytopenias > acute leukemia

Summary

Presentation predicts prognosis

Go with the FLOW

Tailor treatment

References

- Avery AC, Avery PR. Determining the significance of persistent lymphocytosis. Vet Clin North Am Small Anim Pract. 2007 Mar;37(2):267-82, vi. doi: 10.1016/j.cvsm.2006.11.001. PMID: 17336675.
- Bennett AL, Williams LE, Ferguson MW, Hauck ML, Suter SE, Lanier CB, Hess PR. Canine acute leukaemia: 50 cases (1989-2014). Vet Comp Oncol. 2017 Sep;15(3):1101-1114. doi: 10.1111/vco.12251. Epub 2016 Jul 12. PMID: 27402031; PMCID: PMC5233675.
- Davis LL, Hume KR, Stokol T. A retrospective review of acute myeloid leukaemia in 35 dogs diagnosed by a combination of morphologic findings, flow cytometric immunophenotyping and cytochemical staining results (2007-2015). Vet Comp Oncol. 2018 Jun;16(2):268-275. doi: 10.1111/vco.12377. Epub 2017 Dec 14. PMID: 29239119.
- Evans SJM. Flow Cytometry in Veterinary Practice. Vet Clin North Am Small Anim Pract. 2023 Jan;53(1):89-100. doi: 10.1016/j.cvsm.2022.07.008. Epub 2022 Oct 19. PMID: 36270838.
- Frankhouse KA, Rout ED, Hughes KL, Labadie JD, Yoshimoto JA, Lana SE, Avery PR, Avery AC. An aggressive CD4- CD8- T-cell neoplasm in young English bulldogs. Vet Comp Oncol. 2022 Jun;20(2):416-426. doi: 10.1111/vco.12787. Epub 2021 Dec 9. PMID: 34792269.
- Fine DM, Tvedten HW. Chronic granulocytic leukemia in a dog. J Am Vet Med Assoc. 1999 Jun 15;214(12):1809-12, 1791. PMID: 10382023.
- Hatamkhani, A., & Intile, J. How To Approach Canine Leukemias in General Practice. Today's Veterinary Practice. Retrieved March 20, 2026, from https://todaysveterinarypractice.com/oncology/how-to-approach-canine-leukemias-in-general-practice/
- Hu, T., & Intile, J. Bone Marrow Aspiration in Dogs: Indications and a Step-by-Step Tutorial. Today's Veterinary Practice. Retrieved March 20, 2026, from https://todaysveterinarypractice.com/clinical-pathology/bone-marrow-aspiration-in-dogs/
- Kaur J, Diamantino G, Morrison K, Meichner K, Springer NL, Hoffman M, Bienzle D, Stokol T. Acute myeloid leukemia with peripheral lymph node involvement in dogs: A retrospective study of 23 cases. Vet Pathol. 2025 Mar;62(2):195-205. doi: 10.1177/03009858241295397. Epub 2024 Nov 14. PMID: 39540621.
- Leukemia. EClinPath. Retrieved March 20, 2026, from https://eclinpath.com/hematology/leukemia/
- Matsuyama A, Beeler-Marfisi J, Wood RD, Richardson D, Calvalido J, Mutsaers AJ, Bienzle D. Treatment of myeloid neoplasia with doxorubicin and cytarabine in 11 dogs. Vet Comp Oncol. 2023 Mar;21(1):54-61. doi: 10.1111/vco.12860. Epub 2022 Oct 7. PMID: 36153810.
- Meredith AM, Beeler-Marfisi J, Berke O, Mutsaers AJ, Bienzle D. Standardized bone marrow assessment, risk variables, and survival in dogs with myelodysplastic syndrome and acute myeloidleukemia. Vet Pathol. 2025 Jan;62(1):64-73. doi: 10.1177/03009858241277982. Epub 2024 Sep 18. PMID: 39291964; PMCID: PMC11697499.
- Meichner, K., & Schlemmer, S. (n.d.). Blood Smear Review: Lymphocyte Changes in Dogs and Cats. Today's Veterinary Practice. Retrieved March 20, 2026, from https://todaysveterinarypractice.com/cytology/blood-smear-review-lymphocyte-changes-in-dogs-and-cats/
- Meichner, K. (n.d.). Flow Cytometry: Introduction to Basics. Today's Veterinary Practice. Retrieved March 20, 2026, from https://todaysveterinarypractice.com/wp-content/uploads/sites/4/2023/10/TVP-2023-1112_Flow-Cytometry.pdf
- Musser, Margaret. Viruses, FeLV, FIV. March. 2026, https://canvas.iastate.edu/courses/65120/files/27278176?module_item_id=6358742. PowerPoint Presentation.
- Rout ED, Labadie JD, Curran KM, Yoshimoto JA, Avery AC, Avery PR. Immunophenotypic characterization and clinical outcome in cats with lymphocytosis. J Vet Intern Med. 2020 Jan;34(1):105-116. doi: 10.1111/jvim.15650. Epub 2019 Nov 6. PMID: 31693230; PMCID: PMC6979106.
- Rout ED, Labadie JD, Yoshimoto JA, Avery PR, Curran KM, Avery AC. Clinical outcome and prognostic factors in dogs with B-cell chronic lymphocytic leukemia: A retrospective study. J Vet Intern Med. 2021 Jul;35(4):1918-1928. doi: 10.1111/jvim.16160. Epub 2021 May 17. PMID: 33998726; PMCID: PMC8295712.
- Rout ED, Moore AR, Burnett RC, Labadie JD, Hughes KL, Navin PA, Yoshimoto JA, Avery PR, Avery AC. Polyclonal B-cell lymphocytosis in English bulldogs. J Vet Intern Med. 2020 Nov;34(6):2622-2635. doi: 10.1111/jvim.15913. Epub 2020 Oct 15. PMID: 33058280; PMCID: PMC7694837.
- Vail DM, Thamm DH, Liptak JM. Hematopoietic tumors. In: Vail DM, Thamm DH, Liptak JM, eds. Withrow and MacEwen's Small Animal Clinical Oncology. 6th ed. W.B. Saunders; 2019:688-772. doi:10.1016/B978-0-323-59496-7.00033-5

Image credits

https://eclinpath.com/hematology/leukemia/three-leukemia-types_v2-lal/

https://eclinpath.com/hematology/leukemia/transforming-aligorithm/

https://eclinpath.com/atlas/hematology/leukemia/nggallery/

https://taylorswiftartist.web.app/taylor-swift-speak-now.html

https://axolbio.com/wpcontent/uploads/2022/04/ir_attachment_12465.png

https://www.nih.gov/sites/default/files/2025-01/fighting-cancer-case-study.pdf

Questions?

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Reference list available upon request