Applied Fluid Therapy in Bovine Practice (practical-economical)

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In a game of Poker, nothing inspires a confident bet more than a handful of aces. In the game of veterinary medicine, when faced with a difficult clinical situation, you are figuratively dealt a hand of therapeutic cards. After discarding inappropriate choices, you draw new cards to hopefully create a winning hand; i.e., a positive clinical response. The application of fluid therapy is analagous to drawing three aces; a draw which gives bovine practitioners a safe wager on therapeutic success. Too often therapeutic failure is not the fault of misdiagnosis or improper treatment; but rather a failure to recognize fluid and electrolyte disturbances which undermine the treatment plan. This logic may apply to the "Ivory Tower" environment of a teaching hospital, but why, when, and how can a veterinarian in the field apply the principles and practices of fluid therapy to his daily routine.

Affordability, Convenience, and Effectiveness produce an **Ace** card answer to why you, the bovine practitioner, should incorporate fluid therapy into your routine treatment schemes. In the following discussion, we will examine how inexpensively and easily fluid treatment can be accomplished, as well as the therapeutic benefits obtained by its use.

In response to the question of "when should fluid therapy be used?" we draw another card which reads: Always Commence Early, another fluid therapy **Ace.** Fluid usage should not be viewed as a last resort type measure; but rather, as routine ancillary treatment for many common, yet often therapeutically challenging bovine diseases.

After understanding why and when fluid therapy should be used, you then need to know how. In the veterinary medicine game, our last card drawn also turns up an **Ace.** Through example cases we will illustrate how you can Assess the patient's hydration status and electrolyte balance, Calculate her fluid requirements, and handily Execute supportive care involving fluid administration.

With the draw completed it's time to wager. The size of the wager in poker as well as in food animal practice is based on economics; i.e., what is the animal worth, and how much can you afford to spend on its treatment to effect a cure? The gamble is based on the odds of an animal's favorable or unfavorable response to your therapeutic plan. Therefore you must implement accurate treatment schemes, but at the same time, recognize the cost effectiveness of that treatment as it relates to the animal's dollar value.

This financial awareness concept holds especially true in terms of ancillary treatments like fluid therapy. When dealing with critically ill bovine patients, fluid treatment costs must be kept reasonable to provide a fiscal margin in the event of a fatality. By keeping fluid therapy practical and economical, it can be applied to almost any appropriate clinical situation irregardless of the animal's dollar value.

To achieve this fiscal freedom, inexpensive salt solution recipes are substituted for sterile, commercial, fluid preparations. Formulation and dosage is based on careful clinical examination and logical estimations, instead of laboratory sample analyses. Table salt, baking soda, and Morton Lite salt can be combined with hot tap water to produce electrolyte solutions suitable for oral or intravenous use.

Another means of reducing treatment costs comes from clinical proficiency involving oral and intravenous fluid administration, thereby keeping professional service fees reasonable. A very labor efficient method of delivering oral fluid solutions is the Magrath Cattle Pump System.[1] Combining an esophageal probang with a hand bilge pump, the Magrath unit allows for rapid, safe delivery of the large oral fluid volumes needed by adult cattle.

Similarly, intravenous fluid administration can be simplified by using a 25 liter jug,[2] connected to a 12 gauge indwelling catheter. The catheter is comprised of infusion set tubing[3] threaded through a 7 gauge bleeding trochar.[4] This system is easily adapted to most field situations, and will stay secure even when left unattended. In contrast to smaller conventional systems, this design satisfies the high volume fluid needs of the acutely ill bovine patient. After becoming familiar with this reusable system, you will find intravenous fluids increasingly applicable to a wide variety of clinical situations.

Once you decide to incorporate fluid therapy into your treatment schedule, a few simple calculations must be performed to determine the fluid volume and electrolyte formulation required by that particular bovine patient. As illustrated in the following tables, estimates of hydration status and acid-base balance can be derived from an assessment of abdominal fullness, manure character, skin

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[1] *Magrath Manufacturing Co., McCook, Nebraska*
[2] *Scientific Products, McGaw Park, Illinois*
[3] *Diamond Laboratories, Des Moines, Iowa*
[4] *Jorgensen Laboratories, Loveland, Colorado*

elasticity, eye orbit depth, and desired body weight. In addition, a thorough understanding of the pathogenesis of a particular disease process is invaluable when predicting fluid and electrolyte defecits.

Guidlines For Assessment of Dehydration Status*

Weight Loss (%)	Sunken Eyes	Skin Tent (secs.)	PCV (%)	Total Protein (gr/dl)	Fluid R'qd. (ml/kg)
4	—	—	45	8	25
6	2+	5	50	9	50
8	3+	10	55	10	75
10	4+	30	60	11	100

* **Veterinary Medicine,** 5th ed. Blood, Henderson, Radostits, 1979.

