CRP: CANARY IN THE BLOODSTREAM

By Dr. LEE, YEE LIN
BSc BVMS (Murdoch)
&
Dr. CHANG, LIWEN(RITA)
DVM. PhD. IDEXX TW

DR LEE YEE LIN

FOUNDER, HEAD OF VET
GENTLE OAK VETERINARY CLINIC (SINGAPORE)
BOWEN THERAPIST FOR SMALL ANIMALS
CERT BODYTALK PRACTITIONER

Gentle Oak
VETERINARY CLINIC

Agenda

CRP: Say whuuuuut???

Understand the importance of identifying systemic inflammation

Cases, cases, cases!!

Q&A

slido

Tell me what you know about C-reactive Protein (CRP)

ⓘ Start presenting to display the poll results on this slide.

WHY "CANARY IN THE BLOODSTREAM"

Much like a canary in a coal mine signaling danger

CRP is an early warning indicator of inflammation

WHAT'S THE BIG DEAL?

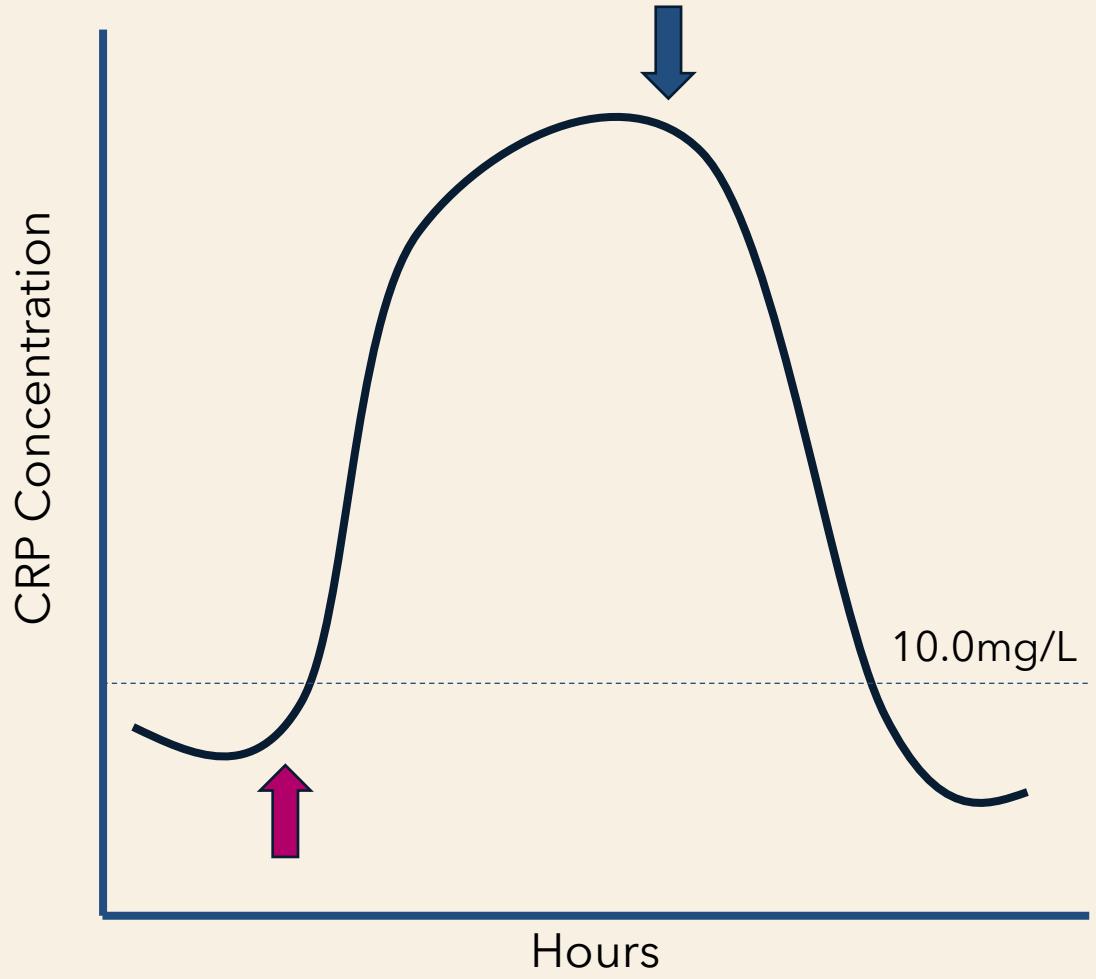
Systemic Inflammation → **SIRS** → **MODS**

SIRS: Systemic Inflammatory Response Syndrome
MODS: Multi Organ Dysfunction Syndrome

C-REACTIVE PROTEIN (CRP)

- Rapid production + Clearance
  - Increase within 6hrs of onset

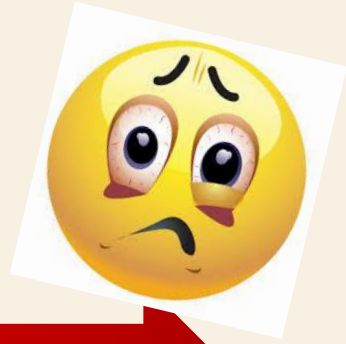
- Used in combo with CBC:
  - ✓ Detect + monitor systemic inflammation

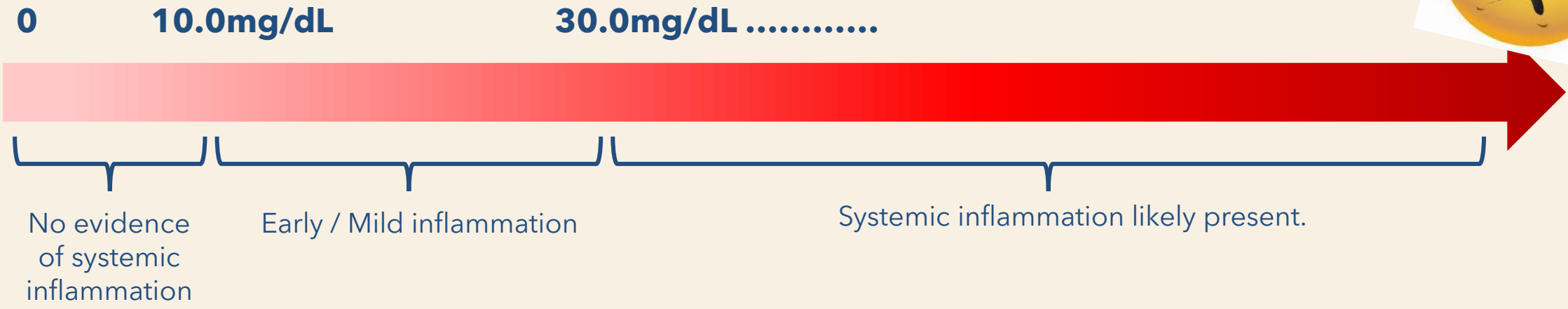


C-REACTIVE PROTEIN (CRP)

- Increasing levels of CRP = worsening inflammation
- SI Unit >30.0mg/L = clinically significant systemic inflammation

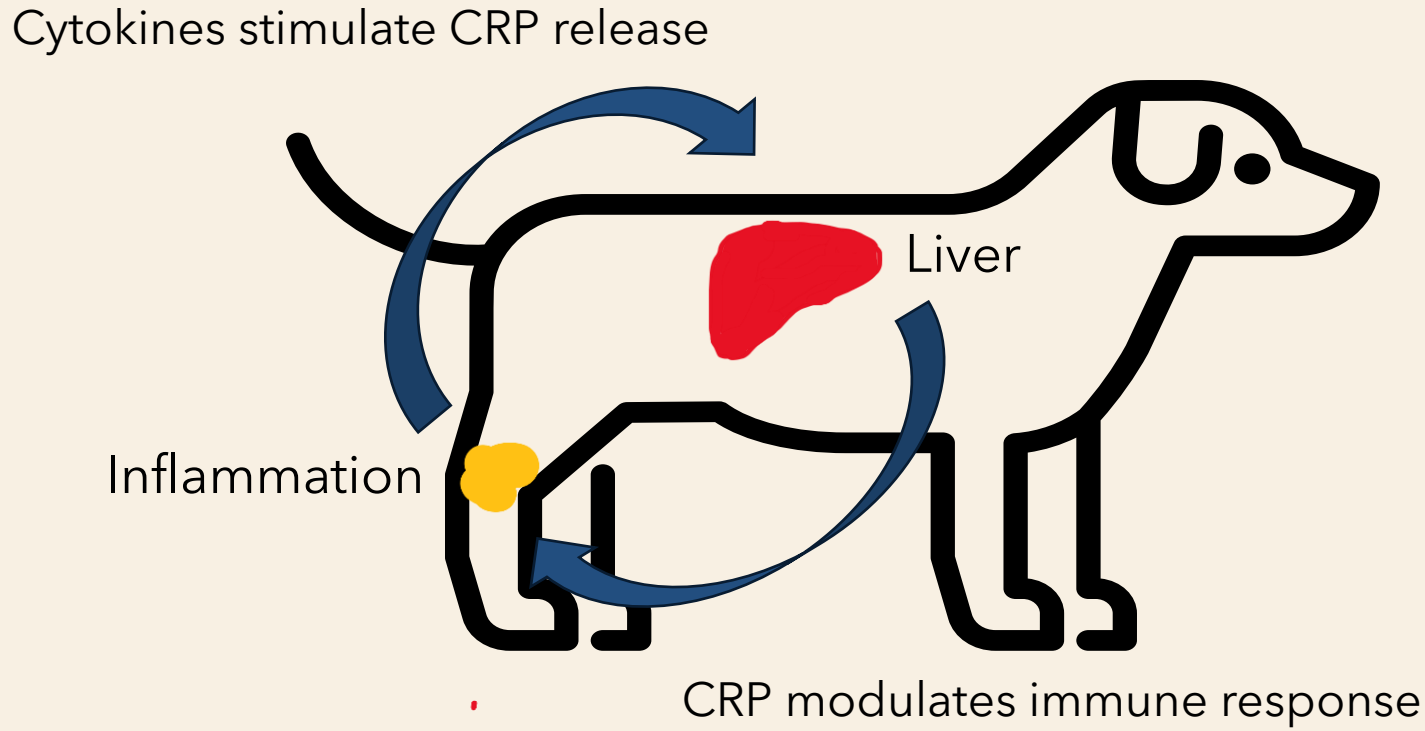
*Note: may sometimes be recorded in mg/dL (ie >3.0mg/dL)





C-REACTIVE PROTEIN (CRP)

- CRP is an acute phase protein produced by the liver.
- It is non-specific for cause of inflammation
- Does not imply that the focus is patient-wide



Pyometra

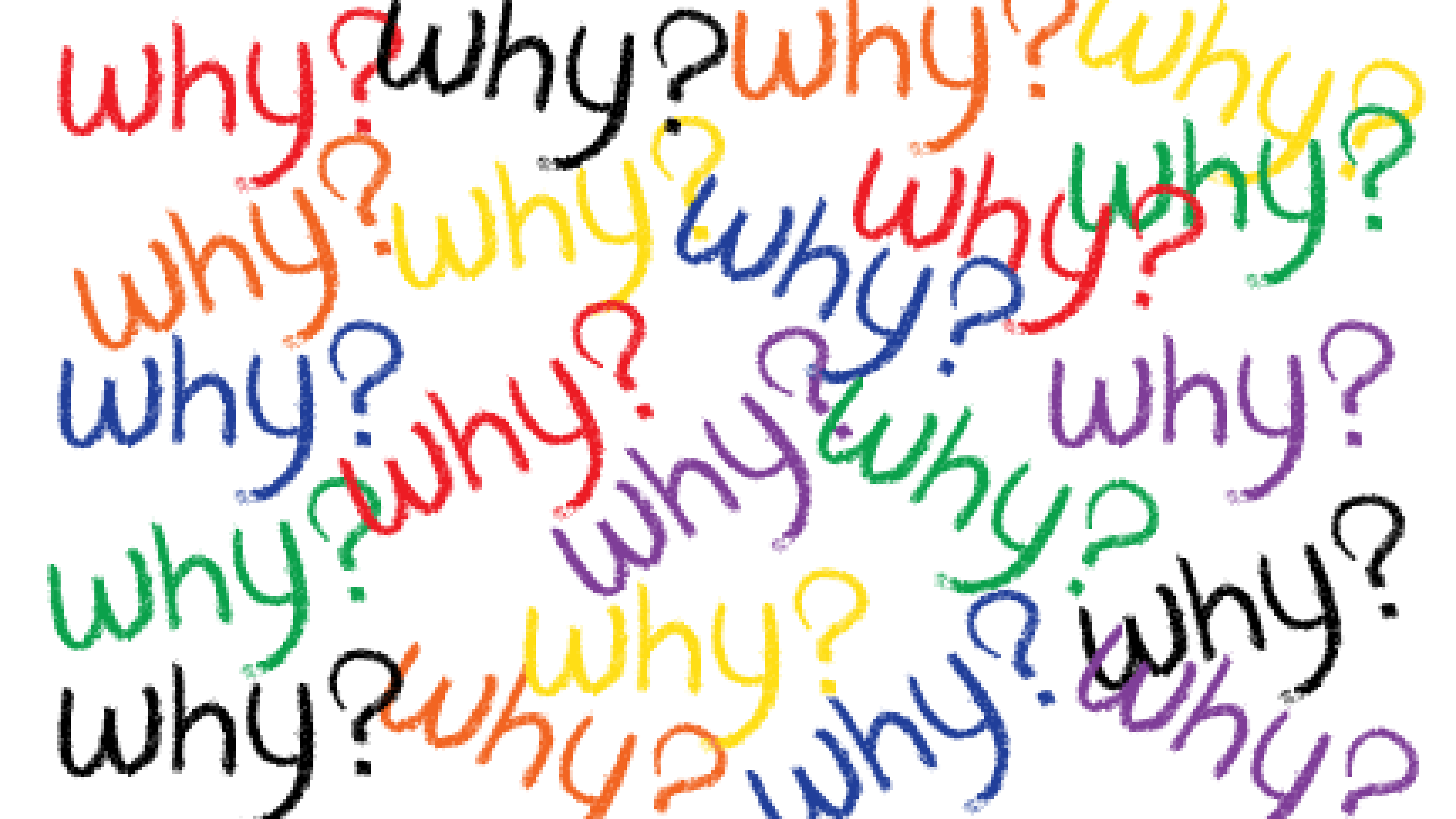
Infected joint

Poor pup!

