Fluid therapy in real-life practice: All you need to know!

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Dr. Lee’s financial disclosure
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View System Requirements:
Fluid therapy: Why do we care?

Life-saving!
Goals of this talk

- Body water
- Water requirements
- Fluid balance
- Types of fluid loss
- Hypovolemia
- Dehydration

- Fluid therapy and choices
  - Routes
  - Choices
- Types of fluid
  - Crystalloids
  - Colloids
  - Blood transfusion medicine
- Complications
Why do we need fluid therapy?

- Shock resuscitation
- Rehydration
- Maintenance requirements
- Replacement of ongoing losses
- Anemia
Goals of fluid therapy

- Increase & maintain organ tissue perfusion
- Maintain blood pressure
- Maintain euvolemic state
- Correct electrolyte or acid-base imbalances
- Treat for hypoproteinemia

All this for $2/bag!
Water requirements

- Small dogs/cats: 60 ml/kg/day
- Larger dogs: 50 ml/kg/day
- Neonates: 60-180 ml/kg/day
Hypovolemia ≠ Dehydration
HYPOVOLEMIA: “SHOCK”

cellular hypoxia
Physical assessment of hypovolemic shock:

- Tachycardia
- Tachypnea
- Pallor
- Prolonged CRT
- Poor pulse quality
- Cold peripheral limbs
- Dull mentation
- Decreased UOP
- Septic shock
  - Tachycardia
  - Brick, red mm
  - Rapid CRT
  - Bounding pulse quality
Clinical signs of Hypovolemic Shock

- Pale mucous membranes
- Prolonged capillary refill time
- Cold extremities
- Tachycardia
- Tachypnea
- Dull mentation
- Decreased urine output
Physical assessment of hypovolemia

- Pulse quality
- Femoral pulse
  - Systolic > 60 mmHg
- Dorsal metatarsal pulse
  - Systolic > 90 mmHg
What route?

- Oral
- Subcutaneous
- Intraperitoneal
- Intravenous
- Intraosseous
Treatment for hypovolemia

- #1 crystalloid fluid therapy
- #2 colloid support if indicated
- “Shock dose” = blood volume

Beware "SHOCK DOSE"
Treatment for hypovolemic shock

- "Shock dose" = 60-90 ml/kg canine
  = 60 ml/kg feline

- ¼ of a shock dose over 15 minutes, reassess

- Repeat as indicated

- Serial physical examinations!
Hypovolemic shock

- If no improvement, repeat...

- After that (if no improvement) consider:
Hypovolemic shock

- Bolus 10-20 ml/kg crystalloid IV/20 minutes and reassess, or

- Bolus 5 ml/kg colloid IV/20 minutes and reassess
Calculations:

Shock: ___ ml bolus to effect

Dehydration: ___ ml/hr
+ Maintenance: ___ ml/hr
+ Ongoing Losses: ___ ml/hr

= Initial Fluid Rate ___ ml/hr

THEN ....
Fluid Therapy

Dehydration?

__% dehydration x __wt in kg = ___L

20 kg patient is 10% dehydrated
20 kg x.10 = 2.0 liters (2000 ml)
Response to treatment for hypovolemic hypotension?
Clinical improvement?

- Improved pulse pressure and quality
  - femoral > 60 mmHg
  - dorsal metatarsal > 90 mmHg
- Improved mentation
- Improved CRT and mm color
- Resolution of hypothermia
- Improved heart rate?
Make sure the patient is NOT in cardiogenic shock...as long as you rule that out, proceed with IV fluid therapy based on reassessment.
Don’t put on vasopressors if the vessels are empty!
Dehydration
Is skin turgor always the best?
## Physical assessment of dehydration

<table>
<thead>
<tr>
<th>% dehydration</th>
<th>Clinical signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5%</td>
<td>Not detectable</td>
</tr>
<tr>
<td>5-6%</td>
<td>Subtle loss of skin elasticity</td>
</tr>
<tr>
<td>6-8%</td>
<td>Definite delay in return of skin to normal position</td>
</tr>
<tr>
<td></td>
<td>Slight prolongation of CRT</td>
</tr>
<tr>
<td></td>
<td>Possibly dry mm</td>
</tr>
<tr>
<td>10-12%</td>
<td>Tented skin stands in place</td>
</tr>
<tr>
<td></td>
<td>Definite prolongation in CRT</td>
</tr>
<tr>
<td></td>
<td>Sunken eyes</td>
</tr>
<tr>
<td></td>
<td>Dry mm</td>
</tr>
<tr>
<td></td>
<td>Possible signs of shock</td>
</tr>
<tr>
<td>12-15%</td>
<td>Definite signs of shock</td>
</tr>
<tr>
<td></td>
<td>Death imminent</td>
</tr>
</tbody>
</table>
Laboratory/Diagnostic Assessment of Dehydration

