



## VENOUS BLOOD GAS ANALYSIS

Amanda A Cavanagh, DVM, DACVECC  
Consultant to Heska  
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### ROAD MAP

Traditional  
Acid Base

Non-Trad  
Acid Base

Cases

### HYDROGEN

H<sup>+</sup> ← 40 nanomoles/L

**Na<sup>+</sup>**  
145 MILLION  
nanomoles/L

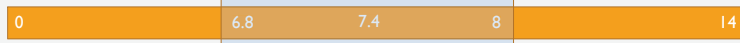
### PH: TWO COMPONENTS

$$\text{pH} = 6.1 + \log_{10} \left( \frac{[\text{HCO}_3^-]}{0.03 \times \text{pCO}_2} \right)$$

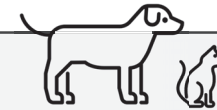
METABOLIC

RESPIRATORY

STEP 1: EVALUATE PH



STEP 1: EVALUATE PH



Acidemia

Alkalemia

STEP 2: EVALUATE THE PCO2



Alkalosis

PCO2  
40mmHg

Acidosis

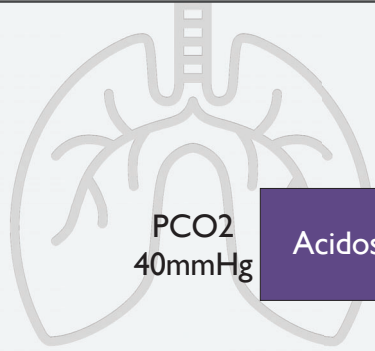
RESPIRATORY DERANGEMENTS

Hyperventilation  
Hypoxemia  
Parenchymal Dz  
Anxiety  
Pain

Alkalosis

PCO2  
40mmHg

## RESPIRATORY DERANGEMENTS



PCO<sub>2</sub>  
40mmHg

Acidosis

Hypoventilation  
CNS lesion  
Muscle Weakness  
NM Junction Dz  
Airway Obs.  
Sedation

## STEP 3: EVALUATE HCO<sub>3</sub>

Acidosis

HCO<sub>3</sub>  
24mg/dL

Alkalosis



## BASE EXCESS

The amount of **ACID** you need to add to one liter of blood to return the pH to normal

Negative BE = ACIDOSIS

Positive BE = ALKALOSIS

Need to take away acid  
To return pH

Need to add acid  
To return pH

## DEFINE PRIMARY DISTURBANCE

ACID BASE DISTURBANCE	PH	PRIMARY DISORDER
RESPIRATORY ACIDOSIS	DECREASED	INCREASED PCO <sub>2</sub>
RESPIRATORY ALKALOSIS	INCREASED	DECREASED PCO <sub>2</sub>
METABOLIC ACIDOSIS	DECREASED	DECREASED HCO <sub>3</sub>
METABOLIC ALKALOSIS	INCREASED	INCREASED HCO <sub>3</sub>

## COMPENSATION

ACID BASE DISTURBANCE	PH	PRIMARY DISORDER	EXPECTED COMPENSATION
RESPIRATORY ACIDOSIS	DECREASED	INCREASED PCO <sub>2</sub>	INCREASED HCO <sub>3</sub>
RESPIRATORY ALKALOSIS	INCREASED	DECREASED PCO <sub>2</sub>	DECREASED HCO <sub>3</sub>
METABOLIC ACIDOSIS	DECREASED	DECREASED HCO <sub>3</sub>	DECREASED PCO <sub>2</sub>
METABOLIC ALKALOSIS	INCREASED	INCREASED HCO <sub>3</sub>	INCREASED PCO <sub>2</sub>

## COMPENSATION

ACID BASE DISTURBANCE	PH	PRIMARY DISORDER	EXPECTED COMPENSATION
RESPIRATORY ACIDOSIS	DECREASED	INCREASED PCO <sub>2</sub>	INCREASED HCO <sub>3</sub>
RESPIRATORY ALKALOSIS	INCREASED	DECREASED PCO <sub>2</sub>	DECREASED HCO <sub>3</sub>
METABOLIC ACIDOSIS	DECREASED	DECREASED HCO <sub>3</sub> : Acidosis	DECREASED PCO <sub>2</sub> : Alkalosis
METABOLIC ALKALOSIS	INCREASED	INCREASED HCO <sub>3</sub>	INCREASED PCO <sub>2</sub>

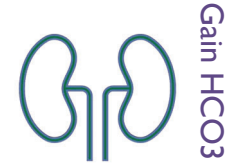
## COMPENSATION

ACID BASE DISTURBANCE	PH	PRIMARY DISORDER	EXPECTED COMPENSATION	ACTUAL CHANGE in CO <sub>2</sub>
METABOLIC ACIDOSIS	DECREASED	DECREASED HCO <sub>3</sub> : Acidosis	DECREASED PCO <sub>2</sub> : Alkalosis	INCREASED PCO <sub>2</sub> : Acidosis