C-REACTIVE PROTEIN (CRP)

- Pneumonia
- Immune-mediated polyarthritis
- Immune-mediate haemolytic anaemia
- Neoplasia
- Acute pancreatitis
- Post-surgical infection
- Endocarditis
- Pyometra
- Prostatitis
- Leptospirosis
- Tick-borne disease (e.g. ehrlichiosis)
- Viral infection (e.g. parvovirus)
- Etc… Etc… Etc…

CRP is highly sensitive and specific for systemic inflammation, BUT it does not provide an indication of CAUSE.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CBC VS CRP

- CRP is much more sensitive than WBC / neutrophil count
- CRP is not affected by bone marrow activity
  - e.g. severe inflammation → low neutrophil count
- CRP DOES NOT replace nor diminish the value of a CBC!

CANINE CRP IS DIFFERENT FROM HUMAN CRP!!

HOW CAN CRP HELP?

"Aint Quite Right"

"He's not himself..."

CASE 1: "CAIRO"
10.5YR, SINGAPORE SPECIAL, MN

Presented for 1 week of lethargy

Saw another vet 3 days prior:
- Mild pyrexia
- "Fine"
- No Diagnostics done

CASE 1: "CAIRO"
10.5YR, SINGAPORE SPECIAL, MN

On presentation:

- Mild pyrexia (39.5°C)
- Quiet but Alert
- Slight swelling of submandibular lymph nodes
- PE otherwise within normal limits

LET'S RUN SOME TESTS!

Hematology

8/30/24 **10:37 AM**

TEST	RESULT	REFERENCE VALUE	
RBC	6.98	5.65 - 8.87 x10^12/L	
Hematocrit	0.43	0.373 - 0.617 L/L	
Hemoglobin	141	131 - 205 g/L	
MCV	61.6	61.6 - 73.5 fL	
MCH	**20.2**	**21.2 - 25.9 pg**	L
MCHC	328	320 - 379 g/L	
RDW	17.2	13.6 - 21.7 %	
% Reticulocytes	0.2	%	
Reticulocytes	16.1	10.0 - 110.0 K/µL	
Reticulocyte Hemoglobin	**22.1**	**22.3 - 29.6 pg**	L
WBC	10.24	5.05 - 16.76 x10^9/L	
% Neutrophils	80.1	%	
% Lymphocytes	10.3	%	
% Monocytes	6.3	%	
% Eosinophils	2.9	%	
% Basophils	0.4	%	
Neutrophils	8.20	2.95 - 11.64 x10^9/L	
Lymphocytes	1.05	1.05 - 5.10 x10^9/L	
Monocytes	0.65	0.16 - 1.12 x10^9/L	
Eosinophils	0.30	0.06 - 1.23 x10^9/L	
Basophils	0.04	0.00 - 0.10 x10^9/L	
Platelets	159	148 - 484 x10^9/L	
PDW	14.6	9.1 - 19.4 fL	
MPV	**14.4**	**8.7 - 13.2 fL**	H
Plateletcrit	0.23	0.14 - 0.46 %	

LET'S RUN SOME TESTS!

Chemistry

8/30/24 **10:45 AM**

TEST		RESULT	REFERENCE VALUE	
Glucose		4.55	3.89 - 7.95 mmol/L	
IDEXX SDMA	a	8	0 - 14 µg/dL	
Creatinine		86	44 - 159 µmol/L	
BUN		4.5	2.5 - 9.6 mmol/L	
BUN: Creatinine Ratio		13		
Total Protein		77	52 - 82 g/L	
Albumin		27	22 - 39 g/L	
Globulin		**51**	**25 - 45 g/L**	H
Albumin: Globulin Ratio		0.5		
ALT		68	10 - 125 U/L	
ALP		70	23 - 212 U/L	

a SDMA:

SDMA and CREA within reference interval: impairment of GFR is unlikely.
Recommended next step: evaluate complete urinalysis.


UH OH

Immunology

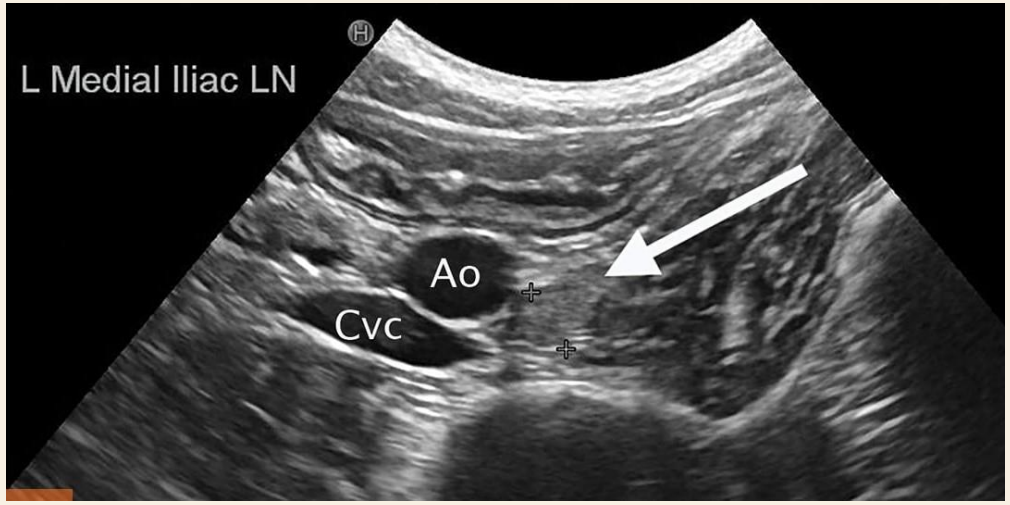
8/30/24 **10:58 AM**

TEST		RESULT	REFERENCE VALUE	
C-Reactive Protein (CRP)	a	**74.9**	**0.0 - 10.0 mg/L**	H

a C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.

FURTHER DIAGNOSTICS:

Abdominal ultrasound – larger than normal abdominal lymph nodes



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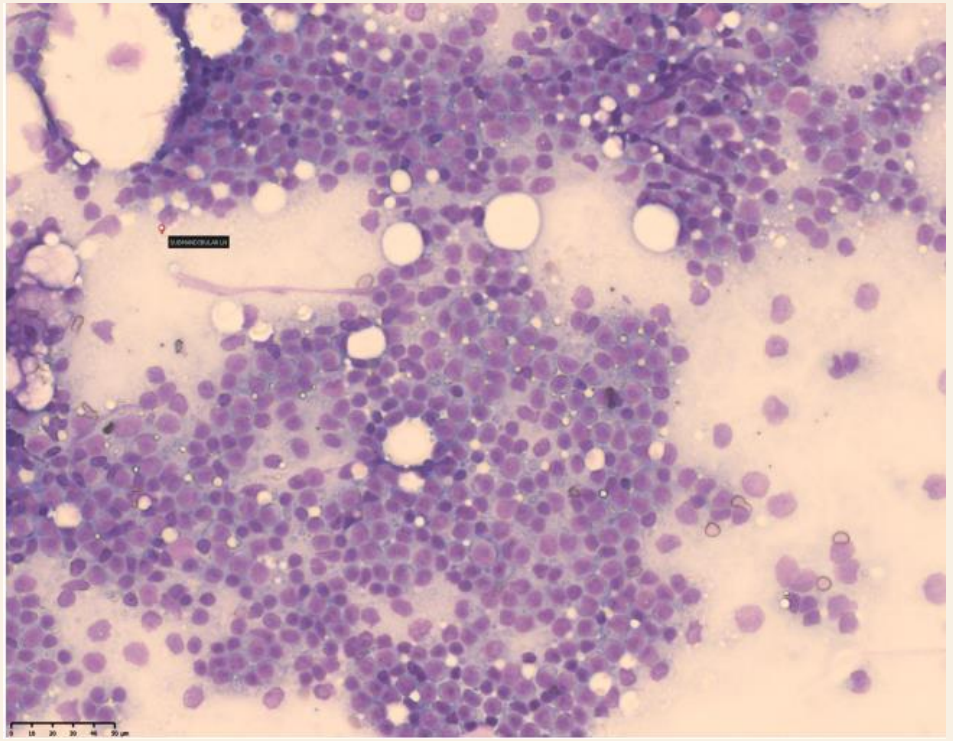
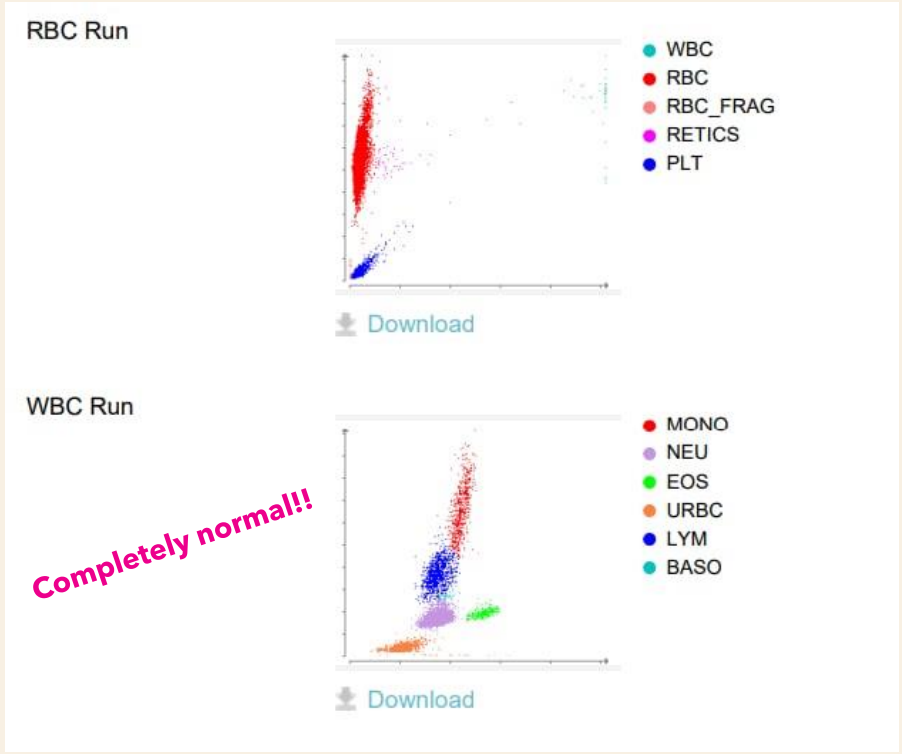
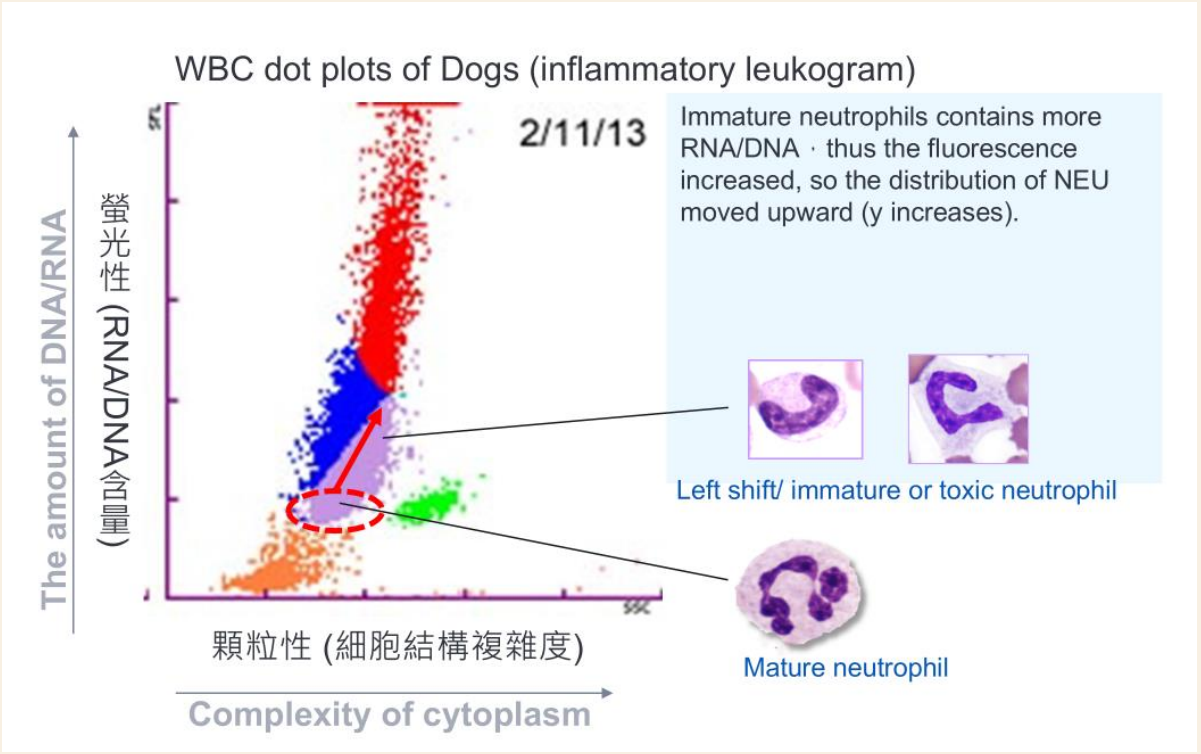


MICROSCOPIC FINDINGS:

~ LYMPHOMA

WAIT... DID WE LOOK AT THE DOT-PLOTS?