- Hemoconcentration
- Pre-renal azotemia
- Urine volume and specific gravity*
- Central venous pressure (CVP)
- Lactate → perfusion
Treatment for dehydration

- Stability of the patient
- Routes of fluid administration
- Fluid choices

*what happens slowly, treat slowly*
Treatment for dehydration

- **Dehydration:** % dehydration X kg X 1000 ml/s
  - Replace over 6-48 hours
  - Cats: replace dehydration > 24 hours

- **Maintenance:** 50-60 ml/kg/day

- **Ongoing losses**
  - eg, polyuric renal failure, diabetes, mannitol therapy
Fluid therapy in critical care

- Fluid routes
  - Oral (PO)
  - Intraperitoneal (IP)
  - Subcutaneous (SC)
  - Intraosseous (IO)
  - Intravenous (IV)

- Types of fluids
Oral water

- Underrated
- Safest
- CRIs of Clinicare here
- 20-30 ml warm water boluses q. 4 hours
- Heart friendly
  - Lack of fluid overload
- GI friendly
  - Stimulates enterocytes
  - Liquid diet
Oral water – baited food
Subcutaneous

- Rehydration
- NOT for shock
- Only isotonic solutions
- Avoid dextrose
- Maintain hydration in renal failure patients
Subcutaneous fluids

- SQ fluids
  - Maintenance rate
    - 5 kg cat \( \times \) 60 ml/kg/day = 300 mls SC

Contraindications?
Intraperitoneal (IP) fluids

- IP fluids
  - NOT for adults
  - Reptiles
  - No birds! Air sacs!
  - Puppies/kittens
    - If warm, stable
    - Plasma if no colostrum
Intraosseous

- 18 to 22 ga. spinal needle or hypodermic needle
  - Head of the tibial crest
  - Tibial tuberosity
  - Wing of ileum
  - Trochanteric fossa – femur
  - Greater tubercle – humerus

Contraindications?
IV fluids

- Aseptic catheter placement

- Catheter type
  - Poiseuille’s law $Q = \Delta P \frac{r^4 \pi}{nL}$
  - Size
  - Length
  - Vessel choice

- Appropriate fluid choice
IV fluids

- Appropriate fluid choice
  - Sodium
  - Hydration
  - $$
  - $$
  - 24 hour care?
    - If not available, consider aggressive IV fluids + SC fluids
Goals of IV fluid therapy

- Daily catheter care
- Daily PCV/TS/BG/Na⁺/K⁺ monitoring
**Treatment**

- **Goal of assessing hydration**
  - Hemodilution (PCV/TS 35/5)
  - Isosthenuria (aim for 1.015-1.018)
  - Drinking water in the cage
  - Weight gain $\rightarrow$ weigh q. 12-24

- **Why is weight so important?**
  - 30 kgs, 10% dehydrated $= 3$ L
Crystalloids

- Isotonic with plasma
- $\text{Na}^+$: major osmotically active particle
- 25% remains in IVS of the ECF after 1 hour

Buffered vs. non-buffered
Crystalloids

- **Lactated Ringers**
  - Provides buffer – lactate → bicarbonate (via liver)
  - Contains calcium (not for transfusions, P-containing meds, fluids)
  - Contraindicated: liver disease, LSA

- **Normosol-R**
  - Provides buffer
  - Acetate & gluconate → bicarbonate (via muscle, tissues)
Crystallloids

- **Plasmalyte-R**
  - Lactate and acetate
  - 10 mEq potassium
  - Balanced, isotonic

