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An en-lyte-ening guide to electrolyte interpretation Elizabeth Schooley, DVM, MS, DACVIM (SAIM)



Conflict of Interest Disclosure:

I have financial interest, arrangement or affiliation with:

Name of Organization Relationship

IDEXX Employee, own stock



Learning Objectives

- Recall the importance of electrolytes as part of a complete chemistry panel
- Interpret electrolytes through case examples
- Establish primary diagnostic tools for confirmation of disease
- Design appropriate management strategies



Why are electrolytes important?



- Electrolytes are minerals found blood and other body fluids
- Essential for:
- Function of most body systems
- Maintaining hydration
- Maintaining acid/base balance
- Electrolyte imbalance is often an indicator of a disease process



Electrolytes in biochemical profile? YES!

- Normal values essential for health
- Abnormal = poor outcome
 - More abnormal = worse outcome
- Dehydration, GI, renal, endocrine disease
- Aid in diagnosis
- Important monitoring tool
- Can be abnormal in nonclinical pets



Electrolyte Concentration

Goggs, Robert, Sage De Rosa, and Daniel J. Fletcher. "electrolyte Disturbances are associated with non-survival in Dogs—a Multivariable analysis." Frontiers in veterinary science 4 (2017): 135.

Goggs R, De Rosa S, Fletcher DJ. Multivariable analysis of the association between electrolyte disturbances and mortality in cats. J Feline Med Surg. 2018 Dec;20(12):1072-1081.



Prevalence of electrolyte abnormalities in pets

Wellness Testing¹

All Cause Testing²



Source:

 Data based on analyses of 167,993 canine welfness profiles (a complete chemistry profile [including the IDEX SDMA⁺Test tark); IDEXC GC⁺, uninalysis, and 54,211 felne welfness profiles (a complete chemistry profile [including the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the including the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis, and al⁺, p 2 years and a set of the IDEX SDMA⁺ Test and electrolysis]. IDEXC GC⁺, uninalysis]. IDEXC GC⁺, uninalysis

2025 VETERINARY MEETING & EXPO

2. Data based on analyses of A1283 calmie in-base profiles (a complete chemistry profile (including the IDEXXSMA*Test and eterorytes), IDEXXCBC*, utinalysis) and 45,864 Heline inhouse profiles (a complete chemistry profile [including the IDEXXSDMA*Test and electrolytes], IDEXXCBC*, utinalysis, total T₁ (≥ 7 years of age)); testing performed at on IDEXX VetLab analyses in Mohr Menrica on January 1, 2021–June 1, 2022. Data on the at IDEX Laboratories, INC VetExCb. (Nestbrock, Mane USA.



WHEN to obtain electrolytes?

- Baseline in healthy patients
- Preanesthetic evaluation
- Every sick patient
- *Every* animal on fluid therapy
- Monitoring

How often?









The big three



Sampling considerations

Electrolytes change quickly in vitro

Sensitive to **hemolysis**

Sample **quality** critical!

Do not sample from IV catheter after fluids

Do not use EDTA plasma

Do not freeze



Sources:

- Wenneke, Gitte. " Useful tips to avoid preanalytical errors in blood gas testing: electrolytes" Oct 2003. Accessed 20 Jul 2021 <u>https://acutecaretesting.org/en/articles/useful-tips-to-avoid-preanalytical-errors-in-blood-gas-testingelectrolytes</u>
- Baruah A, Goyal P, Sinha S, Ramesh KL, Datta R. Delay in specimen processing-major source of preanalytical variation in serum electrolytes. J Clin Diagn Res. 2014;8(12):CC01-CC3. doi:10.7860/JCDR/2014/10150.5285



Potassium



Meet Whitney

- 2-year-old, FS, Labrador
- History
 - Waxing and waning history of lethargy
 - Polyphagic
 - Polydipsic



Physical exam



QUIET, ALERT, RESPONSIVE 10%+ DEHYDRATED T – 100.4^oF, P – 84 BPM, R – 16 BPM

Hematology

TEST	RESULT
RBC	9_44
Hematocrit	59.2
Hemoglobin	21.7
MCV	62.7
МСН	23.0
MCHC	36.7
RDW	19.2
% Reticulocytes	0.3
Reticulocytes	31,2
Reticulocyte Hemoglobin	20,9
WBC	9.14
% Neutrophils	46.5
% Lymphocytes	36.4
% Monocytes	5.0
% Eosinophils	11.4
% Basophils	0.7
Neutrophils	4.25
Lymphocytes	3.33
Monocytes	0.46
Eosinophils	1.04
Basophils	0.06
Platelets	* 228
PDW	,
MPV	15,8
Plateletcrit	0.36