LITERATURES FOR LYMPHOMA

Table 1. Representative diseases with significantly high plasma CRP levels

Diseases*	(n)	CRP (mg/dl) Median**	Min.	Max.	Number of dogs ≥1 mg/dl (%)	≥10 mg/dl (%)
Pyometra	7	20.0	3.5	>20	7 (100%)	5 (71%)
Sterile nodular panniculitis	7	20.0	10.0	>20	7 (100%)	5 (100%)
Acute pancreatitis	5	15.0	6.1	>20	5 (100%)	3 (60%)
Idiopathic polyarthritis	31	13.0	1.7	>20	31 (100%)	21 (67%)
Hemangiosarcoma	5	7.6	3.1	16	5 (100%)	2 (40%)
Nasal adenocarcinoma	5	6.7	0.1	9	4 (80%)	0 (0%)
Immune-mediated hemolytic anemia	35	6.5	0	>20	30 (86%)	9 (26%)
Cholangiocellular carcinoma	7	6.3	0.1	19	6 (86%)	2 (29%)
Acute lymphoblastic leukemia	6	4.5	0.1	>20	5 (83%)	1 (17%)
Malignant histiocytosis	16	4.3	0.3	>20	11 (69%)	4 (25%)
Lymphoma	127	3.5	0	>20	91 (72%)	26 (21%)
Bronchopneumonia/Pneumonia	16	3.3	0.2	11	12 (75%)	1 (6%)
Malignant mesothelioma	7	2.7	0.7	15	5 (71%)	1 (14%)
Demodicosis	7	2.6	0	7.1	5 (71%)	0 (0%)
Chronic hepatitis	7	1.6	0	9.7	4 (57%)	0 (0%)
Cardiac tamponade	6	1.5	0.7	6.7	3 (50%)	0 (0%)
Myelodysplastic syndrome	5	1.3	0	14	3 (60%)	1 (20%)
Intestinal adenocarcinoma	13	1.0	0	14	8 (62%)	3 (23%)
Immune-mediated thrombocytopenia	7	1.0	0	12	4 (57%)	1 (14%)

* Diseases (n≥5) in which the median of the CRP concentration exceeded the reference range (≥1 mg/dl) were shown.
** CRP values higher than the measurement limit (>20 mg/dl) were statistically analyzed as 20 mg/dl.

Nakamura, M., M.Takahashi, et al. 2008. C-reactive protein concentration in dogs

Other Studies:

- **MCT, Sarcomas**

Chase D, McLauchlan G, Eckersall PD, Pratschke J, Parkin T, Pratschke K. Acute phase protein levels in dogs with mast cell tumours and sarcomas. Vet Rec. 2012 Jun 23;170(25):648. doi: 10.1136/vr.100401. Epub 2012 Jun 1. PMID: 22659923.

- **MGT**

Tecles F, Caldín M, Zanella A, Membiela F, Tvarijonaviciute A, Subiela SM, Cerón JJ. Serum acute phase protein concentrations in female dogs with mammary tumors. J Vet Diagn Invest. 2009 Mar;21(2):214-9. doi: 10.1177/104063870902100206. PMID: 19286500.

Table-3: Median value of pre-treatment levels of serum CRP and circulating inflammatory parameters in lymphoma dogs.

Biomarkers	All cases (n = 34)	Advanced stage (IV and V)	Stage I–III	p-value
Serum CRP level	56.65	109.4	40.8	0.00048*
Serum albumin	2.6	2.25	2.7	0.019
White blood cell count	11,815	11,840	14,530	0.293
Neutrophils count	8,423	7,980	9691	0.294
Lymphocytes count	1,357	1,114	1494	0.542
Monocyte count	543	479	1,201	0.107
Platelets count	142,000	97,000	165,000	0.103
Neutrophil to lymphocyte ratio	4.9	5.47	3.7	0.395
Lymphocyte to monocyte ratio	2.12	1.97	2.09	0.379
Platelet to lymphocyte ratio	122.20	98.16	125.69	0.516

*p < 0.05, CRP=C-reactive protein

Table-2: Distribution of clinical staging affected by high (more than 10 mg/L) and low (≤10 mg/L) level of serum CRP in dogs with lymphoma.

Level of serum CRP	All lymphoma dogs (n=34)	Advanced stage (IV and V) lymphoma dogs (n=11)	Stage I – III lymphoma dogs (n=21)
Low	7	0	7
High	27	11	15

CRP=C-reactive protein

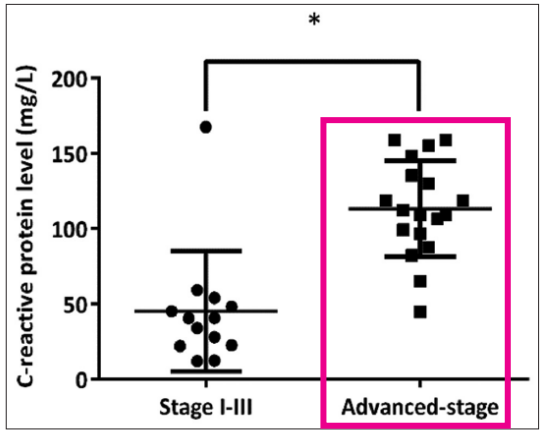


Figure-1: Box and whisker plot showing the serum C-reactive protein level between Stage I and III and advanced-Stage IV and V of canine lymphoma with *p < 0.01.

Manachai N, Umnuayyonvaree D, Punyathi P, Rungsipipat A, and Rattanapinyopituk K (2022) Impact of serum C-reactive protein level as a biomarker for cancer dissemination in canine lymphoid neoplasia, Veterinary World, 15(12): 2810–2815.

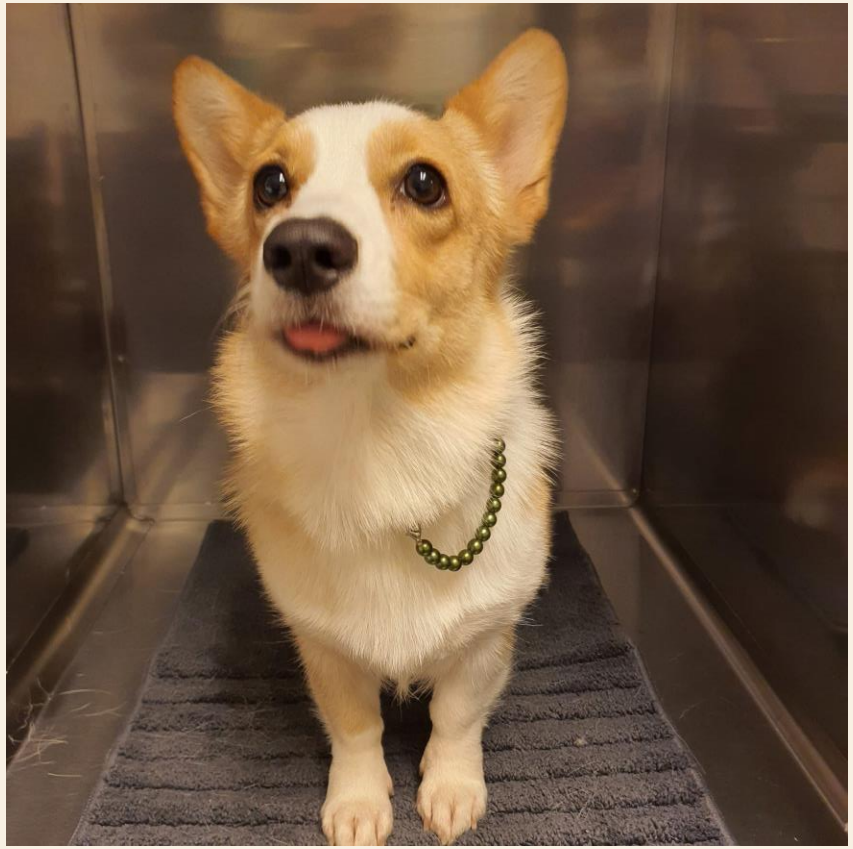
HOW ELSE CAN WE USE CRP?

MONITORING TOOL:

- Post-Op patients
- In house monitoring of hospitalized patients:
  - ➢ Infectious Diseases
  - ➢ Inflammatory Diseases

MONITORING TOOL:

SUMO – 2YR, MN, CORGI



- Presented for vomiting on an hourly basis since night before.
- Was brought to an emergency service but discharged home on oral meds
- Started to have spots of frank blood in vomitus.
- Inappetant; normally very food motivated
- On PE:
  - Quiet but responsive
  - Mm pink, crt<2sec, temp 39.4°C
  - Discomfort on abdominal palpation

Test	Results	Unit	Lowest Value	Highest Value
RBC	7.64	M/µL	5.65	8.87
HCT	54.8	%	37.3	61.7
HGB	19.0	g/dL	13.1	20.5
MCV	71.7	fL	61.6	73.5
MCH	24.9	pg	21.2	25.9
MCHC	34.7	g/dL	32.0	37.9
RDW	18.7	%	13.6	21.7
%RETIC	0.9	%		
RETIC	65.7	K/µL	10.0	110.0
RETIC-HGB	25.7	pg	22.3	29.6
WBC	9.06	K/µL	5.05	16.76
%NEU	61.7	%		
%LYM	27.0	%		
%MONO	5.8	%		
%EOS	5.4	%		
%BASO	0.1	%		
NEU	5.58	K/µL	2.95	11.64
LYM	2.45	K/µL	1.05	5.10
MONO	0.53	K/µL	0.16	1.12
EOS	0.49	K/µL	0.06	1.23
BASO	0.01	K/µL	0.00	0.10
PLT	280	K/µL	148	484
MPV	9.4	fL	8.7	13.2
PDW	12.0	fL	9.1	19.4
PCT	0.26	%	0.14	0.46

CBC from emergency service

Test	Results	Unit	Lowest Value	Highest Value
GLU	118	mg/dL	74	143
SDMA	14	µg/dL	0	14
CREA	1.3	mg/dL	0.5	1.8
BUN	16	mg/dL	7	27
BUN/CREA	13			
PHOS	3.7	mg/dL	2.5	6.8
CA	10.0	mg/dL	7.9	12.0
TP	7.3	g/dL	5.2	8.2
ALB	3.4	g/dL	2.3	4.0
GLOB	3.8	g/dL	2.5	4.5
ALB/GLOB	0.9			
ALT	79	U/L	10	125
ALKP	41	U/L	23	212
GGT	0	U/L	0	11
TBIL	0.1	mg/dL	0.0	0.9
CHOL	202	mg/dL	110	320
AMYL	755	U/L	500	1500
LIPA	660	U/L	200	1800
Na	148	mmol/L	144	160
K	3.8	mmol/L	3.5	5.8
Na/K	38			
Cl	116	mmol/L	109	122
Osm Calc	296	mmol/kg		

Biochem from emergency service


WHAT
NOW?

Catalyst One (August 3, 2019 12:03 PM)

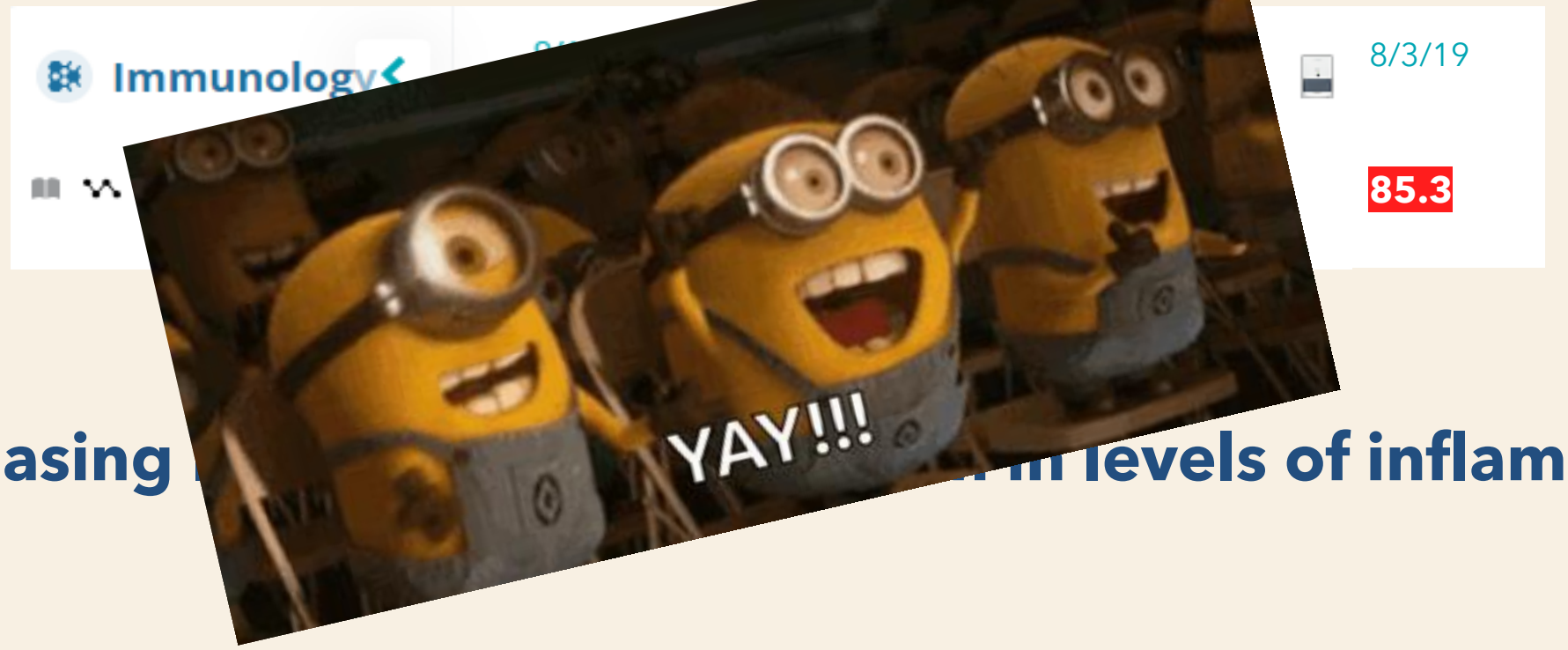
Na	144 mmol/L	144 - 160	
K	3.5 mmol/L	3.5 - 5.8	
Na/K	41		
Cl	115 mmol/L	109 - 122	
CRP	85.3 mg/L	0.0 - 10.0	HIGH

C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.

SNAPshot Dx (August 3, 2019 12:35 PM)

cPL	Abnormal

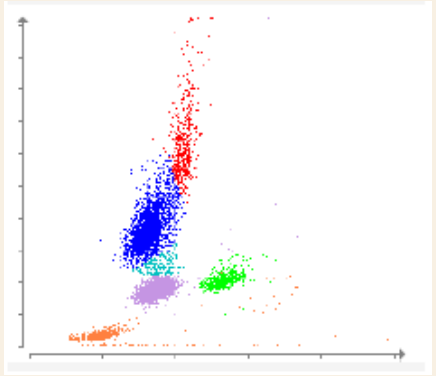
IS SUMO GETTING BETTER?