## COMPENSATION

ACID BASE DISTURBANCE	PH	PRIMARY DISORDER	EXPECTED COMPENSATION	ACTUAL CHANGE in CO <sub>2</sub>
METABOLIC ACIDOSIS	DECREASED	DECREASED HCO <sub>3</sub> : Acidosis	DECREASED PCO <sub>2</sub> : Alkalosis	INCREASED PCO <sub>2</sub> : Acidosis

Mixed Metabolic and  
Respiratory Acidosis



METABOLIC ALKALOSIS: ↑HCO<sub>3</sub>

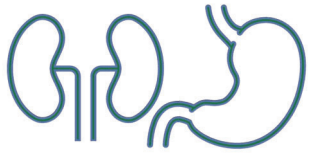


Selective GI acid loss  
NG tube suction  
Renal loss: loop diuretic



Contraction Alkalosis  
NaHCO<sub>3</sub> Admin.  
Metabolism of Anions  
HypoK<sup>+</sup>

Lose  $\text{HCO}_3$



Add Acid

METABOLIC ACIDOSIS: ↓  $\text{HCO}_3$

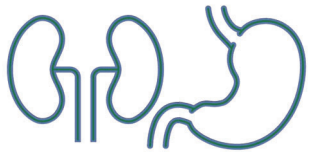
Lose  $\text{HCO}_3$



Add Acid

Hyperchloremia  
Normal Anion Gap

Lose  $\text{HCO}_3$



Add Acid

SI Diarrhea  
Proximal RTA  
Distal RTA

Compensation for Resp  
Alkalosis

Lose  $\text{HCO}_3$



Add Acid

Elevated Anion Gap  
Normal Chloride

Lose  $\text{HCO}_3^-$



Add Acid

Unmeasured Anions

Ketones  
Uremia  
Ethylene Glycol  
Lactate  
Salicylates

METABOLIC ACIDOSIS:  
UNMEASURED ANIONS

$$\text{Anion Gap} = \text{Cations} - \text{Anions}$$

Cations

Anions



METABOLIC ACIDOSIS:  
UNMEASURED ANIONS

$$\text{Anion Gap} = \text{Cations} - \text{Anions}$$

Cations

Anions

Alb<sup>-</sup>  
Phos<sup>-</sup>



METABOLIC ACIDOSIS:  
UNMEASURED ANIONS

$$\text{Anion Gap} = \text{Cations} - \text{Anions}$$

Cations

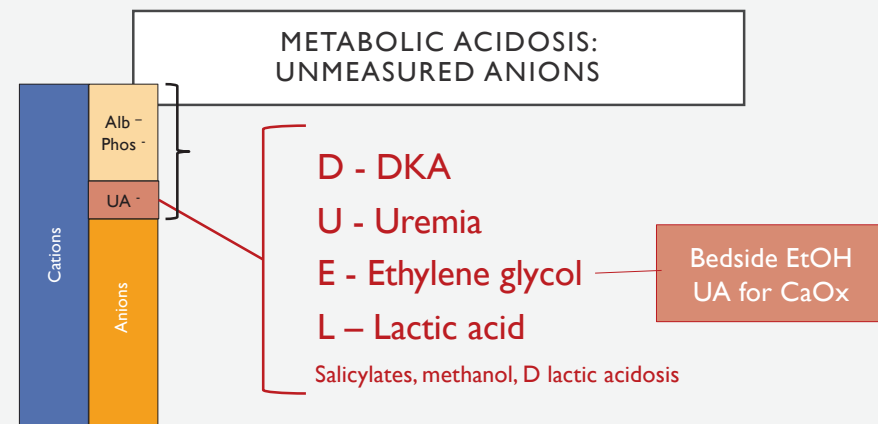
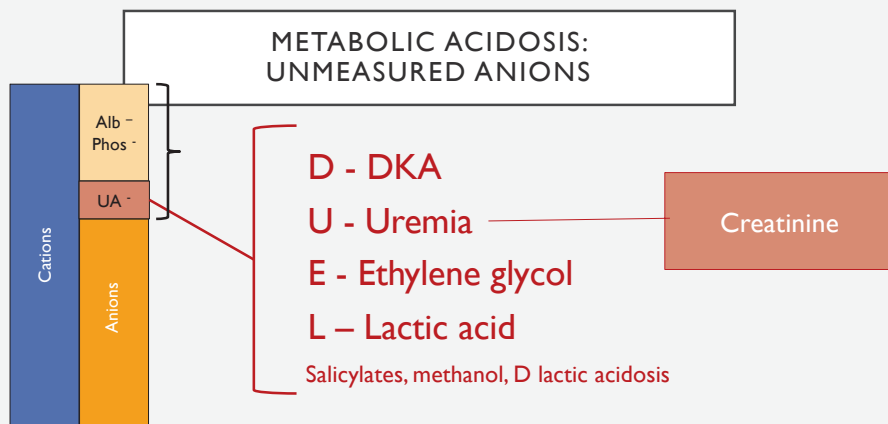
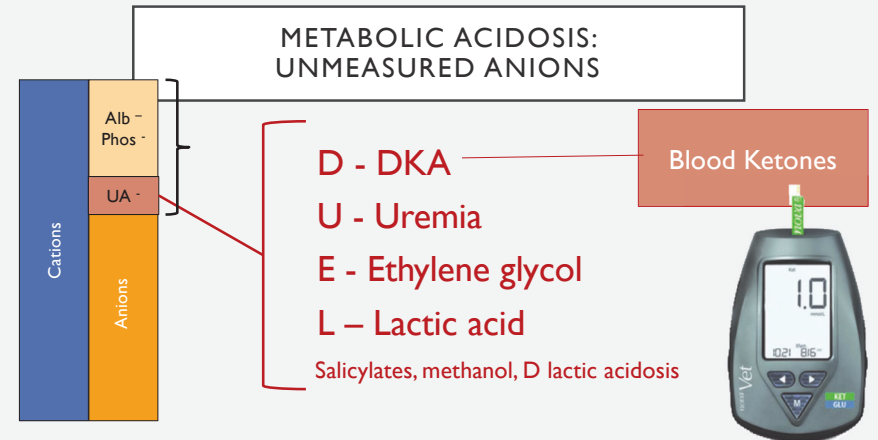
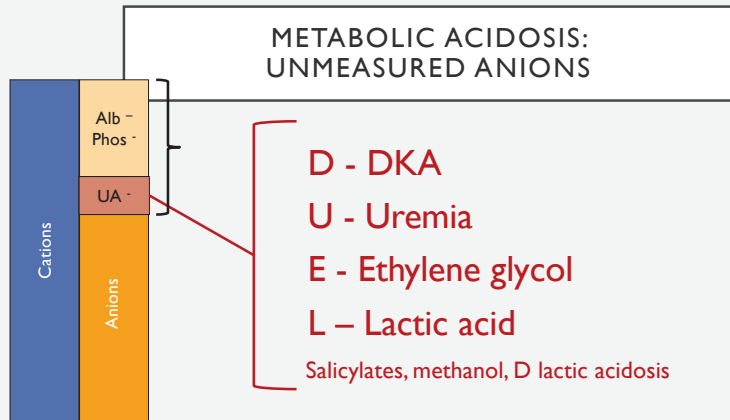
Anions

