Hydrating the Dehydrated Horse: Practical Fluid Therapy for the General Practitioner

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Goals for the Presentation

- What is the Fluid Composition of the horse
  - Where is all the water?
  - What are the maintenance needs?
- Assessing Fluid Loss
  - Dehydration
  - Hypovolemia
- Oral Fluid Therapy
- Practical Intravenous Fluid Therapy
- What to do With Fluid Shortage?
Introduction

- Fluid Therapy
  - Corner stone of treatment
  - Part almost every treatment plan
    - General farm veterinary care
    - Hospital veterinary care

- Fluid therapy is one of the oldest therapies

- Fluid therapy is continuously widely debated in veterinary and human medicine
  - What is debated about it?
    - Volume, shock dose vs. maintenance dose?
      - How should each be defined?
    - Types of fluids colloid vs. crystalloid?
    - Fluid additives?
Critical Care Medicine

- Delivery of large volumes of IV fluids
- Polyionic fluids (IV vs. Orally), colloids, and partial or total parenteral nutrition
- Long term fluid therapy
  - Replacement therapy
  - Maintenance therapy
    - No ideal solution for this
IV fluid therapy (USA)
- 5L fluid bags: ~1 million used annually (Abbott, Baxter, Dechra)
- Considered replacement fluids
  - Composition similar to ECF
  - No energy source provided
- Requires additives
  - Potassium chloride
  - Magnesium sulfate
  - Calcium gluconate

Replacement fluids = Lots of salt
>50,000 kg salt
>$30 million

Currently the best that we have
Route of Fluid Therapy

- Oral
- Intravenous
“Critical” In the Field Medicine

- Are there Other Options?
- Will paste salt solutions work?
“Critical” In the Field Care

- Must consider:
  - Type of patient (neonate vs. adult)
  - Lesion that is present/suspected
    - To date large colon impaction/displacement and spasmotic colic remain the two most common causes of colic
      - Primary care facility vs. referral hospital
  - Enteral fluid therapy +/- hypertonic electrolyte paste/slurries remain viable therapies for these types of colic
    - Potentially more physiologic → increased colonic motility
      - Gastrocolic reflex
      - Potentially more economically appealing
What makes up the Horse

450-500 kg (1000-1200 lb)

Horse

60% H₂O BWT

300 liters (80 gallons)

2/3 or 66% ICF
200 liters (60 gallons)

1/3 or 33%
ECF
100 liters (30 gallons)

25% intravascular
50% interstitial
25% transcellular
Central Osmoreceptors = THIRST

- Within the CNS, osmoreceptors sense changes in plasma osmolality
  - Normal ~280 mOsm/L
  - Increased sodium (Na+)
  - Receptors triggered with ≤ 2% change in osmolality
- Activate thirst receptors
- ↓ saliva / sensation of dry mouth
- Encourages water consumption
How is Fluid Balance controlled in the Body

- **Effective circulating volume ➔ Blood volume**
  - Renin angiotensin aldosterone system
    - Control renal reabsorption of Na and water in the collecting ducts

- **Regulation of Osmolality**
  - ADH controls plasma osmolality
  - Hypothalamic osmole receptors
    - Sense change in plasma osmolality
    - Changes of <2-3 mOsm/kg compensatory mech
      - Normalize plasma osmolality
      - ADH and thirst
How is Fluid Balance controlled in the Body

Ineffective Osmole

Effective Osmole
Considered Na, Glucose, Cl, K
Water Movement Between Compartments?

- Movement of water:
  - Continuous revolving door
  - Cellular, interstitial, transcellular, and vascular compartments
  - Requirement for survival

- Movement of water is related to:
  - “Effective” osmoles
    - DO NOT cross the cell membrane freely
      - Main effective osmoles (Na, glucose)
      - Mannitol, ketoacids, lactic acid, phosphate, sulfate, contrast
  - “Ineffective” osmoles
    - DO cross the cell membrane freely
      - BUN, ethylene glycol, ethanol, methanol, acetylsalicylic acid, isopropyl alcohol
Semi-permeable membranes separate the fluid compartments: fluids are in constant motion between the 3 compartments.
Oncotic Pressure:

- Proteins create oncotic pressure (COP)
  - Albumin 70%
  - Globulins, fibrinogen, SAA
Edema

Venular end

plasma

endothelium

reabsorption

interstitial fluid

filtration

tissue cells

Arteriolar end

osmosis
Bandaging: Increase Interstitial Pressure
Daily Fluid Ins and Outs

- 450 kg horse drinks
  - 40-60 ml/kg/day or
  - 18-27 liters of H₂O = 5.25 gallons
  - Dependent on ambient temperature/activity