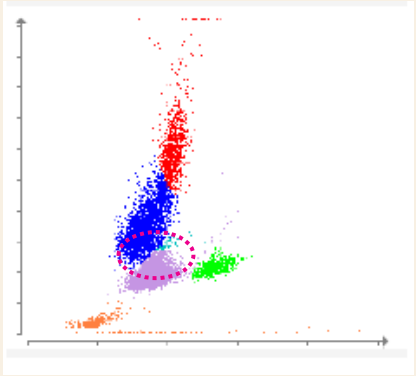


Decreasing … in levels of inflammation!

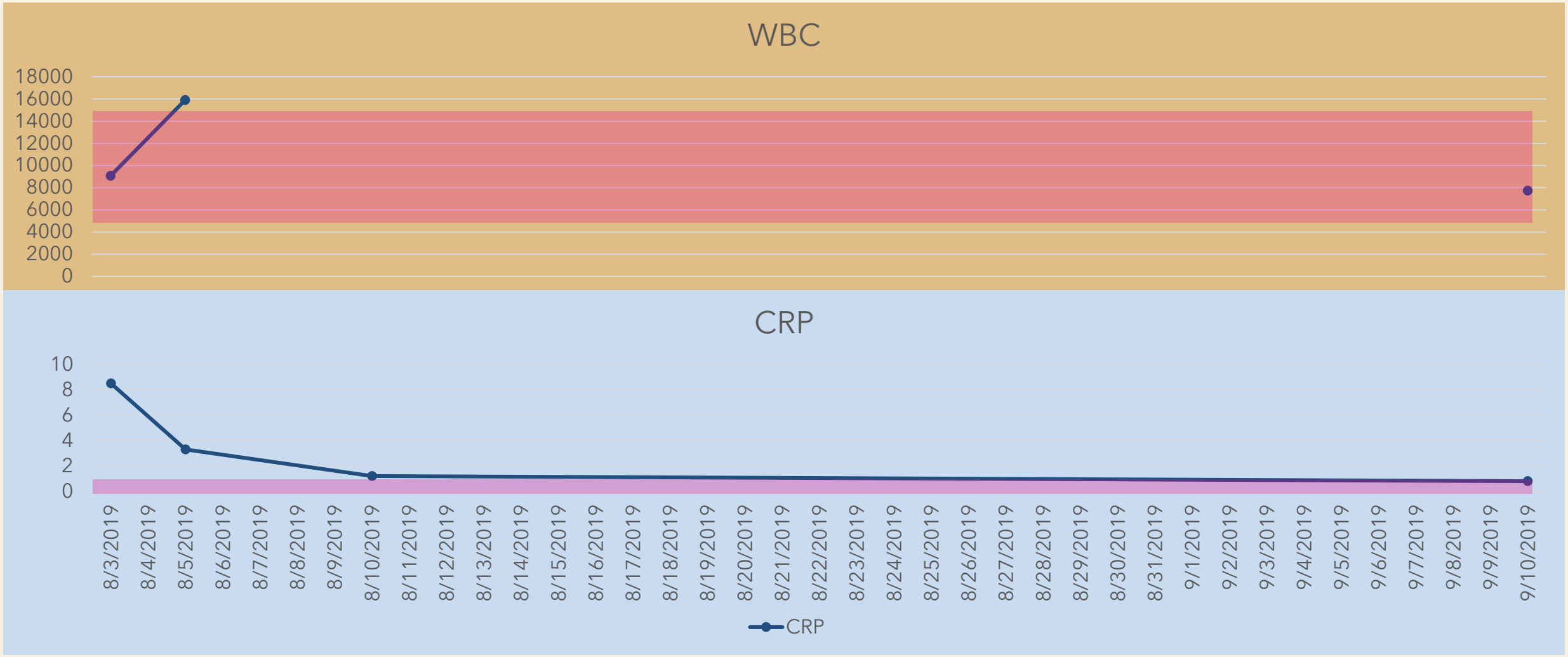
WAIT.. WHAT IF WE LOOKED AT DOT-PLOTS?

Immunology	9/10/19 5:12 PM	8/10/19 3:31 PM	8/5/19 10:27 AM	8/3/19
C-Reactive Protein (CRP)	a 7.6	a **11.8**	a **32.7**	**85.3**





LET'S LOOK AT THE DOT-PLOTS!



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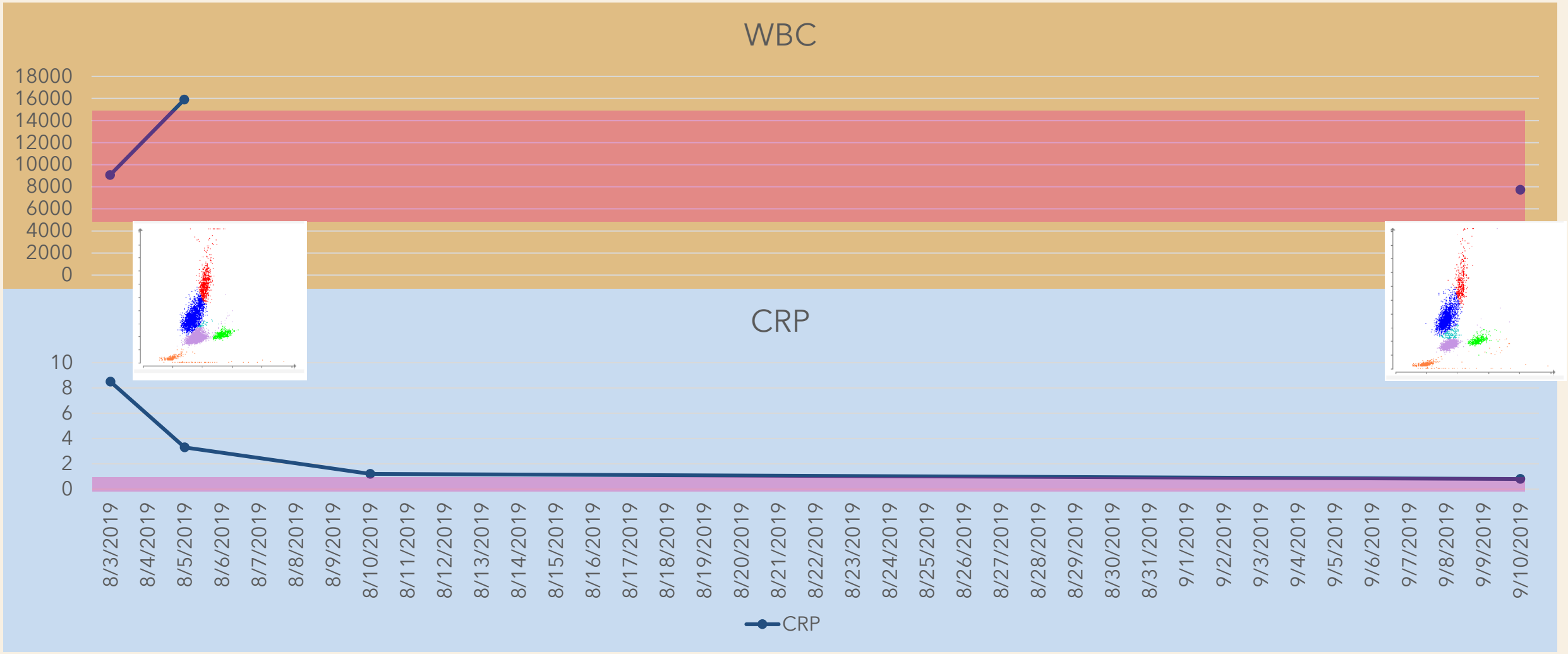
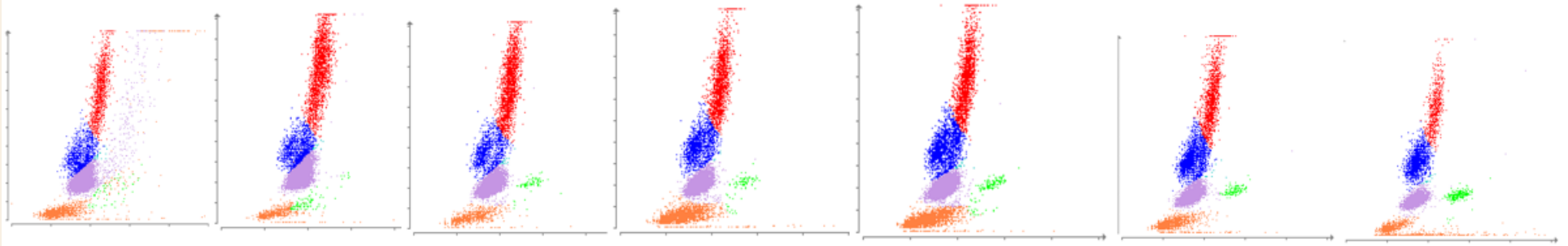
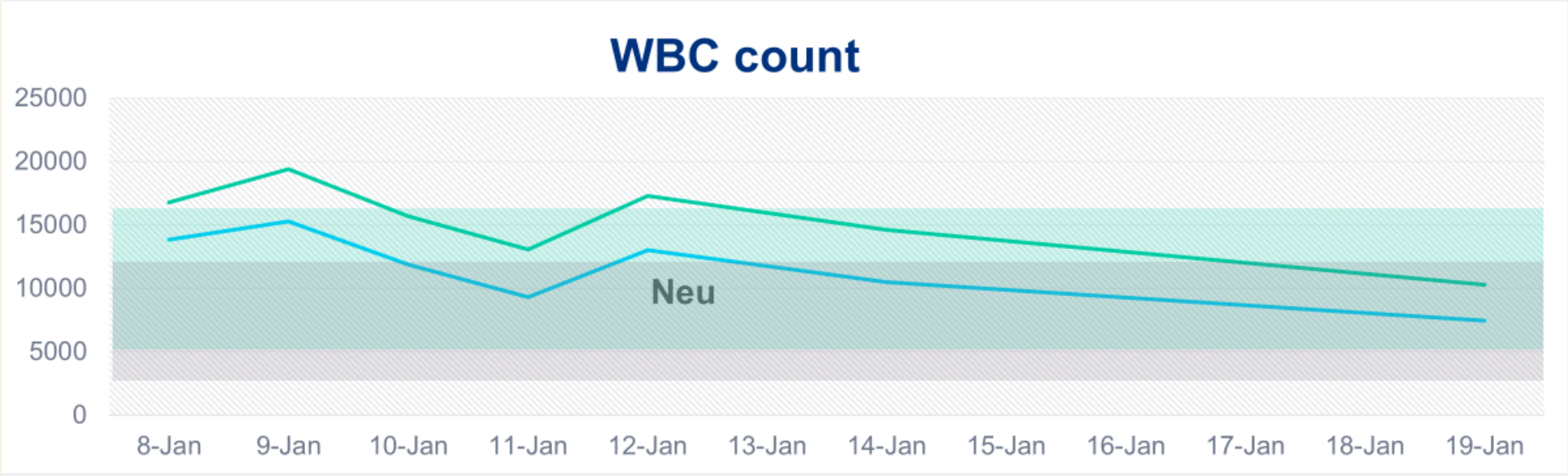
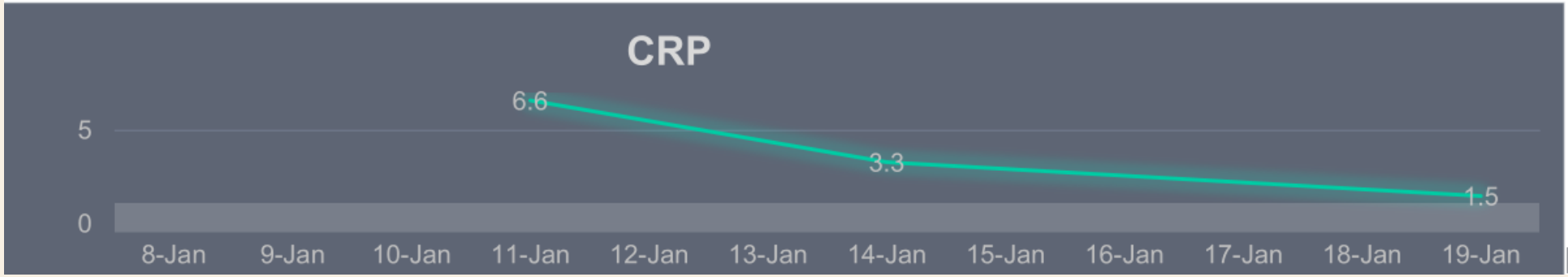


WBC vs Leukogram (dot-plot) vs CRP Trending







LITERATURES IN PANCREATITIS

Table 1. Representative diseases with significantly high plasma CRP levels

Diseases*	(n)	CRP (mg/dl) Median**	Min.	Max.	Number of dogs ≥1 mg/dl (%)	≥10 mg/dl (%)
Pyometra	7	20.0	3.5	>20	7 (100%)	5 (71%)
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Cardiac tamponade	6	1.5	0.7	6.7	3 (50%)	0 (0%)
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* Diseases (n≥5) in which the median of the CRP concentration exceeded the reference range (≥1 mg/dl) were shown.
** CRP values higher than the measurement limit (>20 mg/dl) were statistically analyzed as 20 mg/dl.