Alb<sup>-</sup>  
Phos<sup>-</sup>

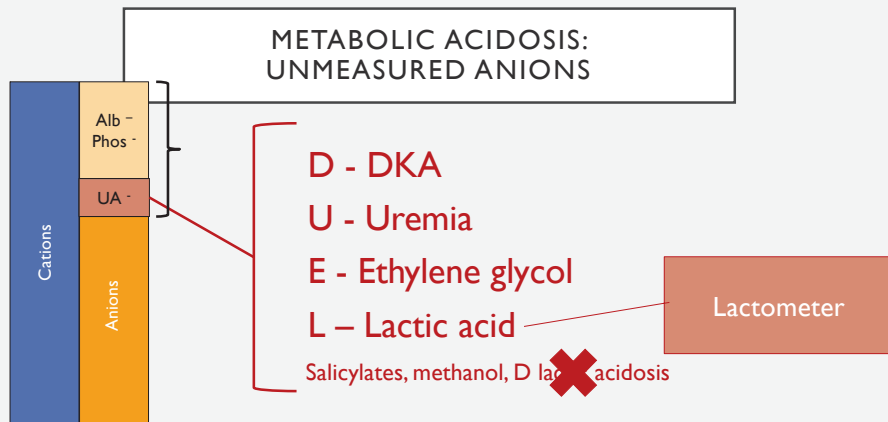
UA<sup>-</sup>



UA<sup>-</sup>

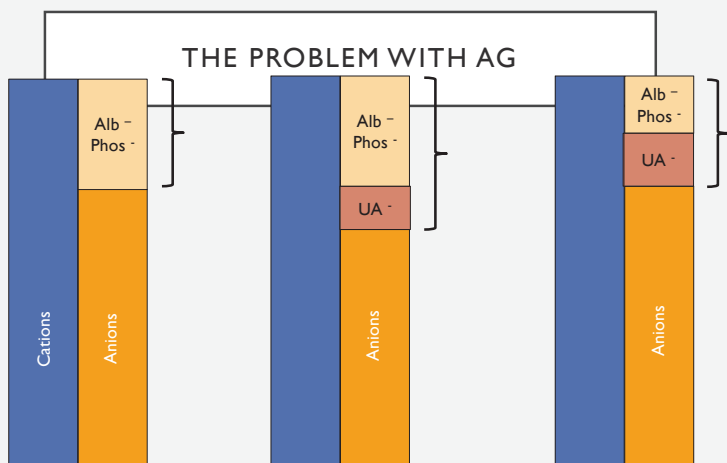






## METABOLIC ACIDOSIS

- If Acids added → anion gap is large and normal chloride
  - D, U, E, L + other acids
- If Bicarbonate lost → normal anion gap and hyperchloremia
  - Diarrhea or kidneys