- Produces 3L daily metabolism
- Urinary loss = 5L
- Fecal loss = 20L
- Incessant losses sweat/breathing
What’s The Difference

DEHYDRATION VS. HYPOVOLEMIA
Failure to Replace Losses

- Failure to replace insensible losses leads to **Dehydration**
  - Loss of total body water
  - Failure or inability to drink

- Failure to replace isotonic fluid loss leads to **Hypovolemia**
  - Loss of water + electrolytes
  - Horses with gastrointestinal losses
    - Diarrhea
    - Nasogastric reflux
  - Blood loss
  - Sepsis/Endotoxemia
    - Vascular fluid pooling
Clinical Signs of Dehydration

- Tachycardia
- Irritability
- Increased skin tent
- Sunken eyes
- Concentrated urine
- Dry mucous membranes
- Muscle spasms and cramping
- Difficult to quantify “opinion driven”
Estimation of % Dehydration:

Exam findings are *insensitive*

- **5 – 7% = Mild dehydration**
  - Decreased skin turgor, slightly tacky membranes

- **8 – 10% = Moderate dehydration**
  - Depressed mentation, tacky mm, CRT > 2 – 3 sec
  - Correlates with hypovolemia

- **> 10% = Severe dehydration**
  - Cool extremities, poor perfusion, CRT > 4 sec

- **> 15% Lethal**
## Parameters used for Estimation of Dehydration in the Horse

<table>
<thead>
<tr>
<th>% Dehydration</th>
<th>Heart Rate BPM</th>
<th>CRT s</th>
<th>PCV% / TP g/dl</th>
<th>Creatinine mg/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>40-50</td>
<td>2</td>
<td>40 / 7</td>
<td>1.5 - 2</td>
</tr>
<tr>
<td>8</td>
<td>51-60</td>
<td>3</td>
<td>45 / 7.5</td>
<td>2 - 3</td>
</tr>
<tr>
<td>10</td>
<td>81-100</td>
<td>4</td>
<td>50 / 8</td>
<td>3 – 4</td>
</tr>
<tr>
<td>12</td>
<td>&gt;100</td>
<td>&gt;4</td>
<td>&gt;50 / &gt;8</td>
<td>&gt;4</td>
</tr>
</tbody>
</table>
Cases!
Case #1: Estimating Volume Deficit from Dehydration

- 400 kg horse
- Sick 3 days
  - Fever
  - Depression
  - Poor appetite
  - Not drinking well
Physical Examination

- S = Depressed
- O = T: 101.0F
  HR: 50 bpm
  RR: 28 bpm
- A = Dehydrated
- P = 400 kg X 0.06 = 24 liters

- % dehydration equation =
- Bw(kg) x % dehydration = Liters
Replace Fluid Deficit

- Oral or enteral fluid therapy
- Intravenous
  - Polyionic (balanced)
  - Polyionic (hypertonic)
  - Colloids
    - Plasma
    - Hetastarch
    - Blood
Enteral Fluid Therapy

- **Advantages**
  - Fluid does not have to be sterile: cheaper
  - Estimate electrolyte supplementation
  - Small intestinal H₂O absorption
  - Stimulates gastro-colic reflex

- **Disadvantages**
  - Patients with moderate to severe dehydration
  - Ileus and/or malabsorption due to ischemia/hypoperfusion
  - Gastric outflow obstruction
    - Positive net reflux
    - Requires intravenous fluid therapy
Gastric Capacity

- 450 – 500 kg horse
- Comfortably 6 - 8 liters
- Accommodates 20 liters
- Emptying time
  - Water 30 minutes
  - Hay 3 – 5 hours
- Delayed emptying
  - Hypoperfusion
  - Colic
400 kg Horse 6% Dehydrated

- Deficit = 24 liters = 400 kg X 0.06
- Maintenance = 20 liters = 400 kg X 40-60 ml/kg/24 hours
- 24 hours: 44 liters
- Plan
  - Pass nasogastric tube
  - Administer 10 liters warm water
    - + 2 oz NaCl
    - + 2 oz KCl
  - Every 2 – 4 hours

“One kidney is smarter than all the internists in the world.”
Oral/Enteral Fluids

- Commercially available
  - Resorb
- Oral electrolyte solution
  - NaCl 10 gm
  - NaHCO3 15 gm
  - KCl 75 gm
  - K2HPO4 60 gm
  - Q 21 liters of water
Oral/Enteral Fluids

- Enteral Fluids
  - Useful for treatment of impaction colic
  - May also include osmotic agents
What About Mineral Oil?