Nakamura, M., M.Takahashi, et al. 2008. C-reactive protein concentration in dogs

Table 3. Time-course (days 1 to 5) change of C-reactive protein (CRP) concentration in survivors and nonsurvivors

Days	Median value (range), mg/dl		*P*-value
	Survivors	Nonsurvivors	
Day 1	6.3 (0.5–14.9)	10 (1.0–17.6)	0.3592
Day 2	3.4 (0.9–9.7)	6.7 (1.6–19.9)	0.3081
Day 3	2.55 (0.3–6.3)	6.8 (1.2–18.8)	0.0252[a)]
Day 4	1.6 (0.3–4.7)	6.6 (0.8–14)	0.0438[a)]
Day 5	1.0 (0.3–18.5)	7.55 (0.6–14.3)	0.3948

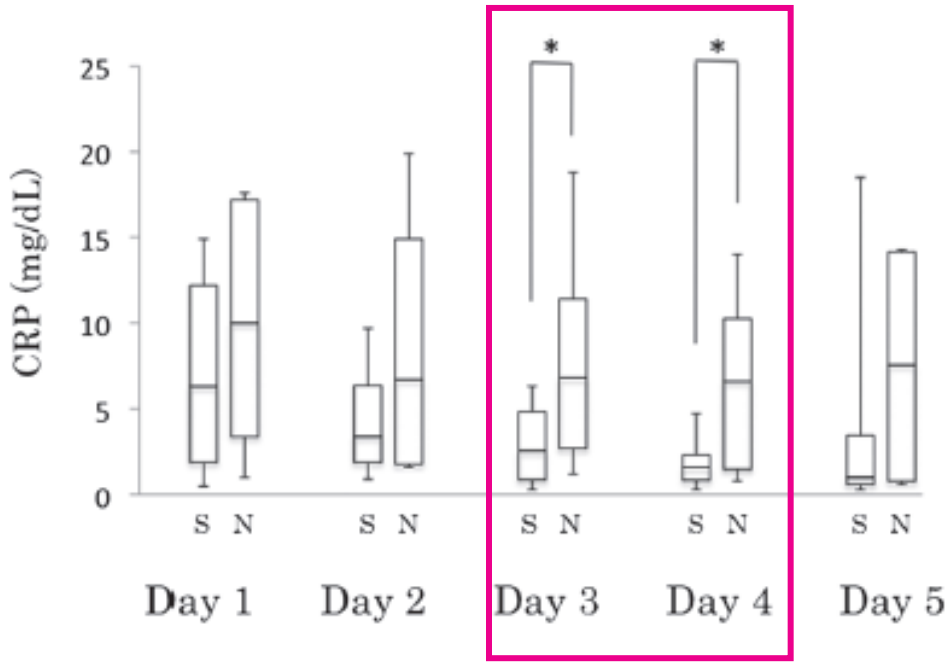
a) $P<0.05$.

Table 4. Differences in the number of survivors and nonsurvivors on days 3 and 4, categorized by C-reactive protein (CRP) concentration (cutoff 6.5 mg/dl)

Days	Groups	No. CRP ≥ 6.5 mg/dl	No. CRP < 6.5 mg/dl	*P*-value
Day 3	Survivors	0	15	0.0048[a)]
	Nonsurvivors	4	3	
Day 4	Survivors	0	15	0.0048[a)]
	Nonsurvivors	4	3	

a) $P<0.05$.

N=22



Sato et al. Assessment of severity and changes in C-reactive protein concentration and various biomarkers in dogs with pancreatitis. J Vet Med Sci 79: 35–40, 2017

“BEAR” – 9 MTHS, F, POMERANIAN

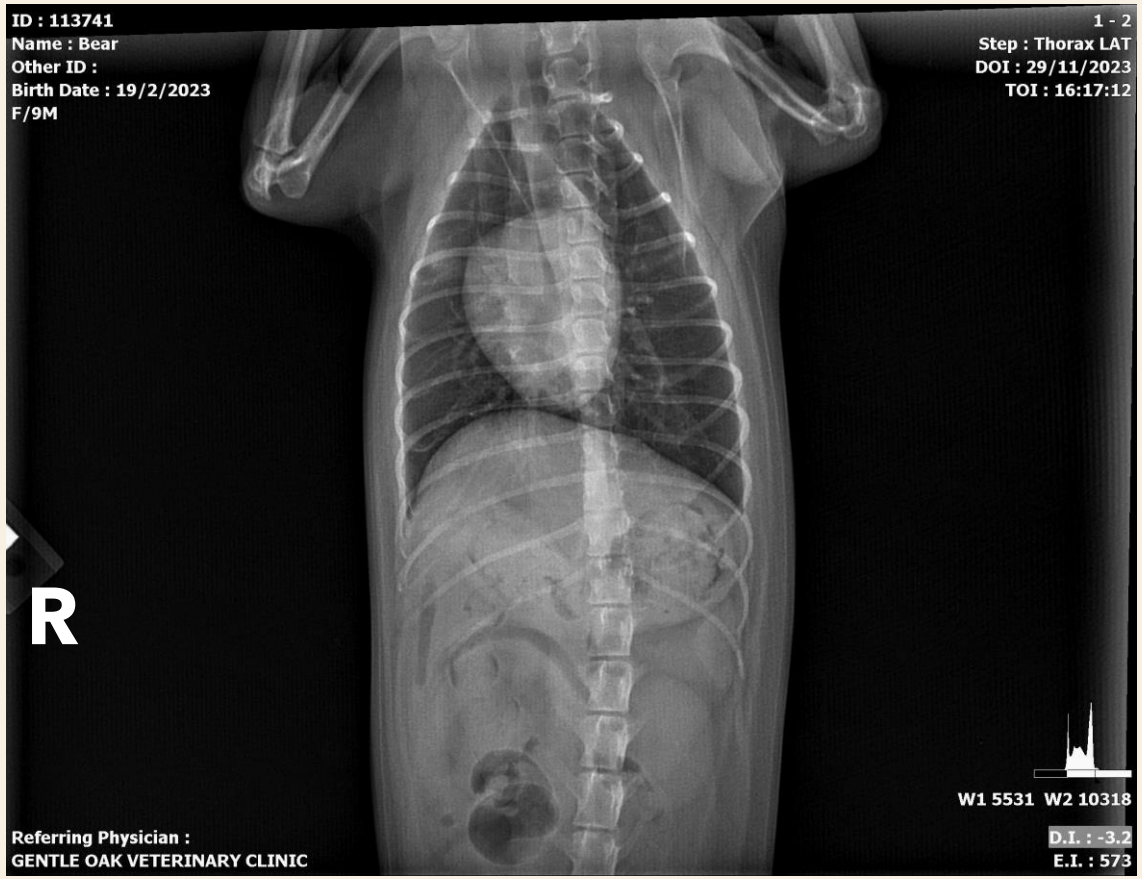
- Presented for severe coughing with slight open-mouthed breathing.
- Was brought to an emergency service but discharged home on natural remedies + mucolytic (bromhexine).
- Still active but slightly more lethargic.
- Appetite - ok
- On PE:
  - Quiet but responsive
  - Mm pink, crt<2sec, temp 39.4°C
  - Harsh lung sounds
  - Productive cough on tracheal palpation

FIRST THOUGHTS?

What would your top differentials be….?

What are your next steps?

CHEST X-RAYS:



Mixed Bronchial and Alveolar pattern

BLOOD WORKS:

IDEXX Services: **ProCyte Dx Hematology Analyzer, Catalyst One Chemistry Analyzer**

Hematology

11/29/23 **4:15 PM**

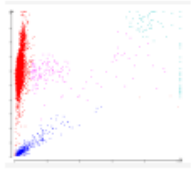
TEST	RESULT	REFERENCE VALUE	
RBC	7.15	5.65 - 8.87 x10^12/L	
Hematocrit	0.461	0.373 - 0.617 L/L	
Hemoglobin	160	131 - 205 g/L	
MCV	64.5	61.6 - 73.5 fL	
MCH	22.4	21.2 - 25.9 pg	
MCHC	347	320 - 379 g/L	
RDW	17.4	13.6 - 21.7 %	
% Reticulocytes	0.7	%	
Reticulocytes	47.9	10.0 - 110.0 K/µL	
Reticulocyte Hemoglobin	24.1	22.3 - 29.6 pg	
WBC	*** 17.49**	**5.05 - 16.76 x10^9/L**	H
% Neutrophils	* 12.6	%	
% Lymphocytes	* 66.8	%	
% Monocytes	* 18.2	%	
% Eosinophils	* 2.4	%	
% Basophils	* 0.0	%	
Neutrophils	*** 2.21**	**2.95 - 11.64 x10^9/L**	L
Bands	* Suspected		
Lymphocytes	*** 11.68**	**1.05 - 5.10 x10^9/L**	H
Monocytes	*** 3.18**	**0.16 - 1.12 x10^9/L**	H
Eosinophils	* 0.42	0.06 - 1.23 x10^9/L	
Basophils	* 0.00	0.00 - 0.10 x10^9/L	
Platelets	*** 142**	**148 - 484 x10^9/L**	L
PDW	* 13.8	9.1 - 19.4 fL	
MPV	*** 14.0**	**8.7 - 13.2 fL**	H

BEAR CHUA PET OWNER: **SHERINE, AI KEE...** DATE OF RESULT: **11/29/23** LAB ID:

Hematology (continued)

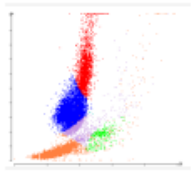
TEST	RESULT	REFERENCE VALUE
Plateletcrit	* 0.20	0.14 - 0.46 %

RBC Run



Download

WBC Run



Download

PLT Aggregates Detected

* Confirm with dot plot and/or blood film review.

Immature and/or toxic neutrophils likely present - Consider inflammation.

Platelet aggregates are detected. Platelet count may be higher than reported.

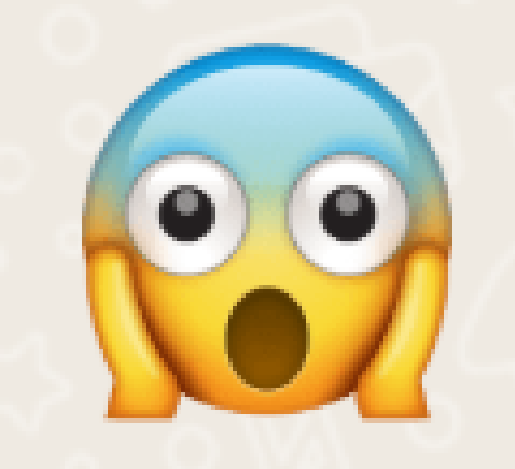
Immunology

11/29/23 **4:41 PM**

TEST		RESULT	REFERENCE VALUE	
C-Reactive Protein (CRP)	b	**218.9**	**0.0 - 10.0 mg/L**	H

b Test results for the latest analyzer run have been multiplied by the dilution factor for a dilution of 1 in 4 total.

C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.



OR

TREATMENT:

- Opted for out patient treatment as dog was clinically stable
- Started on oral antibiotics (Amoxy-Clav @ 15mg/kg BID)
- Enzyme based anti-inflammatory + Western Herbal Formula

IS OUR TREATMENT WORKING?

Review 3 days later:

- Less coughing, but coughs when excited and at night
- Appetite is better

IS OUR TREATMENT WORKING?

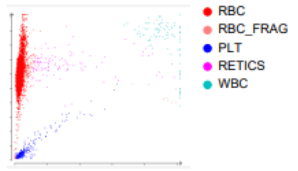
Hematology

TEST	RESULT	REFERENCE VALUE		12/1/23 4:44 PM	11/29/23 4:15 PM
RBC	7.05	5.65 - 8.87 x10^12/L			7.15
Hematocrit	0.455	0.373 - 0.617 L/L			0.461
Hemoglobin	156	131 - 205 g/L			160
MCV	64.5	61.6 - 73.5 fL			64.5
MCH	22.1	21.2 - 25.9 pg			22.4
MCHC	343	320 - 379 g/L			347
RDW	16.9	13.6 - 21.7 %			17.4
% Reticulocytes	0.5	%			0.7
Reticulocytes	36.0	10.0 - 110.0 K/µL			47.9
Reticulocyte Hemoglobin	29.6	22.3 - 29.6 pg			24.1
WBC	* 23.62	5.05 - 16.76 x10^9/L	H		* 17.49
% Neutrophils	* 60.9	%			* 12.6
% Lymphocytes	* 27.6	%			* 66.8
% Monocytes	* 9.5	%			* 18.2
% Eosinophils	* 2.0	%			* 2.4
% Basophils	* 0.0	%			* 0.0
Neutrophils	* 14.39	2.95 - 11.64 x10^9/L	H		* 2.21
Bands	* Suspected				* Suspected
Lymphocytes	* 6.51	1.05 - 5.10 x10^9/L	H		* 11.68
Monocytes	* 2.24	0.16 - 1.12 x10^9/L	H		* 3.18
Eosinophils	* 0.47	0.06 - 1.23 x10^9/L			* 0.42
Basophils	* 0.01	0.00 - 0.10 x10^9/L			* 0.00
Platelets	* 108	148 - 484 x10^9/L	L		* 142
PDW	* 14.4	9.1 - 19.4 fL			* 13.8
MPV	* 14.6	8.7 - 13.2 fL	H		* 14.0

Hematology (continued)

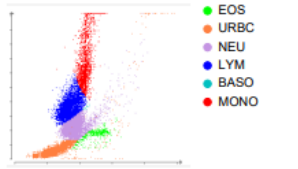
TEST	RESULT	REFERENCE VALUE
Plateletcrit	* 0.16	0.14 - 0.46 %

RBC Run



Download

WBC Run



Download

Immunology

TEST		RESULT	REFERENCE VALUE		12/1/23 4:52 PM	11/29/23 4:41 PM
C-Reactive Protein (CRP)	a	89.5	0.0 - 10.0 mg/L	H		218.9

a C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.

ADDITIONAL TREATMENT:

- Added in Seretide inhaler (Fluticasone + Salmeterol) to regime
- Continue with oral antibiotics

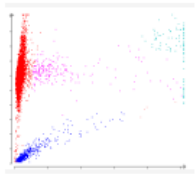
REVIEW 1 WEEK LATER:

Hematology

12/7/23 **2:42 PM**

TEST	RESULT	REFERENCE VALUE	
RBC	7.44	5.65 - 8.87 x10^12/L	
Hematocrit	0.485	0.373 - 0.617 L/L	
Hemoglobin	164	131 - 205 g/L	
MCV	65.2	61.6 - 73.5 fL	
MCH	22.0	21.2 - 25.9 pg	
MCHC	338	320 - 379 g/L	
RDW	18.9	13.6 - 21.7 %	
% Reticulocytes	1.1	%	
Reticulocytes	78.1	10.0 - 110.0 K/µL	
Reticulocyte Hemoglobin	27.3	22.3 - 29.6 pg	
WBC	**26.26**	**5.05 - 16.76 x10^9/L**	H
% Neutrophils	66.8	%	
% Lymphocytes	24.9	%	
% Monocytes	5.8	%	
% Eosinophils	2.4	%	
% Basophils	0.1	%	
Neutrophils	**17.55**	**2.95 - 11.64 x10^9/L**	H
Lymphocytes	**6.53**	**1.05 - 5.10 x10^9/L**	H
Monocytes	**1.53**	**0.16 - 1.12 x10^9/L**	H
Eosinophils	0.62	0.06 - 1.23 x10^9/L	
Basophils	0.03	0.00 - 0.10 x10^9/L	
Platelets	191	148 - 484 x10^9/L	
PDW	17.3	9.1 - 19.4 fL	
MPV	**14.9**	**8.7 - 13.2 fL**	H
Plateletcrit	0.28	0.14 - 0.46 %	

RBC Run



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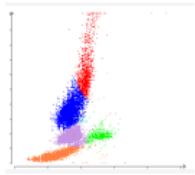
WBC Run



Download

Monocytosis - Consider inflammation (if lymphopenia, consider glucocorticoid response).