REFERENCE VALUE	
5.65 - 8.87 M/µL	н
37.3 - 61.7 %	
13.1 - 20.5 g/dL	H
61.6 - 73.5 fL	
21.2 - 25.9 pg	
32.0 - 37.9 g/dL	
13.6 - 21.7 %	
%	
10.0 – 110.0 K/µL	
22.3 - 29.6 pg	L
5.05 – 16.76 K/µL %	
%	
%	
%	
%	
2.95 - 11.64 K/µ∟	
1.05 – 5.10 K/µL	
0.16 - 1.12 K/µL	
0.06 - 1.23 K/µL	
0.00 - 0.10 K/µL	
148 - 484 K/µL	
9,1 - 19,4 fL	
8.7 - 13.2 fL	H
0.14 - 0.46 %	

Chemistry

Electrolytes



144 - 160 mmol/L	L
3.5 - 5.8 mmol/L	н
109 - 122 mmol/L	L L L L L L L L L L L L L L L L L L L



Na:K ratio in Addison's disease





ACTH Stimulation Test

Endocrinology	3/5/24 3:15 AM	
Cortisol - Pre ACTH	<0.2	µg/dL
Cortisol - Post ACTH	<0.2	µg/dL
Cortisol - Post ACTH #2	a <0.2	µg/dL

Addison's Disease



Treatment





Serial electrolytes

Chemistry <	4/19/24 10:02 AM	3/25/24 4:12 PM	3/25/24 9:56 AM	3/25/24 9:17 AM	3/5/24 9:07 AM	2/29/24 8:56 AM	2/26/24 8:44 AM
🛤 🖴 Sodium	152	154	161	167	133	139	142
🛤 🖴 Potassium	3.9	4.5	8.4	8.4	5.9	6.6	5.7
Na: K Ratio	39	34	19	20	22	21	25
🛤 🖴 Chloride	116	113	107	104	97	106	101











Meet Zephyr

- 14-year-old, male neutered poodle
- History
 - 2 Lbs. weight loss over last 6 months
 - PU/PD
 - Polyphagic



Physical exam



QUIET, ALERT, RESPONSIVE

10% DEHYDRATED

TPR - NORMAL



Hematology

₽

3/26/24 (Order Received) 3/27/24 5:12 AM (Last Updated)

TEST		RESULT	REFERENCE VALUE	
RBC		5.51	5.39 - 8.70 M/µL	
Hematocrit		39.2	38.3 - 56.5 %	
Hemoglobin		12.7	13.4 - 20.7 g/dL	L
MCV		71	59 - 76 fL	
MCH		23.0	21.9 - 26.1 pg	
MCHC		32.4	32.6 - 39.2 g/dL	L
% Reticulocytes		1.1	%	
Reticulocytes		61	10 - 110 K/µL	
Reticulocyte Hemoglobin		25.4	24.5 - 31.8 pg	
WBC		10.1	4.9 - 17.6 K/µL	
% Neutrophils		64.4	%	
% Lymphocytes		19.4	%	
% Monocytes		12.5	%	
% Eosinophils		3.6	%	
% Basophils		0.1	%	
Neutrophils		6.504	2.94 - 12.67 K/µL	
Lymphocytes		1.959	1.06 - 4.95 K/µL	
Monocytes		1.263	0.13 - 1.15 K/µL	H
Eosinophils		0.364	0.07 - 1.49 K/µL	
Basophils	a	0.01	0 - 0.1 K/µL	
Platelets		712	143 - 448 K/µL	н

Chemistry

3/26/24 (Order Received) 3/27/24 5:12 AM (Last Updated)

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TEST	RESULT	REFERENCE VALUE	
Glucose a	484	63 - 114 mg/dL	н
IDEXX SDMA b	10	0 - 14 µg/dL	
Creatinine	0.8	0.5 - 1.5 mg/dL	
BUN	26	9 - 31 mg/dL	
BUN: Creatinine Ratio	32.5		
Phosphorus	5.1	2.5 - 6.1 mg/dL	
Calcium	8.6	8.4 - 11.8 mg/dL	
Sodium	140	142 - 152 mmol/L	L
Potassium	6.5	4.0 - 5.4 mmol/L	н
Na: K Ratio	22	28 - 37	L
Chloride	104	108 - 119 mmol/L	L
TCO2 (Bicarbonate)	16	13 - 27 mmol/L	
Anion Gap	27	11 - 26 mmol/L	н
Total Protein	6.0	5.5 - 7.5 g/dL	
Albumin	3.2	2.7 - 3.9 g/dL	
Globulin	2.8	2.4 - 4.0 g/dL	
Albumin: Globulin Ratio	1.1	0.7 - 1.5	
ALT	187	18 - 121 U/L	н
AST	62	16 - 55 U/L	н
ALP	678	5 - 160 U/L	н
GGT	9	0 - 13 U/L	
Bilirubin - Total	0.1	0.0 - 0.3 mg/dL	