## THE STEWART APPROACH

CO<sub>2</sub>

Total Weak  
Acids  
A<sub>TOT</sub>

Strong Ion  
Difference  
SID

Respiratory

Metabolic

CO<sub>2</sub>

Total Weak  
Acids  
A<sub>TOT</sub>

Strong Ion  
Difference  
SID

Acidosis

CO<sub>2</sub>: Respiratory  
Component

Alkalosis

A<sub>TOT</sub>

Strong Ion  
Difference

Acidosis

A<sub>TOT</sub>: Weak Acids  
Albumin & Phosphorus

Alkalosis

CO<sub>2</sub>

Strong Ion  
Difference

Acidosis

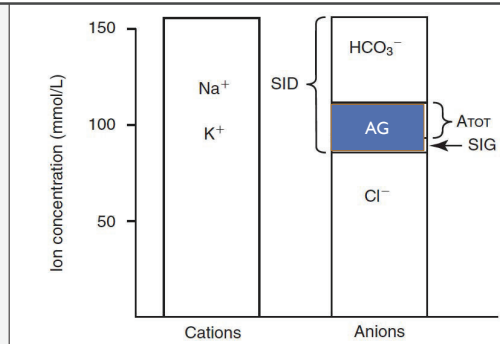
Strong Ion Difference  
Sodium and Chloride

Alkalosis

CO<sub>2</sub>

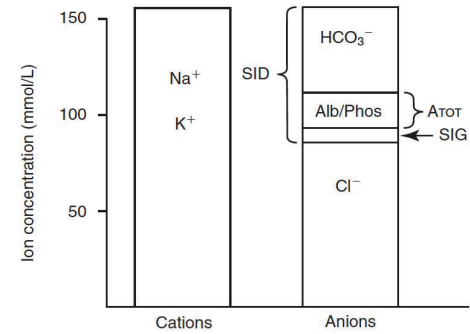
A<sub>TOT</sub>

## STRONG ION GAP



Hopper K. Small Animal Critical Care Medicine, 2015

## STRONG ION GAP



## STRONG ION GAP



$$\text{SIG}_{\text{simplified}} = ([\text{albumin}] \times 4.9) - (\text{AG} + (2.53 - (0.58 \times [\text{phos}])))$$



$$\text{SIG}_{\text{simplified}} = ([\text{albumin}] \times 7.94) - (\text{AG} + (2.53 - (0.58 \times [\text{phos}])))$$

## PH CONCLUSIONS

- Decreased SID acidosis
- Increased SID alkalosis
- Increased Atot acidosis
- Decreased Atot alkalosis
- Increased strong ion gap acidosis

## COLLECTION LOCATIONS

- Significant differences between arterial and venous
- Differences between central and peripheral – especially if unstable
  - Elevated lactate
  - Elevated CO<sub>2</sub>
- Exposure to air
  - CO<sub>2</sub> diffuses into the air and decreases value
  - Remove air bubbles and run within 15 minutes

## EXTRA GOODIES

- (Hemoglobin Conc) x 3 = Estimated PCV
- P<sub>v</sub>O<sub>2</sub> – cannot evaluate oxygenation on venous blood gas
- O<sub>2</sub> Saturation – cannot evaluate on peripheral blood
- Creatinine – increases of 0.3mg/dL concerning for AKI
- Co-oximeter – evaluate dyshemoglobin concentrations

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO <sub>2</sub>	52.0
Blood pO <sub>2</sub>	39.5
Blood HCO <sub>3</sub> <sup>-</sup> (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3
Temp. corrected Blood pH	7.473
Temp corrected pCO <sub>2</sub>	52.0
Temp corrected pO <sub>2</sub>	39.5
Calc Total O <sub>2</sub>	15.0
Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88
Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11
Carboxyhemoglobin	3.6
Methemoglobin	2.2

## CLINICAL CASES

Blood Gas Results Status:	FINAL	
Blood Gas Tech.	NAD	
pH corrected Ca++ is not usable because pH is less than 7.2.		
Barometric Pressure	636	mmHG
Sample Type	Venous	
Blood Gas Temp.	98.6	Deg F
Fraction Inspired O <sub>2</sub>	21.0	%
Hemoglobin Conc.	24.3	g/dL
Blood pH	7.178	P 7.33 - 7.45
Temp. corrected Blood pH	7.178	
Blood pCO <sub>2</sub>	57.1	H 24 - 39
Temp corrected pCO <sub>2</sub>	57.1	mmHG
Blood HCO <sub>3</sub> <sup>-</sup> (calculated)	20.4	17 - 27
Actual Base Excess	-10.6	mEq/L
Blood pO <sub>2</sub>	31.7	P 67 - 92
Temp corrected pO <sub>2</sub>	31.7	mmHG
Oxygen Saturation	39.3	%
Calc Total O <sub>2</sub>	12.8	Vol%
Blood Sodium	131	L 145 - 156
Blood Potassium	7.60	H 4.1 - 5.6
Blood Chloride	99	L 104 - 113
Blood Anion Gap	18.7	13 - 24
Ionized Calcium	1.60	mEq/L
Ionized Calcium Corrected	.	1.12 - 1.40
Blood Glucose	50	L 67 - 114
Blood Lactate	3.5	H 0.20 - 1.44
Blood Creatinine	2.9	H 0.7 - 1.9
		mg/dL



Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH 7.178

Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## STEP 1: EVALUATE THE PH

- pH 7.178 = Acidotic

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH 7.178

Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

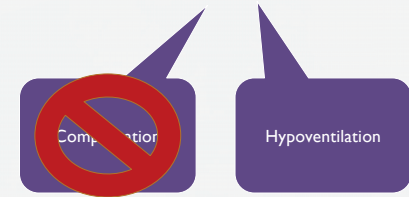
Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## STEP 2: EVALUATE THE CO2

- pH 7.178 = Acidotic
- pCO2 57.1 = Respiratory Acidosis



Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH 7.178

Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## STEP 3: EVALUATE THE HOC3

- pH 7.178 = Acidotic
- pCO2 57.1 = Respiratory Acidosis
- HCO3 20.4 = Normal

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH 7.178

Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## METABOLIC CONTRIBUTIONS

- HCO3 20.4 = Normal
- Base Excess = Negative (acidosis)

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
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Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99

Blood Anion Gap 18.7

Ionized Calcium 1.60

Ionized Calcium Corrected .

Blood Glucose 50

Blood Lactate 3.5

Blood Creatinine 2.9

## METABOLIC CONTRIBUTIONS

- HCO3 20.4 = Normal
- Base Excess = Negative (acidosis)
- Anion Gap = Normal

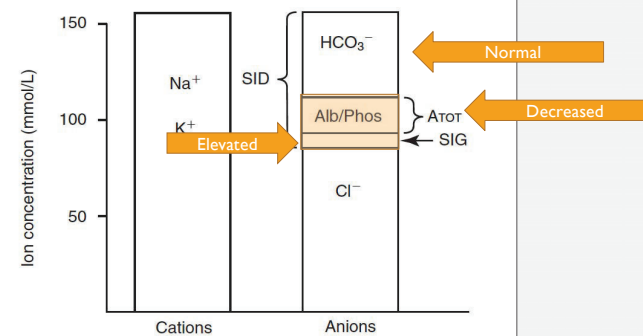
DKA

Uremia

Ethylene Glycol

Lactate

## NORMAL AG WITH UNMEASURED ANIONS



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Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
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Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium 131

Blood Potassium 7.60

Blood Chloride 99

Blood Anion Gap 18.7

Ionized Calcium 1.60

Ionized Calcium Corrected .

Blood Glucose 50

Blood Lactate 3.5

Blood Creatinine 2.9

## METABOLIC CONTRIBUTIONS

- HCO3 20.4 = Normal
- Base Excess = Negative (acidosis)
- Anion Gap = Normal, but unmeasured anions
- Atot = likely decreased (alkalotic effect)

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
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Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium 131

Blood Potassium 7.60

Blood Chloride 99

Blood Anion Gap 18.7

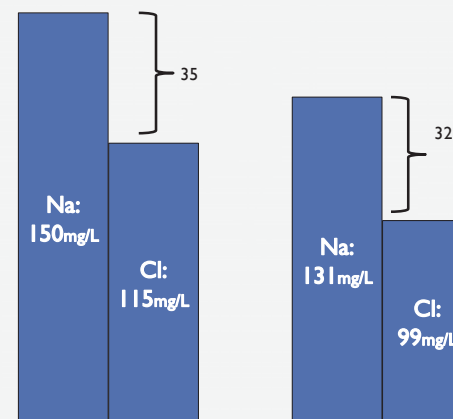
Ionized Calcium 1.60

Ionized Calcium Corrected .

Blood Glucose 50

Blood Lactate 3.5

Blood Creatinine 2.9



Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
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Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## PH CONCLUSION

- pH 7.178 = Acidotic
- Respiratory acidosis
- Metabolic acidosis
  - Acidosis secondary to gain of acids
  - Alkalosis secondary to hypoalbuminemia

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Blood Gas Temp.	98.6
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Hemoglobin Conc.	24.3

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Ionized Calcium	1.60
Ionized Calcium Corrected	.

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## OTHER GOODIES

- Hemoconcentration

Hgb x 3 = approximate PCV = 75%

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Blood Chloride	99
Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## OTHER GOODIES

- Venous Sample – ignore pO2

Barometric Pressure	636
Sample Type	Venous
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Ionized Calcium Corrected	.

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## OTHER GOODIES

- Electrolytes
  - Hyponatremia
  - Hyperkalemia
  - Hypochloremia

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Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## OTHER GOODIES

- Electrolytes
- Ionized Ca = elevated

“GOSH DARNIT”

Gow AG, et al., Calcium metabolism in eight dogs with hypoadrenocorticism. J Small Anim Pract. 2009 Aug;50(8):426-30.