Immunology

				12/1/23 4:52 PM	11/29/23 4:41 PM
12/7/23	**2:50 PM**				
TEST	RESULT	REFERENCE VALUE			
C-Reactive Protein (CRP)	[a] **44.1**	**0.0 - 10.0 mg/L**	H	**89.5**	**218.9**

[a] C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.

REVIEW AFTER 2 WEEKS OF ABX :

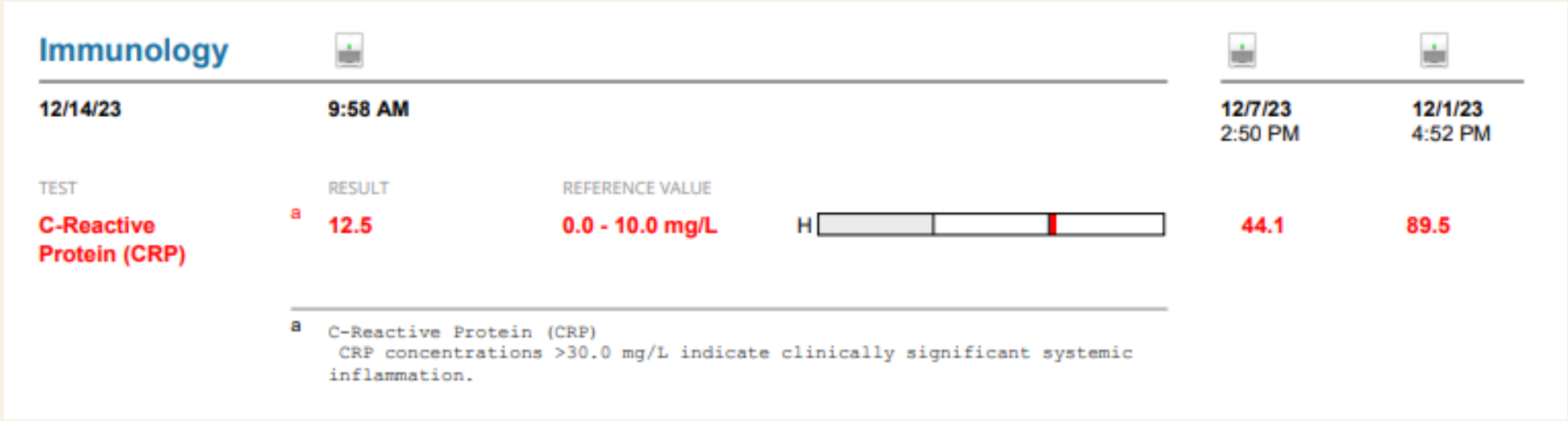
- No more coughing noted at home
- Energy level and appetite back to usual

REVIEW AFTER 2 WEEKS OF ABX :

Hematology

TEST	RESULT	REFERENCE VALUE		12/14/23 9:50 AM	12/7/23 2:42 PM	12/1/23 4:44 PM
RBC	7.74	5.65 - 8.87 x10^12/L			7.44	7.05
Hematocrit	0.512	0.373 - 0.617 L/L			0.485	0.455
Hemoglobin	173	131 - 205 g/L			164	156
MCV	66.1	61.6 - 73.5 fL			65.2	64.5
MCH	22.4	21.2 - 25.9 pg			22.0	22.1
MCHC	338	320 - 379 g/L			338	343
RDW	19.7	13.6 - 21.7 %			18.9	16.9
% Reticulocytes	1.4	%			1.1	0.5
Reticulocytes	108.4	10.0 - 110.0 K/µL			78.1	36.0
Reticulocyte Hemoglobin	27.1	22.3 - 29.6 pg			27.3	29.6
WBC	**24.46**	**5.05 - 16.76 x10^9/L**	H		26.26	* 23.62
% Neutrophils	54.7	%			66.8	* 60.9
% Lymphocytes	36.6	%			24.9	* 27.6
% Monocytes	6.6	%			5.8	* 9.5
% Eosinophils	1.8	%			2.4	* 2.0
% Basophils	0.3	%			0.1	* 0.0
Neutrophils	**13.38**	**2.95 - 11.64 x10^9/L**	H		17.55	* 14.39
Lymphocytes	**8.95**	**1.05 - 5.10 x10^9/L**	H		6.53	* 6.51
Monocytes	**1.62**	**0.16 - 1.12 x10^9/L**	H		1.53	* 2.24
Eosinophils	0.44	0.06 - 1.23 x10^9/L			0.62	* 0.47
Basophils	0.07	0.00 - 0.10 x10^9/L			0.03	* 0.01
Platelets	**606**	**148 - 484 x10^9/L**	H		191	* 108
PDW	12.6	9.1 - 19.4 fL			17.3	* 14.4
MPV	12.2	8.7 - 13.2 fL			14.9	* 14.6
Plateletcrit	**0.74**	**0.14 - 0.46 %**	H		0.28	* 0.16

REVIEW AFTER 2 WEEKS OF ABX :



Immunology

	12/14/23 9:58 AM			12/7/23 2:50 PM	12/1/23 4:52 PM
TEST	RESULT	REFERENCE VALUE			
C-Reactive Protein (CRP)	[a] 12.5	0.0 - 10.0 mg/L	H	44.1	89.5

[a] C-Reactive Protein (CRP)
CRP concentrations >30.0 mg/L indicate clinically significant systemic inflammation.

Assessment:

- marked leucocytosis still present, but much improved CRP and clinical signs
- Decision to continue with inhalers for bronchitis + collapsing trachea

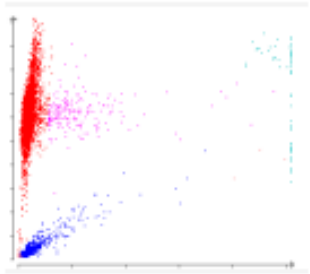
FINAL REVIEW...

Hematology

12/22/23 **3:25 PM**

TEST	RESULT	REFERENCE VALUE	
RBC	7.86	5.65 - 8.87 x10^12/L	
Hematocrit	0.502	0.373 - 0.617 L/L	
Hemoglobin	175	131 - 205 g/L	
MCV	63.9	61.6 - 73.5 fL	
MCH	22.3	21.2 - 25.9 pg	
MCHC	349	320 - 379 g/L	
RDW	19.9	13.6 - 21.7 %	
% Reticulocytes	0.9	%	
Reticulocytes	73.9	10.0 - 110.0 K/µL	
Reticulocyte Hemoglobin	26.5	22.3 - 29.6 pg	
WBC	**19.09**	**5.05 - 16.76 x10^9/L**	H
% Neutrophils	56.1	%	
% Lymphocytes	37.0	%	
% Monocytes	5.1	%	
% Eosinophils	1.7	%	
% Basophils	0.1	%	
Neutrophils	10.70	2.95 - 11.64 x10^9/L	
Lymphocytes	**7.07**	**1.05 - 5.10 x10^9/L**	H
Monocytes	0.98	0.16 - 1.12 x10^9/L	
Eosinophils	0.32	0.06 - 1.23 x10^9/L	
Basophils	0.02	0.00 - 0.10 x10^9/L	
Platelets	369	148 - 484 x10^9/L	
PDW	13.1	9.1 - 19.4 fL	
MPV	**13.5**	**8.7 - 13.2 fL**	H
Plateletcrit	**0.50**	**0.14 - 0.46 %**	H

RBC Run



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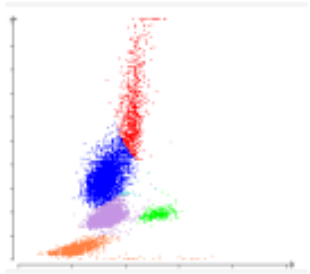
WBC Run



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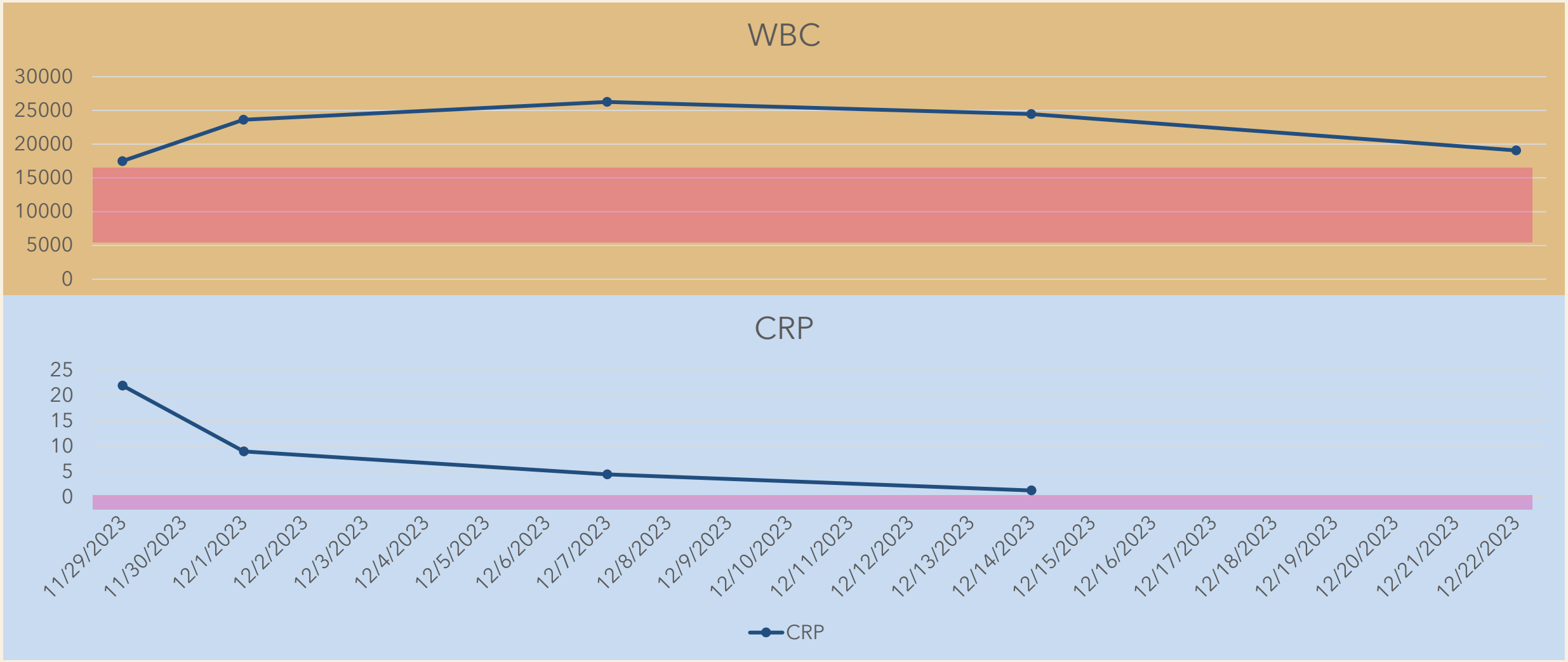
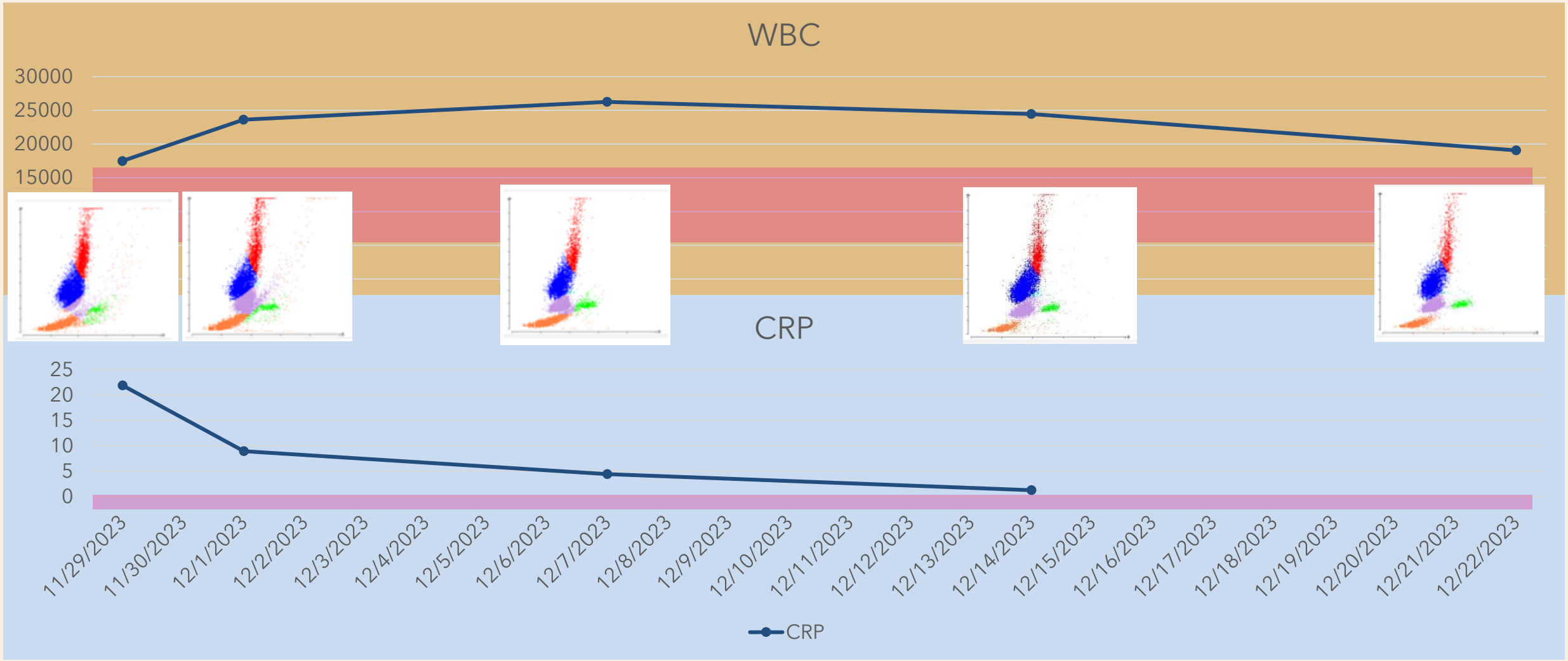
LET'S LOOK AT THE DOT-PLOTS!