- Great marker
  - 8-10 hours
  - Suggests patency
  - Lubricant
- Doesn’t penetrate impaction
  - Does not soften impaction
  - May be absorbed into enterocyte
- Risk of aspiration
  - “Paraffin aspiration”
Goals for the Presentation

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  - Where is the water?
  - Maintenance needs
- Assessing Fluid Loss
  - Dehydration
  - Hypovolemia
- Oral Fluid Therapy
- Practical Intravenous Fluid Therapy
- What to do with fluid shortage?
Hypovolemic Case – Within Hours

- Loss of vascular volume
  - Blood loss
  - Plasma volume
  - Isotonic fluid loss

- Maldistribution of vascular volume
  - Sepsis -/+ 
  - Septic shock
Hypovolemia

- Depressed/abnormal mentation
  - Standing back of stall
  - Head down
  - Ears back
- Tachycardia (> 60 bpm)
- Tachypnea (> 20 bpm)
- Cold appendages
- Prolonged CRT
- Abnormal mucous membranes
- Poor
  - Jugular fill
  - Pulse pressure
- Not urinating
<table>
<thead>
<tr>
<th>Dehydration</th>
<th>Hypovolemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>Hours</td>
</tr>
<tr>
<td>Decrease in TBW</td>
<td>Loss of vascular volume</td>
</tr>
<tr>
<td>Failure to replace water</td>
<td>Very debilitated</td>
</tr>
<tr>
<td>Increased skin tent</td>
<td>Shock states</td>
</tr>
<tr>
<td>Dry membranes</td>
<td>Indices of poor tissue perfusion</td>
</tr>
<tr>
<td>Muscle cramping</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Mild tachycardia</td>
<td>Hemoconcentration</td>
</tr>
</tbody>
</table>
Tools to Aid Your Diagnosis...

- **PCV**
  - Hematocrit
- **Total Solids**
  - Refractometer (combine with PCV)
  - Estimate of oncotic pressure
Additional laboratory data:

- Serum Creatinine
  - Pre-renal azotemia
    - BUN + creatinine
  - Creatinine > 1.5 mg/dl

- Urine specific gravity
  - Concentrated urine (>1.025)
Additional Laboratory Data:

- **Lactate:**
  - Commonly produced
    - anaerobic metabolism
      - poor tissue oxygenation
  - Normal < 2 mmol/l
  - Causes of increased lactate
    - Hypovolemia
    - Endotoxemia
    - Ischemic intestine
    - Myopathy
Fluids Available for Horses

- Intravenous Crystalloids: Isotonic vs. Polyionic

<table>
<thead>
<tr>
<th>Product</th>
<th>pH</th>
<th>mOsmol/L</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Cl</th>
<th>Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactated Ringers</td>
<td>6.5</td>
<td>273</td>
<td>130</td>
<td>4</td>
<td>3</td>
<td></td>
<td>109</td>
<td>Lactate 28</td>
</tr>
<tr>
<td>Plasmalyte 148</td>
<td>7.4</td>
<td>294</td>
<td>140</td>
<td>5</td>
<td>3</td>
<td></td>
<td>98</td>
<td>Acetate 27</td>
</tr>
<tr>
<td>0.9%NaCl</td>
<td>5</td>
<td>308</td>
<td>154</td>
<td></td>
<td></td>
<td></td>
<td>154</td>
<td></td>
</tr>
<tr>
<td>Normasol-R</td>
<td>6.4</td>
<td>295</td>
<td>140</td>
<td>5</td>
<td>3</td>
<td></td>
<td>98</td>
<td>Acetate 27, Gluconate 23</td>
</tr>
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</table>
Designing a Fluid Therapy Regimen

- Determine AMOUNT to give per day
- Determine TYPE of fluid to give
- Determine METHOD of fluid administration
# Fluid Therapy Regimens

<table>
<thead>
<tr>
<th>MAINTENANCE</th>
<th>REPLACEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dehydration</td>
<td>Dehydration</td>
</tr>
<tr>
<td>No additional losses</td>
<td>Ongoing losses</td>
</tr>
<tr>
<td>Fluid composition</td>
<td>Fluid composition</td>
</tr>
<tr>
<td>Low Na</td>
<td>Similar to plasma</td>
</tr>
<tr>
<td>Low Cl</td>
<td></td>
</tr>
<tr>
<td>Higher K</td>
<td></td>
</tr>
<tr>
<td>Higher Mg</td>
<td></td>
</tr>
</tbody>
</table>
Fluid Replacement - Amount

- Maintenance + % dehydration + ongoing losses
  - Total fluid plan/24 hours
    - Dynamic patient

- \( \text{BW(kg)} \times \% \text{ dehydration} = L \) of fluids to correct dehydration

- 40-60 ml/kg/day \( \times \) BW(kg) = L/day Maintenance

- Shock Dose 80-100ml/kg = give in \( \frac{1}{4} \) dose amounts for total of 100ml/kg
  - Reserved for patients displaying signs of hypovolemia
Dehydration Vs. Hypovolemia

○ A horse can be suffering from both dehydration that has progressed to be also hypovolemia

However........................