Estimating Base Defecit or Excess**

Abdomen	Feces	Dehydration	Base Difference
fluid rumen	very scant	4+	+15 Meq.
splashy rumen	scant	3+	+10 Meq.
doughy rumen	firm	2+	+ 5 Meq.
normal	normal	0	− 5 Meq.
drawn	loose	2+	−10 Meq.
gaunt	very loose	3+	−15 Meq.
tucked up	water	4+	

** Robert H. Whitlock, DVM, Personal Communication, 1977.

MEQ/GRAM CONCENTRATION

NaCl	= 17	Meq./gm
$NaHCO_3$	= 12	Meq./gm
Lite Salt (KCl/NaCl)	= 15.5	Meq./gm
KCl	= 14	Meq./gm

ISOTONIC CONCENTRATION OF COMMON SALTS

NaCl	= 9 gm/L
$NaHCO_3$	= 13 gm/L
Morton Lite Salt (KCl/NaCl)	= 10 gm/L
Dextrose	= 50 gm/L

HANDY MEASUREMENTS OF COMMON ELECTROLYTES

NaCl — 21 grams/tbsp.
$NaHCO_3$ — 12 grams/tbsp.
Morton Lite Salt — 17 grams/tbsp.
(KCl/NaCl)

RECIPES

ORAL FLUID RECIPE - DA

8 Tbsp. Table Salt
12 Tbsp. Morton Lite Salt

10 gallons warm water

PERACUTE COLIBACILLOSIS IV FLUID RECIPE

2 tablespoons Baking Soda
1 tablespoon table salt

4 liters warm water

ACUTE MASTITIS - Fluid Recipe

7 Tbsp. table salt (21 gr/tbsp)
5 Tbsp. baking soda (12 gr/tbsp)
1 Tbsp. lite salt (17 gr/tbsp)
3 Bottles Cal Dextro #2
1 Bottle 50% Dextrose

q.s. 25 liters warm water

ORAL FLUID RECIPE CALF SCOURS

1 can Beef Consume Soup
1 pkg. Jelly Pectin (Sure Jell)
2 tablespoons Baking Soda
1 tablespoon lite salt

q.s. 2 quarts warm water

CALCULATIONS

A HOW MUCH FLUID VOLUME NEEDED TO CORRECT DEHYDRATION?

Body Weight (Kg)		Estimated Dehydration (%)		Fluid Required (Liters)
	×		=	

B HOW MUCH ELECTROLYTE IS NEEDED TO CORRECT BASE DEFICIT?

Electrolyte Deficit (Meq/L)		ECF* Volume (Liters)		Electrolyte Needed (Meq.)
	×		=	

* ECF = 30% body weight

C HOW MUCH DOES THE ELECTROLYTE NEEDED WEIGH IN GRAMS?

Electrolyte Needed (Meq.)		Electrolyte Concentration (Meq./gram)		Grams Electrolyte needed (Grams)
	÷		=	

D HOW MUCH ISOTONIC FLUID VOLUME IS CREATED BY CORRECTING BASE DEFECIT?

Electrolyte Needed (Grams)		Isotonic Concentration (grams/l Liter)		Isotonic Volume (liters)
	÷		=	

E HOW MUCH FLUID VOLUME REMAINS AND WHAT SHOULD BE ITS COMPOSITION?

Fluid vol. required		Isotonic volume from calculations		Remaining fluid needed*
	−		=	

* This can be Eltrad IV, saline or another polyionic solution

Recapping our bovine practice poker game: the draw is completed, and the bets have been placed. Holding onto a handful of therapeutic aces, it's time to play the cards! The following case studies will attempt to illustrate the application of fluid therapy under actual practice conditions.

Case #1 concerns Laura, a 5 year old Holstein cow, afflicted with a right sided displaced abomasum. In addition to the characteristic "ping" upon auscultation/percussion, physical examination reveals an increased heart rate, cold ears, sunken eyes, pasty manure, and moderate rumen distention. Based on these clinical signs and an understanding of the pathophysiology of abomasal displacements, you can make the following assessment of Laura's fluid-electrolyte changes. Her abdominal distention and sunken eyes portray an estimated eight percent dehydration. The entrapment of chlorine rich digesta in the forestomachs, results in a serum chloride deficit (−40 Meq./L) and a relative bicarbonate excess (+10 Meq./L).