- **Plasmalyte-A/Norm-R**
  - Gluconate and acetate

- **Plasmalyte-56**
  - Na⁺/Cl⁻ 40
  - Acetate

- **Plasmalyte-148**
  - Gluconate and acetate
  - Na⁺ 148
Crystalloids

- **0.9% NaCl**
  - 154 mEq/L of both Na\(^+\) and Cl\(^-\)
  - Osmolality 310 mOsm/L
  - Beware of sodium loading (CHF, liver disease)
  - Beware raising Na\(^+\) > 0.5 mEq/hr
  - Acidifying

- **0.45% NaCl + 2.5% Dextrose**
  - More free water available
  - Beware dropping Na\(^+\) < 0.5 mEq/hr
  - Best for heart disease, minimal Na\(^+\) load
Fluid Therapy: Bold Statements

Diagram showing the process of a red blood cell in a hypotonic solution and water entering the cell, causing cell swelling.
# Crystalloids

<table>
<thead>
<tr>
<th>Solution</th>
<th>Ringers</th>
<th>LRS</th>
<th>Plasmalyte 56</th>
<th>Plasmalyte R</th>
<th>Plasmalyte A; Norm R</th>
<th>0.9% NaCl</th>
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<tr>
<td>Na⁺</td>
<td>147</td>
<td>130</td>
<td>40</td>
<td>140</td>
<td>140</td>
<td>154</td>
</tr>
<tr>
<td>K⁺</td>
<td>4</td>
<td>4</td>
<td>13</td>
<td>10</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mg⁺</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>156</td>
<td>109</td>
<td>40</td>
<td>103</td>
<td>98</td>
<td>154</td>
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<tr>
<td>Gluconate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0</td>
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<tr>
<td>Lactate</td>
<td>0</td>
<td>28</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acetate</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>47</td>
<td>27</td>
<td>0</td>
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<tr>
<td>Osmolarity</td>
<td>310</td>
<td>270</td>
<td>111</td>
<td>312</td>
<td>294</td>
<td>310</td>
</tr>
</tbody>
</table>
Hypertonic Saline

- 5 mL/kg over 5-10 minutes

- Indications
  Small volume resuscitation, head trauma

- Potential side effects
  Dehydration, hypernatremia (additional fluid therapy should be used)
Turbo-Starch

- Hypertonic saline + colloid
- 13/47 (60cc, 23.4%)
- 5 mL/kg over 5-10 minutes

Indications:
- Small volume resuscitation
- Head trauma
THE USE OF COLLOIDS AND ALBUMIN IN SMALL ANIMAL PATIENTS
Overview

Colloid physiology
- colloid osmotic pressure (COP)
  - albumin (80%)

Artificial colloids
- structure and function

Therapeutic uses
Definitions

Colloid
- large molecular weight substances (> 30 kDa)
- natural colloids (albumin, blood products)
- artificial colloids

Colloid osmotic pressure (COP)
- Pressure produced by osmotically active particles
Osmolarity

- Depends on **number** of osmotically active particles, not size

Colloids: effective osmoles in number; affects oncotic pressure due to size

- does not cross intact endothelium
- maintain number through continuous breakdown
Pressure Balance

- Osmotic pressure
  - plasma proteins
  - holds water within vascular space

- Hydrostatic pressure
  - propulsion of blood from the heart
  - water from vascular space to interstitium
Capillary

P: 15-35 mmHg

Π: 28 mmHg

Interstitial Space

P: 1-2 mmHg

Π: 3 mmHg
What Is A Colloid?

- High molecular weight substance that largely remains in the intravascular compartment, thus generating an oncotic pressure

- Greater intravascular persistence (vs. crystalloids)
  - This property is lost when vasculitis is present
Natural Colloids

- Plasma
  - FP, FFP, cryoprecipitate
  - large volume required to raise albumin/COP

- Concentrated albumin solutions
  - human serum albumin
    - hypersensitivity reactions
  - canine specific albumin
Artificial Colloids

Dextrans
- branched polysaccharide
  - dextran sucrase enzyme synthesizes from *Leuconostoc mesenteroides*
- 10-150 kDa

Gelatins
- protein formed from hydrolysis of bovine collagen
- 5-50 kDa

Hydroxyethyl starch (HES)
- 70-670 kDa
Hydroxyethyl Starch

- Derived from amylopectin (corn starch)
  - structurally resembles glycogen

- Add hydroxyethyl group at C2 and C6
  - stabilizes molecule
Describing HES Solutions

