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

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Fluid therapy: Why do we care?

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

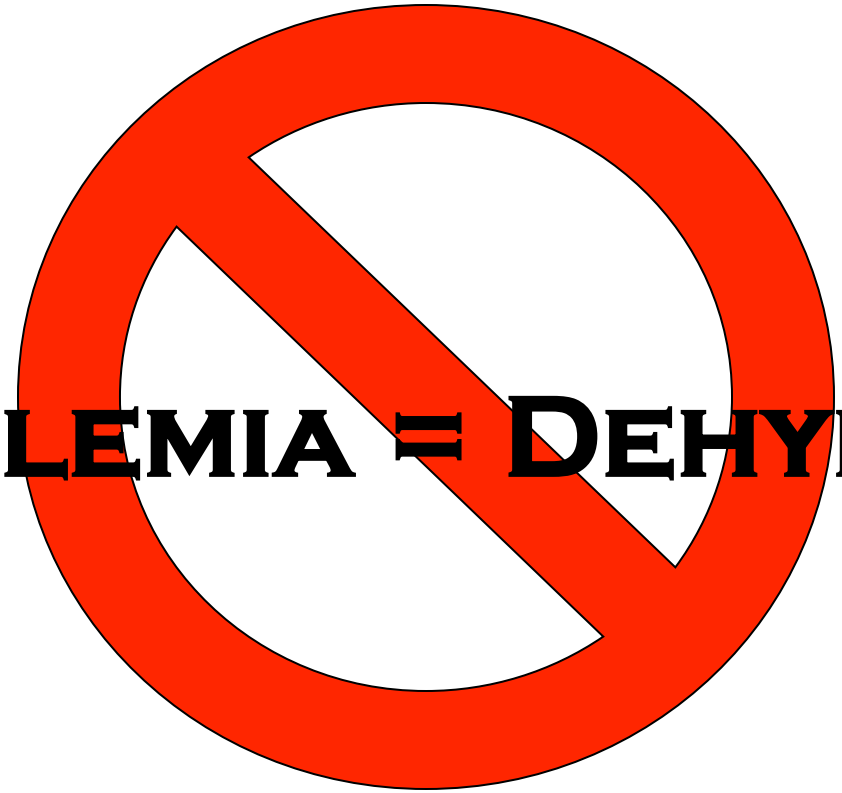
Goals of fluid therapy

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

Water requirements

- Small dogs/cats: 60 ml/kg/day
- Larger dogs: 50 ml/kg/day
- Neonates: 60-180 ml/kg/day

Hypovolemia = Dehydration



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HYPOVOLEMIA: “SHOCK”

Physical assessment of hypovolemia

- 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 Hypovolemia

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

Physical assessment of hypovolemia

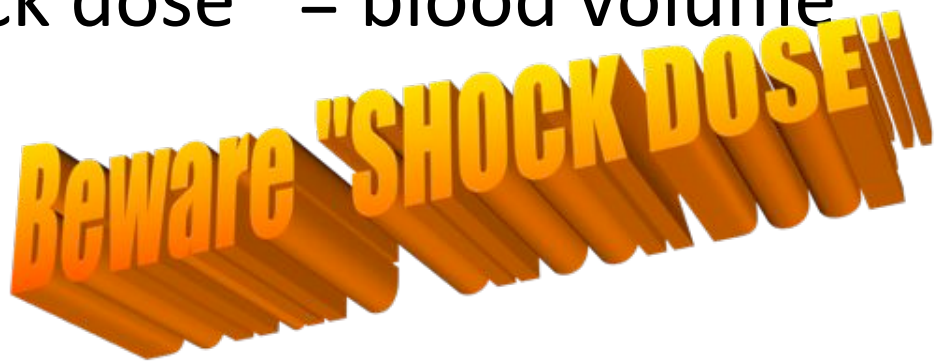
- Pulse quality
- Femoral pulse
  - Systolic > 60 mmHg
- Dorsal metatarsal pulse
  - Systolic > 90 mmHg

What route?

- Oral
- Subcutaneous
- Intraperitoneal
- Intravenous
- Intraosseous

Treatment for hypovolemia

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



Treatment for hypovolemia

- "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

What rate?

Calculations:

Shock: ___ ml bolus to effect

THEN ….

Dehydration: ___ ml/hr

\+ Maintenance: ___ ml/hr

\+ Ongoing Losses: ___ ml/hr

=Initial Fluid Rate ___ ml/hr

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 hypovolemia?

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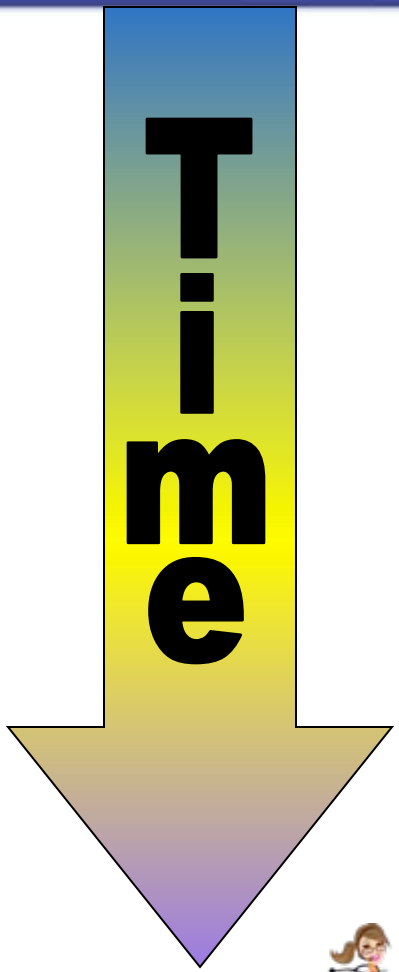
Clinical improvement?