○ A hypovolemic horse CANNOT ever become systemically dehydrated...... It will be dead
Evaluation of Dehydration vs Hypovolemia

- History
  - Acute vs chronic

- Physical exam
  - Heart rate, mucous membranes

- Laboratory data
  - PCV/TP, creatinine
Evaluation of Hypovolemia

- Aggressive volume support
- Intravenous fluids
  - IV catheter
  - Method for administration
- Crystalloids
  - Polyionic (80 – 100 ml/kg)
    - “Shock dose”
    - Give in ¼ volumes and reassess
  - Hypertonic (4 ml/kg)
- Colloids
  - Plasma
  - Hetastarch (10 -25 ml/kg)
Types of Catheters Available

- Catheter material:
  - Teflon
    - Rigid
    - Most thrombogenic
    - Short-term use only
  - Polyurethane
    - Least thrombogenic
    - Supple, may be more difficult to place
    - Long-term use
IV Catheter Placement

- Aseptic technique
- Suture in place
  - ± Bandage useful for protection
- Monitor site for signs of inflammation
  - Thrombophlebitis
- Flush frequently
  - Heparinized saline
  - Heparin lock (3 ml heparin) 12 - 24 hours
- Change extension set / PRN cap as needed
Size of Catheter

- Larger bore catheters for emergency resuscitation 10 – 14 g
- Greater the radius
  - Faster the fluids run into the 4th power
- Shorter the catheter length multiply flow by 8

\[ Q = \pi r^4 P \]
\[ 8 \eta L \]
Using Crystalloid Fluids

• **Emergency Therapy**
  - Hypertonic saline: 4 ml/kg or 2 liters/1000 lbs
    - Administer 2 L 7.2 %NaCl
    - Administer 20 L isotonic replacement
  - Expand the vascular volume
  - Positive ionotropic effects
  - Improve cardiac output
  - Improve oxygen delivery
Hypertonic saline pulls water from the intracellular space into the vascular space. 4 X amount given. Lasts 30 – 60 minutes.
Emergency Crystalloid Therapy
5 yr. old Arabian gelding – 400 kg

- Digital vessel laceration
- Hypovolemia
  - HR = 80 - 100 bpm
  - Membranes = pale
  - Cold ears/muzzle
  - Very quiet
- Stop the bleeding
  - Tight bandage
- Administer
  - 2 liters 7.4% saline
  - 30 liters LRS
Response to therapy:

...following 2L hypertonic + 30L crystalloid...

- Signs at presentation:
  - Quiet
  - HR 80 - 100 bpm
  - Tacky, CRT > 3s
  - Slow jugular fill
  - Poor pulse pressure
  - Cool distal extremities

- Response to Therapy:
  - Brighter, Front of stall
  - HR = 56 bpm
  - Moist, CRT ~1.5 s
  - Improved jugular fill
  - Stronger pulse pressure
  - Urination!!
But I can’t even get IV fluids

But I can’t even get IV fluids

19 liters of 0.9% NaCl  Can mix with 110 g NaCl
But I can’t even get IV fluids

Complications

- Signs of endotoxemia
  - Tachycardia
  - Fever
  - Colicky?
  - Muscle fasciculations/shaking
- Why these clinical signs with fluids
  - Potential risk for endotoxin present in the distilled H₂O
- Potential increased risk of vein phlebitis and thrombophlebitis?
  - Most likely no greater risk then with conventional fluids
- Is this a revelation in “standard of care”
  - Will the shortage end?
Questions?
Thank You
Low Oncotic Pressure

- PCV = 55%
- TS = 3.5 g/dl
- Albumin = 1.0 g/dl
- Colloid Therapy
  - Plasma or hetastarch or both
  - 10 - 25 ml/kg hetastarch
  - 100 kg X 10 ml/kg =
Fluid Therapy Plan

- Place IV catheter
- Administer 1 liter hetastarch
- Follow with 9 liters LRS
  - Bolus 3 liters
  - 6 liters 1 - 2 liters/hr
- Monitor response to therapy
- Will she drink?