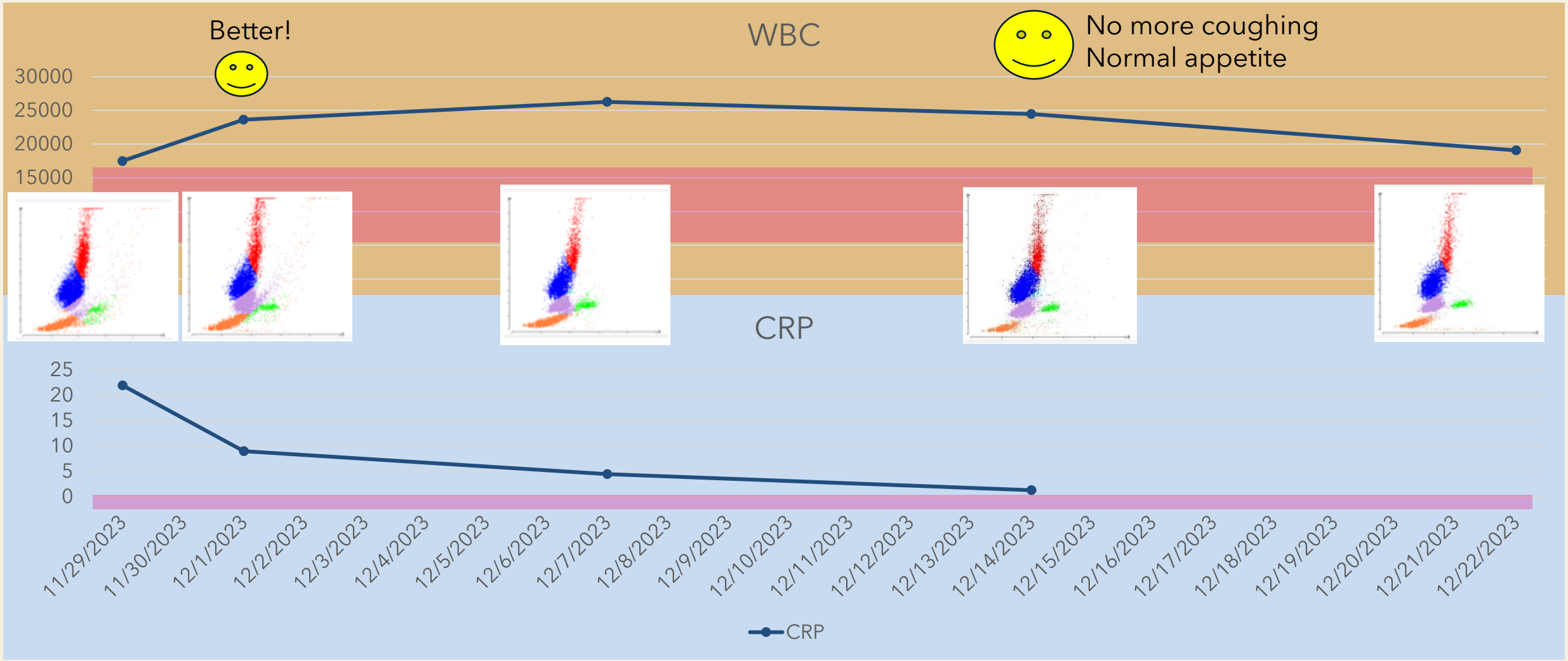


LET'S LOOK AT THE DOT-PLOTS!



Amoxy-Clav + Anti-inflammatory

Seretide inhaler



Hematology

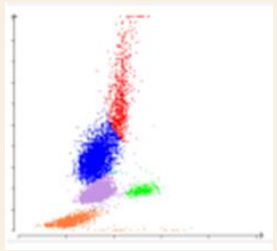
12/22/23 **3:25 PM**

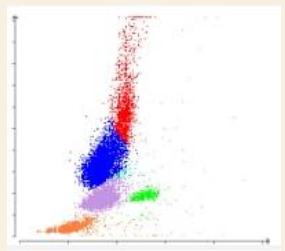
TEST	RESULT
RBC	7.86
Hematocrit	0.502
Hemoglobin	175
MCV	63.9
MCH	22.3
MCHC	349
RDW	19.9
% Reticulocytes	0.9
Reticulocytes	73.9
Reticulocyte Hemoglobin	26.5
WBC	**19.09**
% Neutrophils	56.1
% Lymphocytes	37.0
% Monocytes	5.1
% Eosinophils	1.7
% Basophils	0.1
Neutrophils	10.70
Lymphocytes	**7.07**
Monocytes	0.98
Eosinophils	0.32
Basophils	0.02
Platelets	369
PDW	13.1
MPV	**13.5**
Plateletcrit	**0.50**

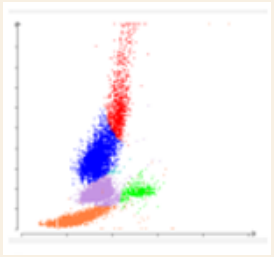
Hematology

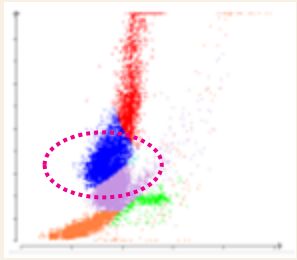
12/14/23 **9:50 AM**

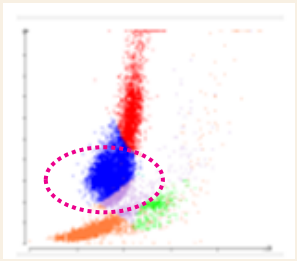
TEST	RESULT	REFERENCE VALUE		12/7/23 2:42 PM	12/1/23 4:44 PM	11/29/23 4:15 PM
RBC	7.74	5.65 - 8.87 x10^12/L		7.44	7.05	7.15
Hematocrit	0.512	0.373 - 0.617 L/L		0.485	0.455	0.461
Hemoglobin	173	131 - 205 g/L		164	156	160
MCV	66.1	61.6 - 73.5 fL		65.2	64.5	64.5
MCH	22.4	21.2 - 25.9 pg		22.0	22.1	22.4
MCHC	338	320 - 379 g/L		338	343	347
RDW	19.7	13.6 - 21.7 %		18.9	16.9	17.4
% Reticulocytes	1.4	%		1.1	0.5	0.7
Reticulocytes	108.4	10.0 - 110.0 K/µL		78.1	36.0	47.9
Reticulocyte Hemoglobin	27.1	22.3 - 29.6 pg		27.3	29.6	24.1
WBC	**24.46**	**5.05 - 16.76 x10^9/L**	H	**26.26**	* **23.62**	* **17.49**
% Neutrophils	54.7	%		66.8	* 60.9	* 12.6
% Lymphocytes	36.6	%		24.9	* 27.6	* 66.8
% Monocytes	6.6	%		5.8	* 9.5	* 18.2
% Eosinophils	1.8	%		2.4	* 2.0	* 2.4
% Basophils	0.3	%		0.1	* 0.0	* 0.0
Neutrophils	**13.38**	**2.95 - 11.64 x10^9/L**	H	**17.55**	* **14.39**	* **2.21**
Lymphocytes	**8.95**	**1.05 - 5.10 x10^9/L**	H	**6.53**	* **6.51**	* Suspected
Monocytes	**1.62**	**0.16 - 1.12 x10^9/L**	H	**1.53**	* **2.24**	* **11.68**
Eosinophils	0.44	0.06 - 1.23 x10^9/L		0.62	* 0.47	* **3.18**
Basophils	0.07	0.00 - 0.10 x10^9/L		0.03	* 0.01	* 0.42
Platelets	**606**	**148 - 484 x10^9/L**	H	191	* **108**	* 0.00
PDW	12.6	9.1 - 19.4 fL		17.3	* 14.4	* **142**
MPV	12.2	8.7 - 13.2 fL		**14.9**	* **14.6**	* 13.8
Plateletcrit	**0.74**	**0.14 - 0.46 %**	H	0.28	* 0.16	* **14.0**



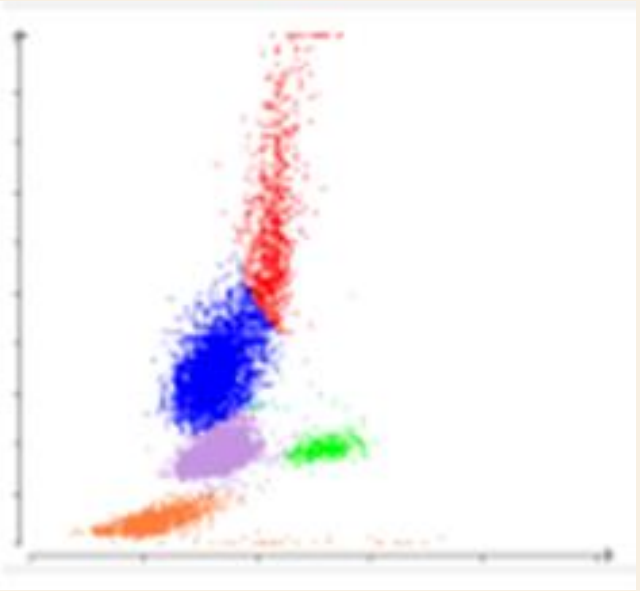


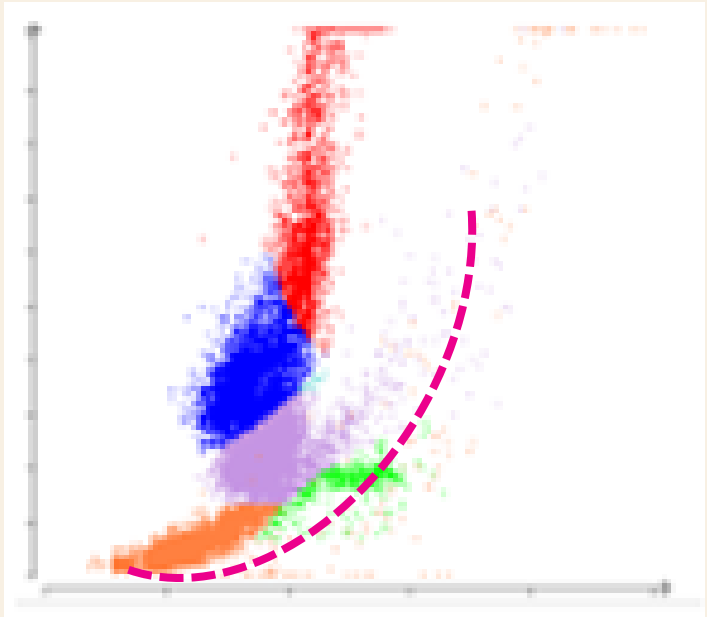


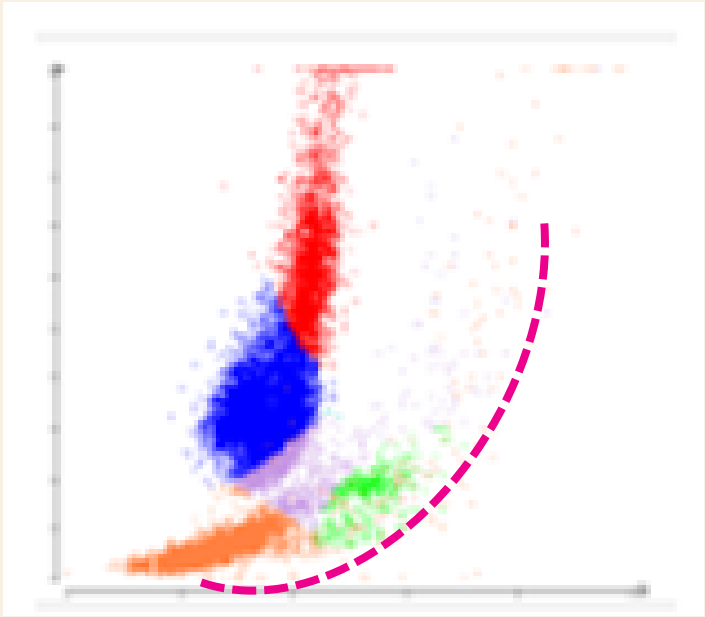




DID YOU SEE WHAT HAPPEN WITH PLT?