This systemic alkalosis triggers an intracellular influx of potassium in exchange for hydrogen ion buffers; thereby depressing serum potassium levels. Therefore in addition to surgical correction of the RDA, medical treatment must be concerned with these distrubed fluid parameters. To develop this fluid therapy scheme, the following calculations are made.

CALCULATIONS
RDA

A HOW MUCH FLUID VOLUME NEEDED TO CORRECT DEHYDRATION?

Body Weight		Estimated Dehydration		Fluid Required
500 (Kg)	×	8 (%)	=	40 (Liters)

B HOW MUCH ELECTROLYTE IS NEEDED TO CORRECT CHLORIDE DEFECIT?

Electrolyte Defecit		ECF* Volume		Electrolyte Needed
40 (Meq./L) Cl—	×	150 (Liters)	=	6000 (Meq.) Cl—

* ECF = 30% body weight

C HOW MUCH DOES THE ELECTROLYTE NEEDED WEIGH IN GRAMS?

Electrolyte Needed		Electrolyte Concentration		Grams Electrolyte Needed
6000 (Meq.) Cl	÷	17 (Meq./gram) NaCl	=	360 (Grams) Cl

D HOW MUCH ISOTONIC FLUID VOLUME IS CREATED BY CORRECTING CHLORIDE DEFICIT?

Electrolyte Needed		Isotonic Concentration		Isotonic Volume
360 (Grams) Cl	÷	9 (grams/l Liter) NaCl	=	40 (liters

E HOW MUCH FLUID VOLUME REMAINS AND WHAT SHOULD BE ITS COMPOSITION?

Fluid vol. required		Isotonic volume from calculations		Remaining fluid needed*
40	–	40	=	0

* This can be Eltrad IV, saline or another polyionic solution

The fluid volume requirements have been met by correcting the chloride deficit. However, additional potassium must be incorporated into the formula to compensate for the hypokalemia. Because potassium is primarily an intracellular ion, its exact deficit can't be calculated. However, a thumb rule for potassium replacement is 20 to 40 milliequivalents per liter of fluid delivered. This represents approximately 100 grams KCl in our 40 liter oral fluid volume. To achieve this formulation and still maintain the solutions isotonicity, the following recipe is devised:

167 grams table salt (8 tbsp.)
204 grams LITE salt (12 tbsp.)
(50% KCl)
(50% NaCl)

371 grams in 40 liters water

This mixture provides:

154 Meq./L Chloride
35 Meq./L Potassium
119 Meq./L Sodium

308 Meq./L (isotonic)
Delivered by **oral** drench with the Magrath Cattle Pump

If needed, additional fluid may be given intravenously using 10 to 20 liters isotonic sodium choride (9 gram/L).

Case #2 deals with a very common, yet often, therapeutically unresponsive condition. A seven year old Holstein cow, at the peak of her lactation, suddenly becomes lethargic and anorexic. Within twelve hours she is nearly recumbent, following an acute bout of coliform mastitis. In her particular case, and many like hers, it is not the inflammation and pyrexia caused by the invading bacteria that is so very lethal; but rather, the by-products of that inflammatory process (toxemia, vasular collapse, and shock). This proposed pathologic mechanism is supported by the mastitic cow's clinical signs which include a subnormal temperature, rapid heart rate, inelastic skin tent, sunken eyes, and generalized muscle weakness.

Based on this premise, antibacterial agents although necessary and beneficial, may in themselves prove inadequate to control the disease process at hand. In addition, the shock-like symptoms must be opposed with aggressive fluid therapy and anti-inflammatory agents. Dexamethazone, phenylbutazone, or aspirin, by clinical impression, seem to have a stabilizing effect. Likewise, oral and intravenous fluids, when supplied early in the disease process and in sufficient quantities, may play a life saving role. The emphasis here is on fluid volume, not formulation. As long as the solution is isotonic, most any polyionic formula will have a positive influence.

CALCULATIONS
Acute Mastitis

A	HOW MUCH FLUID VOLUME NEEDED TO CORRECT DEHYDRATION?			
Body Weight 500 (Kg)	×	Estimated Dehydration 10 (%)	=	Fluid Required 50 (Liters)

B	HOW MUCH ELECTROLYTE IS NEEDED TO CORRECT BASE DEFECIT?			
Electrolyte Defecit 10 (Meq./L) HCO	×	ECF* Volume 150 (Liters)	=	Electrolyte Needed 1500 (Meq.) HCO

* ECF = 30% body weight

C	HOW MUCH DOES THE ELECTROLYTE NEEDED WEIGH IN GRAMS?			
Electrolyte Needed 1500 (Meq.)	÷	Electrolyte Concentration 12 (Meq./gram) NaHCO	=	Grams Electrolyte needed 125 (Grams) NaHCO