- 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

Justine's soapbox

- Don't put on vasopressors if the vessels are empty!

Dehydration

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Is skin turgor always the best?

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Physical assessment of dehydration

% dehydration	Clinical signs
<5%	Not detectable
5-6%	Subtle loss of skin elasticity
6-8%	Definite delay in return of skin to normal position Slight prolongation of CRT Possibly dry mm
10-12%	Tented skin stands in place Definite prolongation in CRT Sunken eyes Dry mm Possible signs of shock
12-15%	Definite signs of shock Death imminent

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

Treatment for dehydration

- Dehydration: % dehydration X kg X 1000 mls
  - 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

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Subcutaneous

- Rehydration
- NOT for shock

- Only isotonic solutions
- Avoid dextrose

- Maintain hydration in renal failure patients

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http://s4.hubimg.com/u/3345679_f520.jpg

Subcutaneous fluids

- SQ fluids
  - Maintenance rate
    - 5 kg cat X 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

life-saving!

- 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 $Q = \Delta P\ r^4\ \pi / {}^{n}L$
  - 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 → weigh q. 12-24

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

Crystalloids

- Isotonic with plasma
- 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)

Crystalloids

- Plasmalyte-R
  - Lactate and acetate
  - 10 mEq potassium
  - Balanced, isotonic
- Plasmalyte-56
  - Na^+ /Cl^- 40
  - Acetate
- Plasmalyte-A/Norm-R
  - Gluconate and acetate
- Plasmalyte-148
  - Gluconate and acetate
  - Na^+ 148

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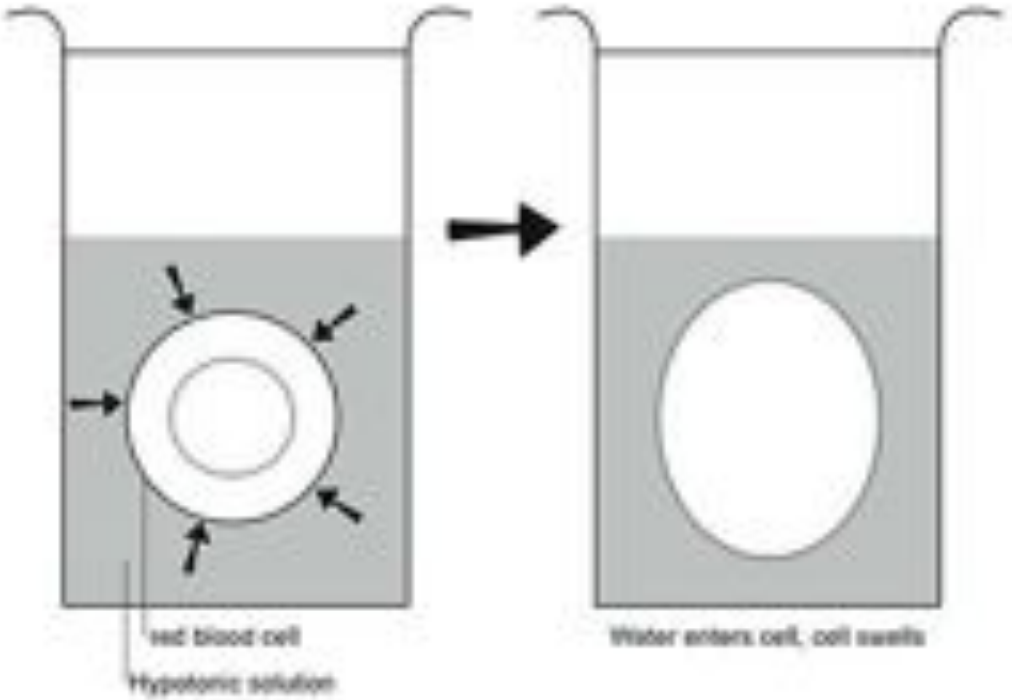
Crystalloids

- 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



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Crystalloids

Solution	Ringers	LRS	Plasmalyte 56	Plasmalyte R	Plasmalyte A; Norm R	0.9% NaCl
Na^+	147	130	40	140	140	154
K^+	4	4	13	10	5	0
Ca^{++}	4	3	0	5	0	0
Mg^+	0	0	3	3	3	0
Cl^-	156	109	40	103	98	154
Gluconate	0	0	0	0	23	0
Lactate	0	28	0	8	0	0
Acetate	0	0	16	47	27	0
Osmolarity	310	270	111	312	294	310

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

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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

Interstitial Space

P:15-35 mmHg

P: 1-2 mmHg

Π: 28 mmHg

Π: 3 mmHg

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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 substituion

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

Albumin Products

- 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

Mathews KA, Barry M. The use of 25% human serum albumin: outcome and efficacy in raising serum albumin and systemic blood pressure in critically ill dogs and cats. *J Vet Emerg Crit Care* 2005;15(2): 110-118

Trow AV, Rozanski EA, deLaforcade AM, Chan DL. Evaluation of use of human albumin in critically ill dogs: 73 cases (2003-2006). J Am Vet Med Assoc 2008;233:607-612

Fabio Viganó, Linda Perissinotto and Valentina R. F. Bosco. Administration of 5% human serum albumin in critically ill small animal patients with hypoalbuminemia: 418 dogs and 170 cats (1994 – 2008). *J Vet Emerg Crit Care* 2010;20(2):237-243

Canine Albumin

- 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

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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 meg/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

MONITORING

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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