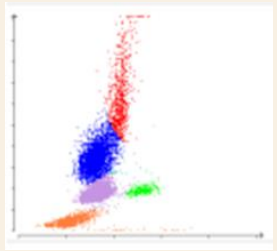
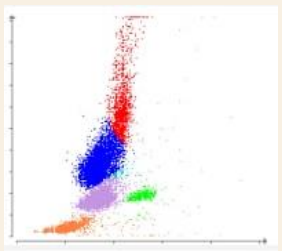
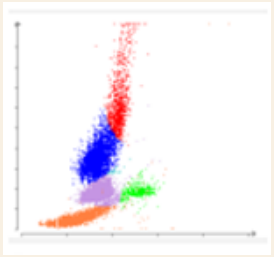
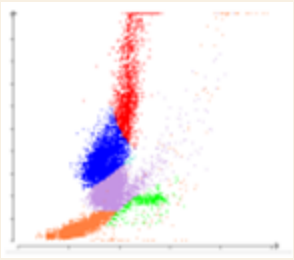
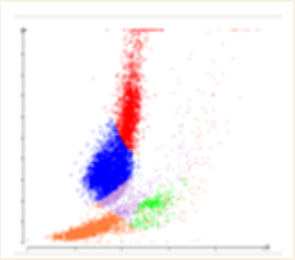


Hematology

TEST	RESULT
	12/22/23 3:25 PM
RBC	7.86
Hematocrit	0.502
Hemoglobin	175
MCV	63.9
MCH	22.3
MCHC	349
RDW	19.9
% Reticulocytes	0.9
Reticulocytes	73.9
Reticulocyte Hemoglobin	26.5
WBC	**19.09**
% Neutrophils	56.1
% Lymphocytes	37.0
% Monocytes	5.1
% Eosinophils	1.7
% Basophils	0.1
Neutrophils	10.70
Lymphocytes	**7.07**
Monocytes	0.98
Eosinophils	0.32
Basophils	0.02
Platelets	369
PDW	13.1
MPV	**13.5**
Plateletcrit	**0.50**

Hematology

TEST	12/14/23 9:50 AM RESULT	REFERENCE VALUE		12/7/23 2:42 PM	12/1/23 4:44 PM	11/29/23 4:15 PM
RBC	7.74	5.65 - 8.87 x10^12/L		7.44	7.05	7.15
Hematocrit	0.512	0.373 - 0.617 L/L		0.485	0.455	0.461
Hemoglobin	173	131 - 205 g/L		164	156	160
MCV	66.1	61.6 - 73.5 fL		65.2	64.5	64.5
MCH	22.4	21.2 - 25.9 pg		22.0	22.1	22.4
MCHC	338	320 - 379 g/L		338	343	347
RDW	19.7	13.6 - 21.7 %		18.9	16.9	17.4
% Reticulocytes	1.4	%		1.1	0.5	0.7
Reticulocytes	108.4	10.0 - 110.0 K/µL		78.1	36.0	47.9
Reticulocyte Hemoglobin	27.1	22.3 - 29.6 pg		27.3	29.6	24.1
WBC	**24.46**	**5.05 - 16.76 x10^9/L**	H	**26.26**	*** 23.62**	*** 17.49**
% Neutrophils	54.7	%		66.8	* 60.9	* 12.6
% Lymphocytes	36.6	%		24.9	* 27.6	* 66.8
% Monocytes	6.6	%		5.8	* 9.5	* 18.2
% Eosinophils	1.8	%		2.4	* 2.0	* 2.4
% Basophils	0.3	%		0.1	* 0.0	* 0.0
Neutrophils	**13.38**	**2.95 - 11.64 x10^9/L**	H	**17.55**	*** 14.39**	*** 2.21**
Lymphocytes	**8.95**	**1.05 - 5.10 x10^9/L**	H	**6.53**	*** 6.51**	* Suspected
Monocytes	**1.62**	**0.16 - 1.12 x10^9/L**	H	**1.53**	*** 2.24**	*** 11.68**
Eosinophils	0.44	0.06 - 1.23 x10^9/L		0.62	* 0.47	*** 3.18**
Basophils	0.07	0.00 - 0.10 x10^9/L		0.03	* 0.01	* 0.42
Platelets	**606**	**148 - 484 x10^9/L**	H	191	*** 108**	*** 142**
PDW	12.6	9.1 - 19.4 fL		17.3	* 14.4	* 13.8
MPV	12.2	8.7 - 13.2 fL		**14.9**	*** 14.6**	*** 14.0**
Plateletcrit	**0.74**	**0.14 - 0.46 %**	H	0.28	* 0.16	

LITERATURE ON CRP IN PNEUMONIA

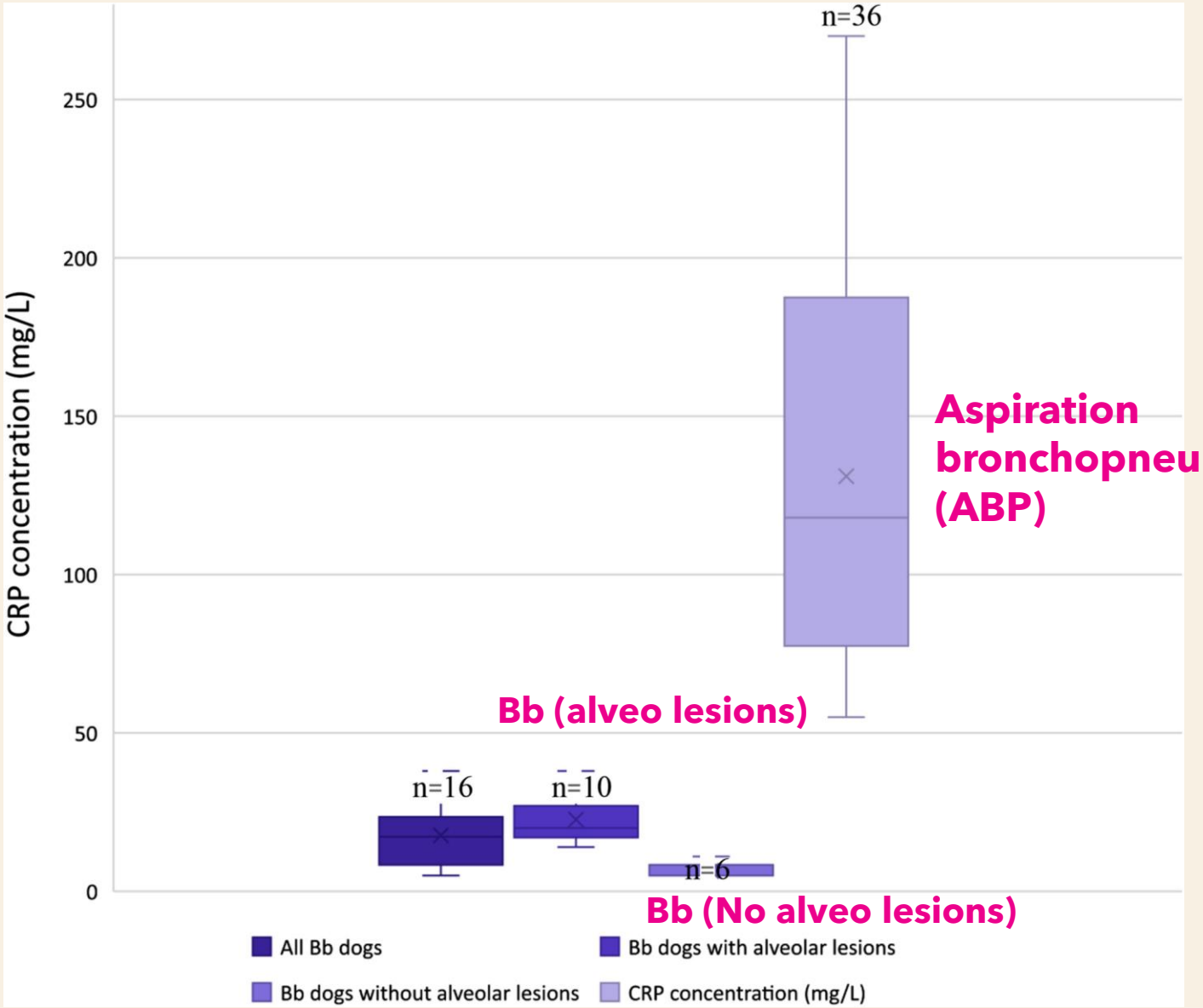
Table 1. Representative diseases with significantly high plasma CRP levels

Diseases*	(n)	CRP (mg/dl) Median**	Min.	Max.	Number of dogs ≥1 mg/dl (%)	≥10 mg/dl (%)
Pyometra	7	20.0	3.5	>20	7 (100%)	5 (71%)
Sterile nodular panniculitis	7	20.0	10.0	>20	7 (100%)	5 (100%)
Acute pancreatitis	5	15.0	6.1	>20	5 (100%)	3 (60%)
Idiopathic polyarthritis	31	13.0	1.7	>20	31 (100%)	21 (67%)
Hemangiosarcoma	5	7.6	3.1	16	5 (100%)	2 (40%)
Nasal adenocarcinoma	5	6.7	0.1	9	4 (80%)	0 (0%)
Immune-mediated hemolytic anemia	35	6.5	0	>20	30 (86%)	9 (26%)
Cholangiocellular carcinoma	7	6.3	0.1	19	6 (86%)	2 (29%)
Acute lymphoblastic leukemia	6	4.5	0.1	>20	5 (83%)	1 (17%)
Malignant histiocytosis	16	4.3	0.3	>20	11 (69%)	4 (25%)
Lymphoma	127	3.5	0	>20	91 (72%)	26 (21%)
Bronchopneumonia/Pneumonia	16	3.3	0.2	11	12 (75%)	1 (6%)
Malignant mesothelioma	7	2.7	0.7	15	5 (71%)	1 (14%)
Demodicosis	7	2.6	0	7.1	5 (71%)	0 (0%)
Chronic hepatitis	7	1.6	0	9.7	4 (57%)	0 (0%)
Cardiac tamponade	6	1.5	0.7	6.7	3 (50%)	0 (0%)
Myelodysplastic syndrome	5	1.3	0	14	3 (60%)	1 (20%)
Intestinal adenocarcinoma	13	1.0	0	14	8 (62%)	3 (23%)
Immune-mediated thrombocytopenia	7	1.0	0	12	4 (57%)	1 (14%)

* Diseases (n≥5) in which the median of the CRP concentration exceeded the reference range (≥1 mg/dl) were shown.
** CRP values higher than the measurement limit (>20 mg/dl) were statistically analyzed as 20 mg/dl.

Nakamura, M., M.Takahashi, et al. 2008. C-reactive protein concentration in dogs

*Bordetella bronchiseptica (Bb) i*nfection in dogs



Canonne AM, Menard M, Maurey C, Benchrekroun G, Fernandes Rodrigues N, Billen F, Clercx C. Comparison of C-reactive protein concentrations in dogs with Bordetella bronchiseptica infection and aspiration bronchopneumonia. J Vet Intern Med. 2021 May;35(3):1519-1524. doi: 10.1111/jvim.16091. Epub 2021 Mar 12. PMID: 33709444; PMCID: PMC8163113.

HOW WAS CRP HELPFUL?

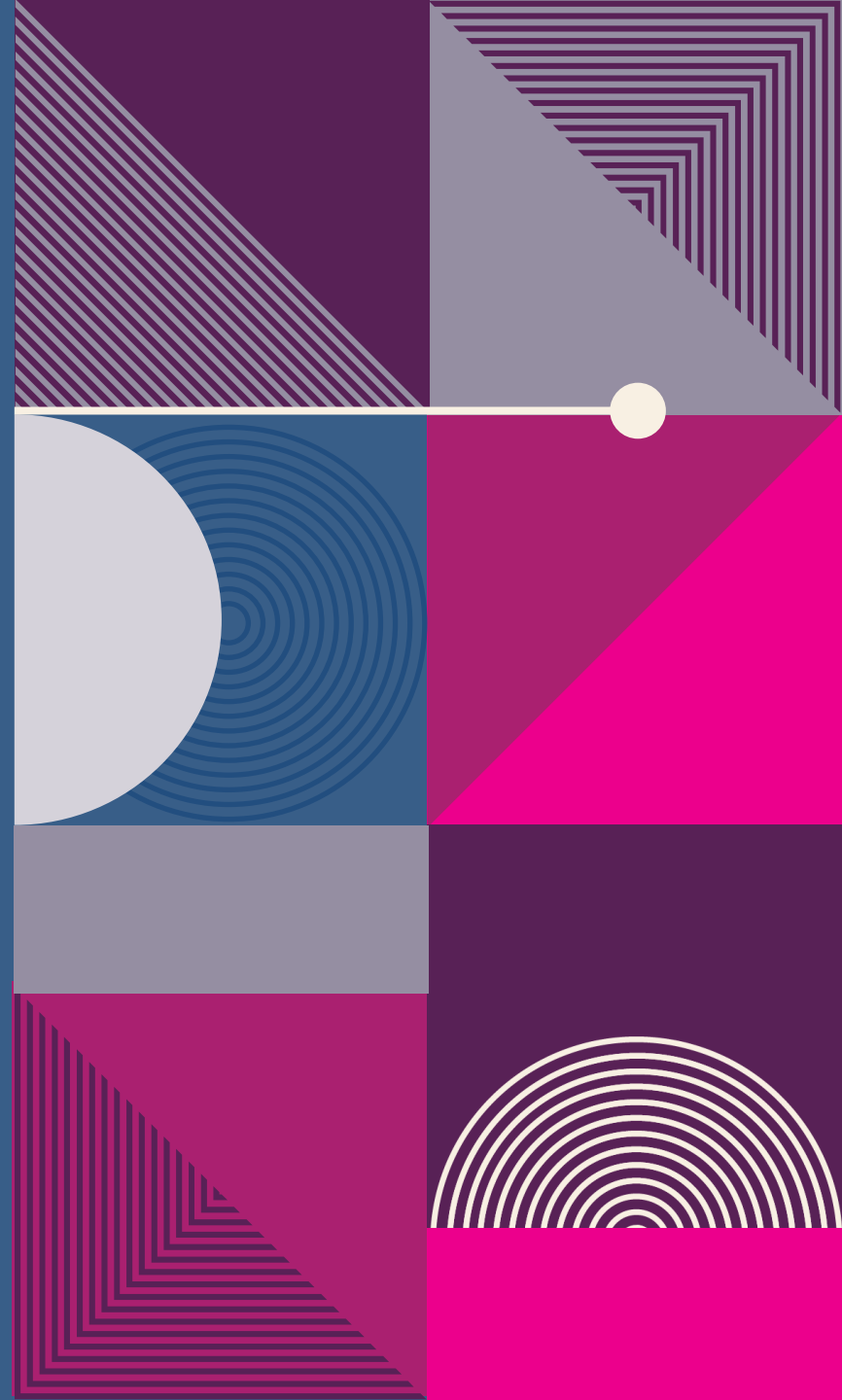
- Indicated that significant systemic inflammation was present
- Allowed deeper investigation for an underlying cause, resulting in immediate and proper treatment
- Excellent monitoring tool to ensure treatment approach is on track.

TAKE HOME MESSAGE

1. Highly **SENSITIVE** and **SPECIFIC** for systemic inflammation

2. Use to quantify the **SEVERITY** of systemic inflammation

3. Use to **MONITOR** treatment efficacy



Yeelin.lee@gentleoakvet.com.sg

@DrLeeYL