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Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## OTHER GOODIES

- Electrolytes
- Hypoglycemia

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7

Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## FINAL DIAGNOSIS

- Mixed respiratory and metabolic acidosis with suspected hypoadrenocorticism
- Suspect poor perfusion
  - Hyperlactatemia
  - Azotemia
  - Elevated CO2 (may not be a ventilation problem)
- Dehydration

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
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Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99
Blood Anion Gap	18.7

Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## TREATMENT

10-20ml/kg LRS to normalize perfusion parameters

1ml/kg 50% dextrose diluted 1:4 in LRS



Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
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Blood HCO3- (calculated)	20.4
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Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99

Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## TREATMENT

Check EKG  
Fluid Therapy  
Calcium Gluconate 1mg/kg IV  
diluted 1:4  
Dextrose +/- Insulin  
Steroids  
Mineralocorticoids

Barometric Pressure	636
Sample Type	Venous
Blood Gas Temp.	98.6
Fraction Inspired O2	21.0
Hemoglobin Conc.	24.3

Blood pH	7.178
Temp. corrected Blood pH	7.178
Blood pCO2	57.1
Temp corrected pCO2	57.1
Blood HCO3- (calculated)	20.4
Actual Base Excess	-10.6

Blood pO2	31.7
Temp corrected pO2	31.7
Oxygen Saturation	39.3
Calc Total O2	12.8

Blood Sodium	131
Blood Potassium	7.60
Blood Chloride	99

Blood Anion Gap	18.7
Ionized Calcium	1.60
Ionized Calcium Corrected	.

Blood Glucose	50
Blood Lactate	3.5
Blood Creatinine	2.9

## TREATMENT

Recheck after perfusion  
parameters normalize

## CONCLUSION

- ACTH Stim
- Pre cortisol < 1mg/dL
- Post cortisol < 1mg/dL

## CLINICAL CASE



Hemoglobin Conc.	18.5			g/dL
Barometric Pressure	637			mmHG
Blood pH	7.473	H	7.33 - 7.44	
Blood pCO2	52.0	H	35 - 42	mmHG
Blood pO2	39.5	L	73 - 92	mmHG
Blood HCO3- (calculated)	37.6	H	15 - 24	mEq/L
Actual Base Excess	11.5			mmol/L
Oxygen Saturation	61.3			%
Temp. corrected Blood pH	7.473			
Temp corrected pCO2	52.0			mmHG
Temp corrected pO2	39.5			mmHG
Calc Total O2	15.0			Vol%
Blood Sodium	139	L	153 - 161	mEq/L
Blood Potassium	3.2	L	3.9 - 5.6	mEq/L
Blood Chloride	77	L	110 - 119	mEq/L
Blood Anion Gap	28.0	H	16 - 27	mEq/L
Ionized Calcium	0.85			mmol/L
Ionized Calcium Corrected	0.88	L	1.20 - 1.32	mmol/L
Blood Glucose	250	H	65 - 141	mg/dL
Blood Lactate	7.7			mmol/L
Blood Creatinine	5.11	H	1.0 - 2.7	mg/dL
Carboxyhemoglobin	3.6			%
Methemoglobin	2.2			%

Hemoglobin Conc.	18.5			g/dL
Barometric Pressure	637			mmHG
Blood pH	7.473			
Blood pCO2	52.0			mmHG
Blood pO2	39.5			mmHG
Blood HCO3- (calculated)	37.6			mEq/L
Actual Base Excess	11.5			mmol/L
Oxygen Saturation	61.3			%
Temp. corrected Blood pH	7.473			
Temp corrected pCO2	52.0			mmHG
Temp corrected pO2	39.5			mmHG
Calc Total O2	15.0			Vol%
Blood Sodium	139			mEq/L
Blood Potassium	3.2			mEq/L
Blood Chloride	77			mEq/L
Blood Anion Gap	28.0			mEq/L
Ionized Calcium	0.85			mmol/L
Ionized Calcium Corrected	0.88			mmol/L
Blood Glucose	250			mg/dL
Blood Lactate	7.7			mmol/L
Blood Creatinine	5.11			mg/dL
Carboxyhemoglobin	3.6			%
Methemoglobin	2.2			%

## STEP 1: EVALUATE PH

- pH 7.473 = Mild Alkalosis

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11
Carboxyhemoglobin	3.6
Methemoglobin	2.2

## STEP 2: EVALUATE CO2

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis

Compensation

Hypoventilation

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

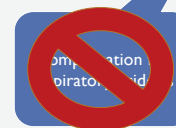
Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11
Carboxyhemoglobin	3.6
Methemoglobin	2.2

## STEP 3: EVALUATE HCO3

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis

- HCO3 37.6 = Alkalosis

Gain HCO3



Loss of Acid  
GI or Kidney

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## METABOLIC CONTRIBUTIONS

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis
- HCO3 37.6 = Metabolic Alkalosis
- **Base Excess = Positive = Alkalosis**

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## METABOLIC CONTRIBUTIONS

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis
- HCO3 37.6 = Metabolic Alkalosis
- Elevated Base Excess = Alkalosis

### Elevated Anion Gap

DKA

Ethylene Glycol

Lactate

Uremia

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## METABOLIC CONTRIBUTIONS

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis
- HCO3 37.6 = Metabolic Alkalosis
- Elevated Base Excess = Alkalosis