D	HOW MUCH ISOTONIC FLUID VOLUME IS CREATED BY CORRECTING BASE DEFECIT?			
Electrolyte Needed 125 (Grams) NaHCO	÷	Isotonic Concentration 13 (grams/l Liter) NaHCO	=	Isotonic Volume 10 (liters)

E	HOW MUCH FLUID VOLUME REMAINS AND WHAT SHOULD BE ITS COMPOSITION?			
Fluid vol. required 50	—	Isotonic volume from calculations 10	=	Remaining fluid needed* 40

* This can be Eltrad IV, saline or another polyionic solution

7 tbsp. table salt (17 L .9% NaCl)
5 tbsp. baking soda (5 L 1.3% NaHCO)
1 tbsp. LITE Salt (2 L 1.0% NaCl/KCl)
3 bottles Cal Dextro #2
(1 L 2.5% Ca gluconate)
1 bottle 50% Dextrose

q.s. to 25 Liters with distilled water
(or hot tap water)

This formula provides:

135 Meq. Na/L	5 Meq. Ca/L
110 Meq. Cl/L	29 Meq. HCO /L
5 Meq. K/L	5 Meq. gluconate/L

in a 2% Dextrose base

This particular fluid recipe comes from calculations based on the following clinical estimations:

1) 500 Kg body weight
2) 150 liters ECF
3) 10% dehydration
4) 10 Meq./L base deficit
5) hypocalcemia?
6) hypokalemia?

The preceeding calculations and fluid formulation was designed for intravenous application. An additional 10 gallon (40 L) of oral fluids, enriched with KCl, should be administered at the onset of IV treatment, and again as needed upon its completion.

Case #3 Grain engorgement or lactic acidosis is the focus of the third case discussion. Especially in feedlot situations, newly received cattle are subjected to sudden dietary changes which may induce dramatic metabolic consequences. An unaccustomed intake of highly fermentable carbohydrate changes the gram negative rumen microflora into gram positive ones. These new bacteria encourage the production of lactic acid, which in turn lowers rumen pH and indirectly increases intra-ruminal osmolality. The animals extracellular fluid follows this osmotic gradient into the rumen, causing cellular dehydration and an enhancement of the existing state of acidosis. If unattended, these metabolic changes produce irreversible shock and death. To successfully address these physiologic derangements, two avenues of treatment are needed. First, remove the source of acid production (gastric lavage), and second, administer appropriately buffered fluid therapy. Based on an assessment of the clinical picture, it is postulated that this 200 kilogram steer is 10 percent dehydrated, and that for every liter of his 60 liters of extracellular fluid volume he lacks 15 milliequivalents of bicarbonate. These values are used in the following computations:

CALCULATIONS
Grain Engorgement

A	HOW MUCH FLUID VOLUME NEEDED TO CORRECT DEHYDRATION?			
Body Weight 200 (Kg)	×	Estimated Dehydration 10 (%)	=	Fluid Required 20 (Liters)

B	HOW MUCH ELECTROLYTE IS NEEDED TO CORRECT BASE DEFECIT?			
Electrolyte Defecit 15 (Meq./L) HCO	×	ECF* Volume 60 (Liters)	=	Electrolyte Needed 900 (Meq.) HCO

* ECF = 30% body weight

C HOW MUCH DOES THE ELECTROLYTE NEEDED WEIGH IN GRAMS?

Electrolyte Needed		Electrolyte Concentration		Grams Electrolyte needed
900 (Meq.) HCO	÷	12 (Meq./gram)	=	75 (Grams) HCO

D HOW MUCH ISOTONIC FLUID VOLUME IS CREATED BY CORRECTING BASE DEFECIT?

Electrolyte Needed		Isotonic Concentration		Isotonic Volume
75 (Grams) HCO	÷	13 (grams/l Liter) NaHCO	=	6 (liters)

E HOW MUCH FLUID VOLUME REMAINS AND WHAT SHOULD BE ITS COMPOSITION?