- Three numbers
  - Concentration of the solution (6% is iso-oncotic)
  - Mean MW
  - Degree of substitution

Molar degree of substitution
- Ave number hydroxyethyl groups/glucose unit
- More substitution = lasts longer

C2/C6 ratio
- Higher the ratio, longer the half-life
- Hydroxyethyl at C2 inhibits alpha-amylase access
Three Numbers

- Concentration of the solution
- Average molecular weight
- Degree of substitution
  - Tetrastarch: 6%/130/0.4
Types of hydroxyethyl starch

- Hetastarch
  - 600/0.6 - 0.75

- Pentastarch
  - 250/0.45 – 0.5

- Tetrastarch
  - 130/0.4
Metabolism and Elimination

- Larger hydroxyethyl molecules cleaved by amylase
  - elevation in serum amylase
  - dogs: 3x amount of amylase as humans

- Renal elimination
  - accumulation in RE system

- Plasma expansion effects (1-6 hours)
Beneficial Effects

- Prevent post-op nausea/vomiting
  - Decreases gut mucosal edema
- Maintenance of colloid osmotic pressure
- Low volume fluid resuscitation
- Traumatic brain injury
- Prevention of capillary leak
  - Pentastarch
Reported Detrimental Effects

- Hypersensitivity reactions
  - Pruritis (humans)

- Renal dysfunction

- Coagulation abnormalities

- Volume overload
Renal Dysfunction

- Decreased tubular filtration
  - excretion of colloid particles

- Osmotic nephrosis

- Rapidly degradable HES safer

- Do NOT use with oliguric/anuric renal failure
Coagulation Abnormalities

- HMW hydroxyethyl starches
  - Decreased Factor VIII/VWF
  - Alteration of fibrin formation
  - Platelet function abnormalities
  - Elevation: PTT

- Evidence of abnormalities with LMW HES
Volume Overload

- Increased intravascular volume
- Cats!

- Cumulative effect
  - Decreased excretion
  - Length of time
  - Heart failure
HES in Sepsis

- Contraindicated in humans

- RTCs show an increase in mortality and need for renal replacement therapy
  - vs. crystalloid therapy alone

- No studies in veterinary patients
Beneficial Effects

- Support of COP
  - Hypoalbuminemia

- Hypotension/hypovolemia
  - Low volume fluid resuscitation

- Traumatic brain injury
- Pulmonary contusions
- Vasculitis?
Dose of HES

- Hetastarch: 20 ml/kg/day CRI
  - Bolus 5-10 ml/kg aliquots

- Tetrastarch: 50 ml/kg/day CRI
  - Vetstarch™ (Abbott Animal Health)
  - Voluven®

- Colloids + crystalloids = maintenance rate
  - Decrease crystalloid dose by 40%
Recommendations, Artificial Colloids

- Use for COP support
  - Hypoalbuminemia
- Vasculitis?
- Watch for fluid overload (cats…)
- Cautious use
  - Coagulopathy
  - Renal disease
Concentrated Albumin Solutions
Human serum albumin
- Reports of type III hypersensitivity
  - Ag-Ab complexes
- Definite Ab formation

Canine serum albumin
Sources of Albumin

- Fresh frozen plasma = **0.025 grams albumin/ml**
  - dose to increase albumin = 20-30 ml/kg/day
  - macroglobulins, coagulation proteins, antithrombin

- Human albumin
  - 25% solution = **0.25 grams albumin/ml**
  - 10x more albumin per ml vs. FFP

- Canine albumin
  - 5 grams/vial
HSA: Clinical Indications

- Chronic disease causing albumin loss?
  - Lose transfused albumin
  - Concern for delayed hypersensitivity reactions, immune-complex disease
    - PLE/PLN

- Reserve use for critically ill patients, acute SIRS/sepsis diseases
Dose, HSA

- Extrapolated from dose used in humans
- 25% HSA solution
- 0.25 grams/ml
- 1 ml/kg/hr x 2 hours, then 0.1-0.3 ml/kg/hr
Human Albumin: Veterinary Studies


Prospective Study
- EM Craft and LL Powell
- Dogs with septic abdomen

14 dogs: randomized
- 7 received CSA
- 7 did not

Raised patient albumin levels
No adverse events
Same hospitalization time
Small number of patients
The SAFE Study