Sodium	140
Potassium	6.5
Na: K Ratio	22
Chloride	104
TCO2 (Bicarbonate)	16
Anion Gap	27

142 - 152 mmol/L 4.0 - 5.4 mmol/L 28 - 37 108 - 119 mmol/L 13 - 27 mmol/L

11 - 26 mmol/L









Cations = Anions



DiBartola, Stephan. *Fluid, Electrolyte and Acid-Base Disorders in Small Animal Practice*. 3rd ed. Saunders Elsevier; 2006.



Urinalysis

3/26/24 (Order Received) 3/27/24 5:12 AM (Last Updated)

IEI		RESULT	REFERENCE VALUE
Collection		CATHETERIZED	
Color		Yellow	
Clarity		CLOUDY	
Specific Gravity		1.044	>= 1.030
рН		5.5	6.0 - 7.5
Urine Protein		1+	
Glucose	a	3+ (1000 mg/dL)	
Ketones	b	3+	
Blood / Hemoglobin		NEGATIVE	
Blood / Hemoglobin Bilirubin		NEGATIVE NEGATIVE	_
Blood / Hemoglobin Bilirubin Urobilinogen		NEGATIVE NEGATIVE NORMAL	_
Blood / Hemoglobin Bilirubin Urobilinogen White Blood Cells		NEGATIVE NEGATIVE NORMAL 0-2	HPF
Blood / Hemoglobin Bilirubin Urobilinogen White Blood Cells Red Blood Cells		NEGATIVE NEGATIVE NORMAL 0-2 0-2	HPF HPF

L

Treatment







Chloride



Meet Luna

- 9-week-old, Fl Chihuahua
- History
 - Picked up from breeder 4 days ago
 - Vomiting
 - Not eating well for 1 day
 - Lethargic



Physical exam



DULL, ALERT, RESPONSIVE

10% DEHYDRATED

TPR - NORMAL



Hematology

Hematology	. A		
1/30/24	7:45 PM		
TEST	RESULT	REFERENCE VALUE	
RBC	6.39	5.65 – 8.87 M/µL	
Hematocrit	40.6	37.3 - 61.7 %	
Hemoglobin	13,6	13,1 - 20,5 g/dL	
MCV	63.5	61.6 - 73.5 fL	
MCH	21,3	21,2 - 25,9 pg	
MCHC	33.5	32.0 - 37.9 g/dL	
RDW	18.0	13.6 - 21.7 %	
% Reticulocytes	1,2	%	
Reticulocytes	75.4	10.0 – 110.0 K/µL	
Reticulocyte Hemoglobin	24.2	22.3 – 29.6 pg	
WBC	10.73	5.05 - 16.76 K/µL	
% Neutrophils	* 70,0	%	
% Lymphocytes	14.2	%	
% Monocytes	7.1	%	
% Eosinophils	* 8,5	%	
% Basophils	0.2	%	
Neutrophils	*7,52	2,95 - 11,64 K/µL	
Lymphocytes	1,52	1,05 – 5,10 K/µL	
Monocytes	0.76	0.16 – 1.12 K/µL	
Eosinophils	* 0,91	0.06 - 1.23 K/µL	
Basophils	0,02	0,00 – 0,10 K/µL	
Platelets	467	148 - 484 K/µL	
PDW	14,7	9,1 - 19,4 fL	
MPV	13.0	8.7 – 13.2 fL	
Plateletcrit	0.61	0.14 - 0.46 %	H

Chemistry

Chemistry			
1/30/24	7:54 PM		
TEST	RESULT	REFERENCE VALUE	
Glucose	418	77 - 150 mg/dL	Н
Creatinine	0.6	0.3 – 1.2 mg/dL	
BUN	69	7 - 29 mg/dL	Н
BUN: Creatinine Ratio	116		
Phosphorus	6.6	5.1 – 10.4 mg/dL	
Calcium	8,0	7,8 - 12,6 mg/dL	
Sodium	157	144 - 160 mmol/L	
Potassium	4,6	3,5 - 5,8 mmol/L	
Chloride	108	109 - 122 mmol/L	
Total Protein	5,7	4,8 – 7,2 g/dL	
Albumin	3.9	2.1 – 3.6 g/dL	Н
Globulin	1.9	2.3 - 3.8 g/dL	L
ALT	62	8 – 75 U/L	
ALP	167	46 - 337 U/L	
GGT	3	0 - 2 U/L	H
Bilirubin – Total	0.5	0.0 – 0.8 mg/dL	