Fluid vol. required		Isotonic volume from calculations		Remaining fluid needed*
20	–	6	=	14

* This can be Eltrad IV, saline or another polyionic solution

An intravenous fluid recipe developed for the management of grain engorgement would be similar to this:

6 tbsp. baking soda
(6 liters isotonic NaHCO)
2 bottles Cal Dextro #2
(7 liters isotonic Ca gluconate and isotonic 5% dextrose)
2 tbsp. LITE salt
(4 liters isotonic NaCl/KCl)
1½ tbsp. table salt
(3 liters isotonic NaCl)

20 liters isotonic solution

Case #4 In bovine practice, the clinical application of fluid replacement theory can't be better exemplified than by its role in combating neonatal calfhood diarrhea. Both oral and intravenous fluid treatment schedules have made a tremendous impact on reducing the scouring calf's mortality rate. Based on traditional antibacterial treatment schemes, profuse, watery diarrhea in a five day old calf with cold nose, ears and feet, dry mucus membranes, and non elastic skin tent, was surely terminal. However today, by combining an accurate assessment of the clinical signs with a thorough understanding of the pathophysiology of Colibacillosis, the application of appropriate fluid therapy may prove life saving. Unlike other types of diarrhea, based on intestinal hypermotility or malabsorbtion; enterotoxic colibacillosis is a hyper-secretory diarrhea. The villous attachment of pathogenic *E. Coli* bacteria induces a massive fluid influx into the bowel, which overwhelms the normal reabsorbtive capacity of the lower gut. This intact reabsorbtive capability, is the reason why oral fluid solutions are so effective in treating the moderately dehydrated calf. Commercial oral fluid preparations are formulated to enhance solute and water absorbtion. A handy, inexpensive cookbook recipe may be substituted here without compromising therapeutic results. One can beef consumé soup, one package jelly pectin (Sure Jell®), two teaspoons baking soda, and one teaspoon Morton Lite® salt, mixed in two quarts warm water, produces a highly palatable, effective oral fluid formula.

This oral therapy must not only correct existing fluid deficits, but must also compete with the contemporary fluid losses produced by the ongoing hypersecretory diarrhea. Therefore, the oral electrolyte solution should be dosed at 20 percent of the calf's body weight per 24 hour treatment period; despite only an 8 percent dehydration estimate at the onset of treatment. For an 80 pound calf, this amounts to 2 quarts of "soup" every 6 hours.

CALCULATIONS
Colibacillosis

A HOW MUCH FLUID VOLUME NEEDED TO CORRECT DEHYDRATION?

Body Weight		Estimated Dehydration		Fluid Required
40 (Kg)	×	10 (%)	=	4 (Liters)

B HOW MUCH ELECTROLYTE IS NEEDED TO CORRECT BASE DEFECIT?

Electrolyte Defecit		ECF* Volume		Electrolyte Needed
15 (Meq./L) HCO	×	20 (Liters)	=	300 (Meq.) HCO

*ECF = 50% body weight

C HOW MUCH DOES THE ELECTROLYTE NEEDED WEIGH IN GRAMS?

Electrolyte Needed		Electrolyte Concentration		Grams Electrolyte needed
300 (Meq.) HCO	÷	12 (Meq./gram)	=	25 (Grams) HCO

D HOW MUCH ISOTONIC FLUID VOLUME IS CREATED BY CORRECTING BASE DEFECIT?

Electrolyte Needed		Isotonic Concentration		Isotonic Volume
25 (Grams) HCO	÷	13 (grams/Liter) NaHCO	=	2 (liters)

E HOW MUCH FLUID VOLUME REMAINS AND WHAT SHOULD BE ITS COMPOSITION?

Fluid vol. required		Isotonic volume from calculations		Remaining fluid needed*
4	–	2	=	2

* This can be Eltrad IV, saline or another polyionic solution

When dehydration exceeds 8 percent, oral fluids alone are not adequate. In this situation, intravenous delivery is needed to prevent further dehydration and hypovolemic shock. In peracute cases of Colibacillosis, blood pH levels are depressed to 7 (normal 7.42), and bicarbonate levels drop to 10 Meq. per liter (normal 25). Although total body potassium is low, serum potassium levels are elevated due to extracellular potassium eflux in exchange for hydrogen ion. Based on this information, and our clinical assessment of a 40 kilogram calf which is 10% dehydrated; the following calculations can be accomplished.**

The remaining two liters of fluid replacement is composed of .9% NaCl as illustrated in this economical IV fluid recipe:

2 tbsp. baking soda / 4 liters warm water
1 tbsp. table salt / Delivery rate: 1 liter/hour

The secret to succeeding at Poker is to bet no more than you can afford to lose. The bottom line is profitability. When your hand is called, the cards you hold must be of winning caliber, or else you forfeit your wager.

This same logic applies to therapeutic schemes in food animal practice. Combining the draw of the fluid therapy aces with sound clinical judgement and sharp business acumen, we hold onto a veterinary medical full house. Wagering on this winning hand will result in improved profits, garnished from therapeutic success and client satisfaction.

Forwarding Planning Committee (House of Lords) in Session.