- Multi-center, randomized, double-blinded
- n = 6997
- 4% albumin vs. crystalloids for fluid resuscitation in ICU patients
- No difference between groups (28 day outcome)
  - mean days in ICU or in the hospital
  - days of mechanical ventilation
  - days of renal-replacement therapy
  - single or multiple organ failure
  - relative risk of death
Recommendations: Albumin

- Reserve use for critically ill, hypoalbuminemic patients
- NUTRITION
- Artificial colloids for COP support
- Studies: no control population
- Marker of illness severity or true improvement with albumin?
- Canine albumin: not available
BLOOD PRODUCTS
Blood transfusion medicine

- Transfusion trigger PCV = 20%

- Clinical signs?
  - Tachycardiac
  - Pallor
  - Tachypneic
  - Hypovolemic shock
  - Snappy or thready pulses
  - Chronicity
Blood transfusion medicine

- Universal donor
- Necessity to crossmatch?
- Blood typing?
- Canine vs. feline

Indications for:
- pRBC
- FFP
- Frozen plasma
- Cryoprecipitate
- Whole blood
Blood products

- **pRBC**
  - 10-20 ml/kg
  - Blood type/crossmatch
  - Treatment for anemia
  - No clotting factors; minimal COP!

- **Whole blood**
  - COP 20
  - Clotting factors
  - Platelets (limited)
  - RBC
Blood products

- **FFP**
  - 10-20 ml/kg
  - COP 20
  - Clotting factors, Vit K dept, alpha-macroglobulins
  - Minimal albumin!!!

- **Frozen plasma**
  - COP = 20
  - 10-20 ml/kg
  - Some clotting factors
  - Use for Vit K deficiency!!!
Blood products

- Cryoprecipitate
  - Concentrated clotting factors - vWF
  - Platelets (limited)
CASE EXAMPLE
Buddy, 1 yr old CM Cocker Spaniel

- HBC 15 minutes prior
- Lost consciousness at the scene, non-ambulatory since
- PE
  - Tachypneic, minimally responsive, laterally recumbent; HR 200
  - Increased bronchovesicular sounds bilaterally
  - Minimally responsive to noxious stimuli
  - Neuro: anisocoria, CNs WNL, normal reflexes x 4
Quick Diagnostics

- PCV 45%  
- TP 4.8 mg/dl  
- Lactate 5.6 mg/dl  
- BP 70 mmHg systolic  
- pH 7.29
  - HCO3: 12 meq/L  
  - PaCO2: 28 mmHg  
  - PaO2: 65 mmHg  
  - BE: -10 meq/L  
  - Metabolic acidosis/respiratory alkalosis  
  - Hypoxemia  
- FAST: positive for bloody fluid (mod amt)
Problem List

- Severe trauma
- Hypoperfusion
  - Lactic acidosis
  - Hypotension
  - Blood loss
- Pulmonary contusions
- Traumatic brain injury
Fluid Therapy Plan

- Traumatic brain injury
  - Smaller volume, consider colloids

- Pulmonary contusions
  - Judicious crystalloid administration
  - Redistribute into pulmonary tissue

- Internal hemorrhage
  - Hypotensive resuscitation

- Blood products?
Fluids Administered

- Hypertonic Saline bolus
  - 4 ml/kg

- Hetastarch (colloid) bolus
  - 10 ml/kg

- Small bolus crystalloids
  - 20 ml/kg

- Continued fluid therapy
  - Plyte at ¼ maintenance rate
  - Hetastarch at 20 ml/kg/day
Conclusions

- Maintenance of COP
- Low volume resuscitation
- TBI, pulmonary contusions

Contraindications

- Coagulopathy
- Oliguric/anuric renal failure
- Sepsis?
Case conclusion

- Maintenance of COP
- Low volume resuscitation
- TBI, pulmonary contusions

Contraindications
- Coagulopathy
- Oliguric/anuric renal failure
- Sepsis?
Conclusions

- Remember goals
- Speed of correction of dehydration?
- Ability to assess the patient?
  - Serial physical examination
  - PCV/TS
  - CVP
  - Body weight
  - Na⁺

Organ tissue perfusion
Blood pressure
Euvolemia
Elyte and acid-base balance
Hypoproteinemia
Questions?

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