💷 🐪 Sodium	157	144 - 160 mmol/L	
💷 🐪 Potassium	4,6	3,5 - 5,8 mmol/L	
👥 🌭 Chloride	108	109 - 122 mmol/L	



Urinalysis

Urinalysis	Ì	
1/30/24	10:27 PM	
TEST	RESULT	REFERENCE VALUE
Collection	Table top	
Color	Pale Yellow	
Clarity	Very Cloudy	
Specific Gravity	1,038	
рН	6.0	
Urine Protein	TR	
Glucose	1,000	mg/dL
Ketones	15	mg/dL
Blood / Hemoglobin	250	Ery/µL
Bilirubin	neg	
Urobilinogen	norm	
Leukocyte Esterase	neg	



Treatment









What does it mean if sodium and chloride are <u>not</u> moving **together**?

💷 ∿ Sodium	157	144 - 160 mmol/L	
💷 🖴 Potassium	4,6	3,5 - 5,8 mmol/L	
🛤 🜭 Chloride	108	109 - 122 mmol/L	

📫 ∿ Sodium	167	150 - 165 mmol/L	
💷 🌭 Potassium	4,1	3,5 - 5,8 mmol/L	
🛄 🌭 Chloride	122	112 - 129 mmol/L	
	450		
Sodium	152	144 - 160 mmol/L	
💷 🎋 Potassium	3,9	3,5 - 5,8 mmol/L	
🛄 Na: K Ratio	39		
📫 🐪 Chloride	121	109 - 122 mmol/L	

Chloride concentration is affected by acid-base disturbances, *but sodium concentration is* <u>not</u> affected by acid-base status



Hypochloremia: due to hydration or acid-base abnormality?

- Na 144-119 = 25 below normal
- Cl 109-69 = 40 below normal
- Hypochloremic metabolic alkalosis

рН	7.5
HCO ₃	31
pCO ₂	39
Na	119 mmol/L (144 – 160)
K	2.7 mmol/L (3.5 – 5.8)
CI	69 mmol/L (109 – 122)
AG	22 (12 – 24)

• Don't miss this in vomiting patients... what does it indicate?

GI Obstruction



Key takeaways

- Electrolytes are important!
- Include electrolytes on biochemical profiles
- Essential in critical patients and patients on fluid therapy
- Serial assessment important to detect new problems and monitor treatment



Hyperkalemia

- Urinary tract obstruction/rupture
- Acute kidney injury / oliguric renal failure
- Addison's disease (hypoadrenocorticism)
- Body cavity effusion
- Whipworms, Salmonella
- Acute tumor lysis syndrome
- Reperfusion after aortic thromboembolism
- Pseudohyperkalemia
 - Thrombocytosis
 - Japanese breeds
 - EDTA contamination

Hypokalemia

- Administration of potassium-free fluids
- Alkalemia
- Vomiting/diarrhea
- Renal disease
- Primary hyperaldosteronism
- Diuretics

Hypernatremia

- Pure water deficit
 - Primary hypodipsia
 - Diabetes insipidus
 - Fever/increased environmental temperature
 - Decreased access to water
- Hypotonic fluid loss
 - Gastrointestinal
 - Third-space loss
 - Cutaneous loss
 - Renal/urinary disease
- Solute gain
 - Salt poisoning
 - Hypertonic fluid administration
 - Hyperaldosteronism
 - Hyperadrenocorticism

Hyponatremia

- High Plasma Osmolality
 - Hyperglycemia
 - Mannitol administration
- Low Plasma Osmolality
 - Congestive heart failure
 - Severe liver disease
 - Nephrotic syndrome
 - Psychogenic polydipsia
 - Renal disease
 - Addison's disease
 - Vomiting and diarrhea
 - Excess diuretic
- Normal osmolality
 - Marked lipemia
 - Possibly marked hyperproteinemia

Hyperchloremia

- Diarrhea
- Salt poisoning
- Renal disease
- Chronic respiratory alkalosis
- Artifact Lipemia, bromide therapy

Hypochloremia

- Vomiting gastric (upper GI) contents
- Diuretics
- Chronic respiratory acidosis
- Hypoadrenocorticism
- Artifact lipemia







he thank god, with all our hearts

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