### Elevated Anion Gap

DKA

Ethylene Glycol

Lactate

Uremia

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## STEP 4: DEFINE PRIMARY DISTURBANCE

- pH 7.473 = Mild Alkalosis
- pCO2 52mmHg = Respiratory Acidosis
- HCO3 37.6 = Metabolic Alkalosis

Metabolic Alkalosis (and a bit of acidosis)  
with suspected respiratory compensation

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

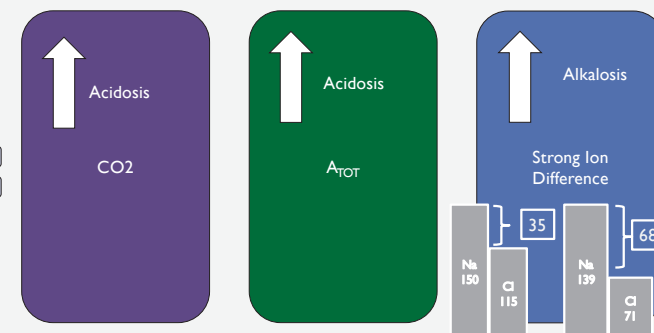
Carboxyhemoglobin	3.6
Methemoglobin	2.2

## STEP 5: COMPENSATION

- Expected Compensation
  - Increased PCO2 of 0.7mmHg per 1mEq/L decrease in HCO3 (+/- 3mmHg)
  - Expected increase around 49.5mmHg +/- 3mmHg
  - Appropriate compensation

GLUCOSE	222	H
BUN	79	H
CREATININE	4.67	H
PHOSPHORUS	14.7	H
CALCIUM	9.0	L
MAGNESIUM	3.0	H
Total Protein	9.0	H
ALBUMIN	4.4	H
GLOBULIN	4.6	H
AG RATIO	0.96	
CHOLESTEROL	194	
CK	312	
T-BILIRUBIN	0.1	
ALP	21	
ALT	28	L
AST	35	
GGT	0	
IRON	31	L
SODIUM	139	L
POTASSIUM	3.40	L
CHLORIDE	70.9	L
BICARB(HCO3-)	32.2	H
ANION GAP	39	H
CALC. OSMOLALITY	305	
LIPEMIA	4	
HEMOLYSIS	72	H
ICTERUS	0	

## THE STEWART APPROACH



Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
Temp corrected pO2	39.5
Calc Total O2	15.0

Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## STEP 6: CONCLUSION

Hypochloremic Metabolic alkalosis  
Metabolic acidosis (Lactate and Uremia; Hyperphosphatemia)

with respiratory compensation

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
Actual Base Excess	11.5
Oxygen Saturation	61.3

Temp. corrected Blood pH	7.473
Temp corrected pCO2	52.0
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Blood Sodium	139
Blood Potassium	3.2
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Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## TREATMENT

Respiratory acidosis should resolve  
with resolution of metabolic disease

Hemoglobin Conc. 18.5  
 Barometric Pressure 637  
 Blood pH 7.473  
 Blood pCO2 52.0  
 Blood pO2 39.5  
 Blood HCO3- (calculated) 37.6  
 Actual Base Excess 11.5  
 Oxygen Saturation 61.3

Temp. corrected Blood pH 7.473  
 Temp corrected pCO2 52.0  
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 Calc Total O2 15.0

Blood Sodium 139  
 Blood Potassium 3.2  
 Blood Chloride 77  
 Blood Anion Gap 28.0  
 Ionized Calcium 0.85  
 Ionized Calcium Corrected 0.88

Blood Glucose 250  
 Blood Lactate 7.7  
 Blood Creatinine 5.11

Carboxyhemoglobin 3.6  
 Methemoglobin 2.2

## TREATMENT

Cannot evaluate  
 oxygenation on a  
 venous blood gas

Hemoglobin Conc. 18.5  
 Barometric Pressure 637  
 Blood pH 7.473  
 Blood pCO2 52.0  
 Blood pO2 39.5  
 Blood HCO3- (calculated) 37.6  
 Actual Base Excess 11.5  
 Oxygen Saturation 61.3

Temp. corrected Blood pH 7.473  
 Temp corrected pCO2 52.0  
 Temp corrected pO2 39.5  
 Calc Total O2 15.0

Blood Sodium 139  
 Blood Potassium 3.2  
 Blood Chloride 77

Blood Anion Gap 28.0  
 Ionized Calcium 0.85  
 Ionized Calcium Corrected 0.88

Blood Glucose 250  
 Blood Lactate 7.7  
 Blood Creatinine 5.11

Carboxyhemoglobin 3.6  
 Methemoglobin 2.2

## TREATMENT

0.9% NaCl 10ml/kg IV boluses until perfusion parameters  
 normalize

Low SID Fluid

Na	Cl
154mEq/L	154mEq/L

## CLINICAL PEARL: STRONG IONS

FLUID TYPE	COMPONENT (unit)							BUFFER(S)
	pH	Sodium (mEq/L)	Chloride (mEq/L)	Potassium (mEq/L)	Magnesium (mEq/L)	Calcium (mEq/L)	Osmolarity (mOsm/L)	
0.9% Saline	5.5	154	154	0	0	0	308	None
Plasmalyte A	7.4	140	98	5	3	0	294	Acetate (27 mEq/L) Gluconate (23 mEq/L)
Normosol-R	7.4	140	98	5	3	0	294	Acetate (27 mEq/L) Gluconate (23 mEq/L)
Lactated Ringer's solution (LRS)	6.5	130	109	4	0	2.7	273	Lactate (28 mEq/L)

Modified from: <https://navc.com/todaysveterinarynurse/wp-content/uploads/sites/3/2016/07/Table-1-Composition-of-Common-Vet-Fluids.jpg>

Hemoglobin Conc. 18.5  
 Barometric Pressure 637  
 Blood pH 7.473  
 Blood pCO2 52.0  
 Blood pO2 39.5  
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 Actual Base Excess 11.5  
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Temp. corrected Blood pH 7.473  
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Blood Sodium 139  
 Blood Potassium 3.2  
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 Blood Anion Gap 28.0  
 Ionized Calcium 0.85  
 Ionized Calcium Corrected 0.88

Blood Glucose 250  
 Blood Lactate 7.7  
 Blood Creatinine 5.11

Carboxyhemoglobin 3.6  
 Methemoglobin 2.2

## TREATMENT

Check USG prior to fluid resuscitation

Recheck following fluid resuscitation to achieve  
 normovolemia



Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
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Temp. corrected Blood pH	7.473
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Blood Sodium	139
Blood Potassium	3.2
Blood Chloride	77
Blood Anion Gap	28.0
Ionized Calcium	0.85
Ionized Calcium Corrected	0.88

Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## TREATMENT

Administer potassium supplementation in maintenance fluids  
0.1 – 0.4 mEq/Kg/Hr

Hemoglobin Conc.	18.5
Barometric Pressure	637
Blood pH	7.473
Blood pCO2	52.0
Blood pO2	39.5
Blood HCO3- (calculated)	37.6
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Temp. corrected Blood pH	7.473
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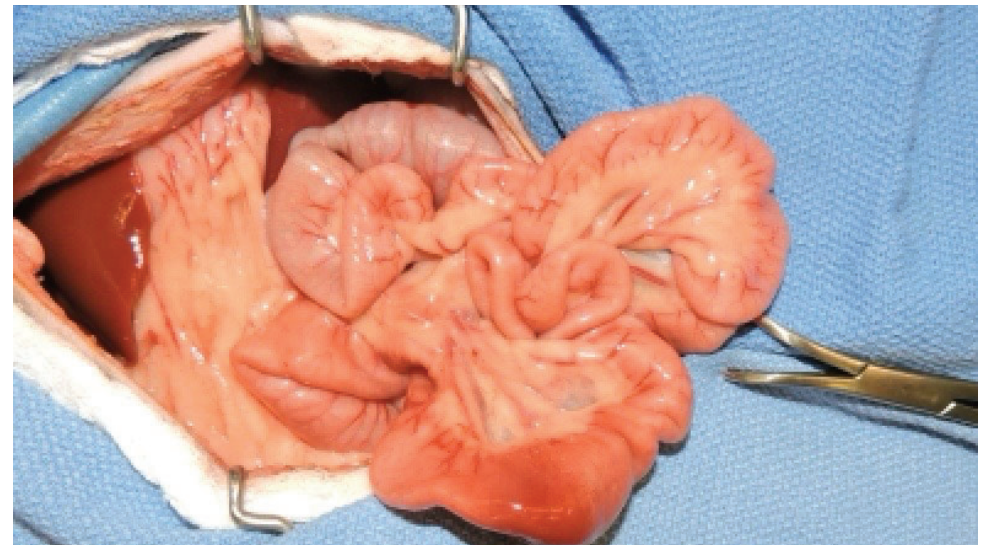
Blood Glucose	250
Blood Lactate	7.7
Blood Creatinine	5.11

Carboxyhemoglobin	3.6
Methemoglobin	2.2

## TREATMENT

I would hesitate to correct iCa with calcium gluconate...

GLUCOSE	222	H
BUN	79	H
CREATININE	4.67	H
PHOSPHORUS	14.7	H
CALCIUM	9.0	L
MAGNESIUM	3.0	H
Total Protein	9.0	H
ALBUMIN	4.4	
GLOBULIN	4.6	H
AVG RATIO	0.96	
CHOLESTEROL	194	
CK	312	
T-BILIRUBIN	0.1	
ALP	21	
ALT	28	L
AST	35	
GGT	0	
IRON	31	L
SODIUM	139	L
POTASSIUM	3.40	L
CHLORIDE	70.9	L
BICARB(HCO3-)	32.2	H
ANION GAP	39	H
CALC. OSMOLALITY	305	
LIPEMIA	4	
HEMOLYSIS	72	H
ICTERUS	0	





## QUESTIONS?

Remember to  
**download the CE certificate**  
in the handouts panel of  
the webinar control panel.  
NOTE: CE certificate not available  
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Questions about topic?  
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