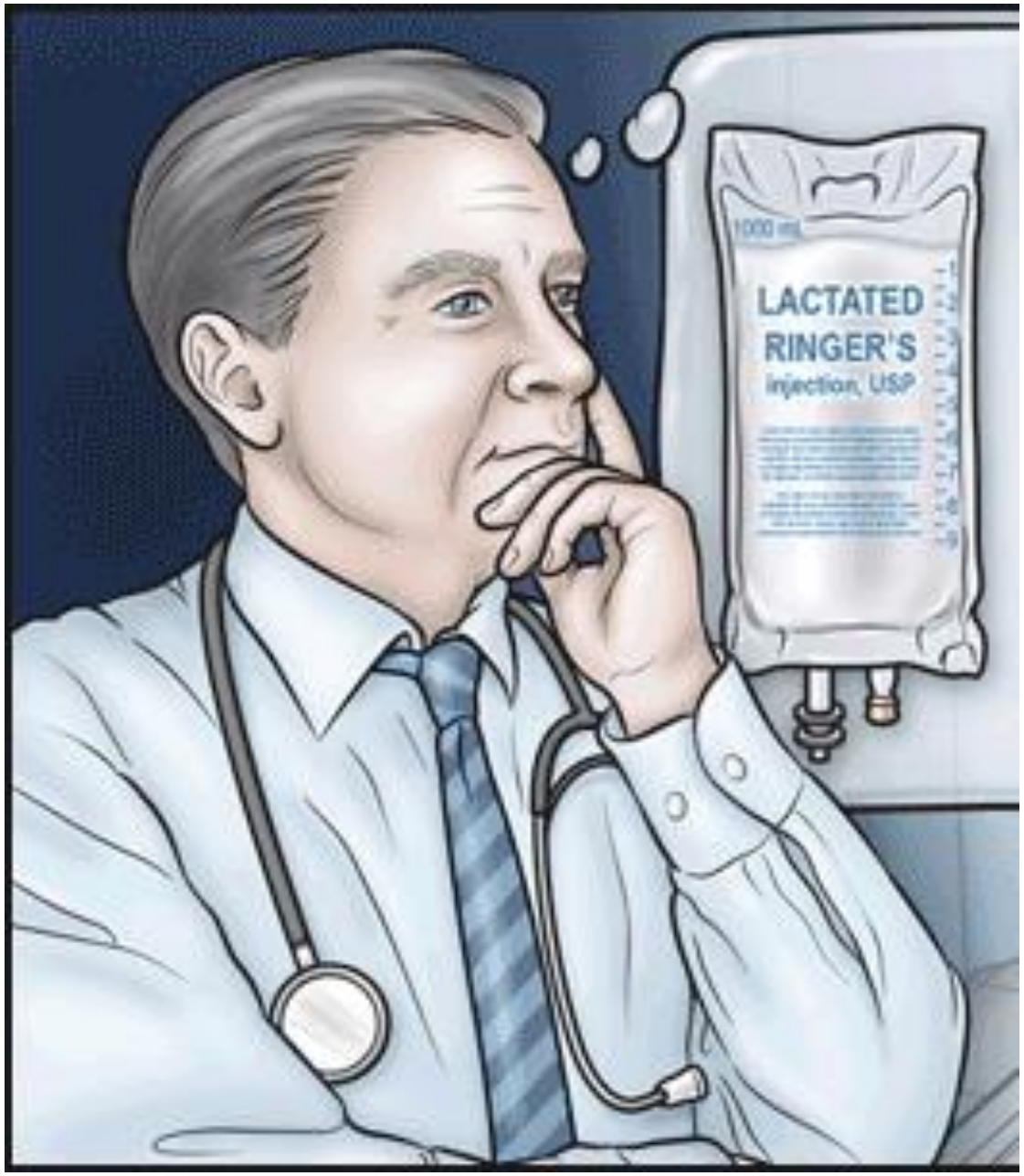
Murdoch University

Fluid Therapy
Types and Indications

Dr Corrin Boyd BVMS PhD MANZCVS DACVECC

Ngala kwop biddi.
Building a brighter future, together.



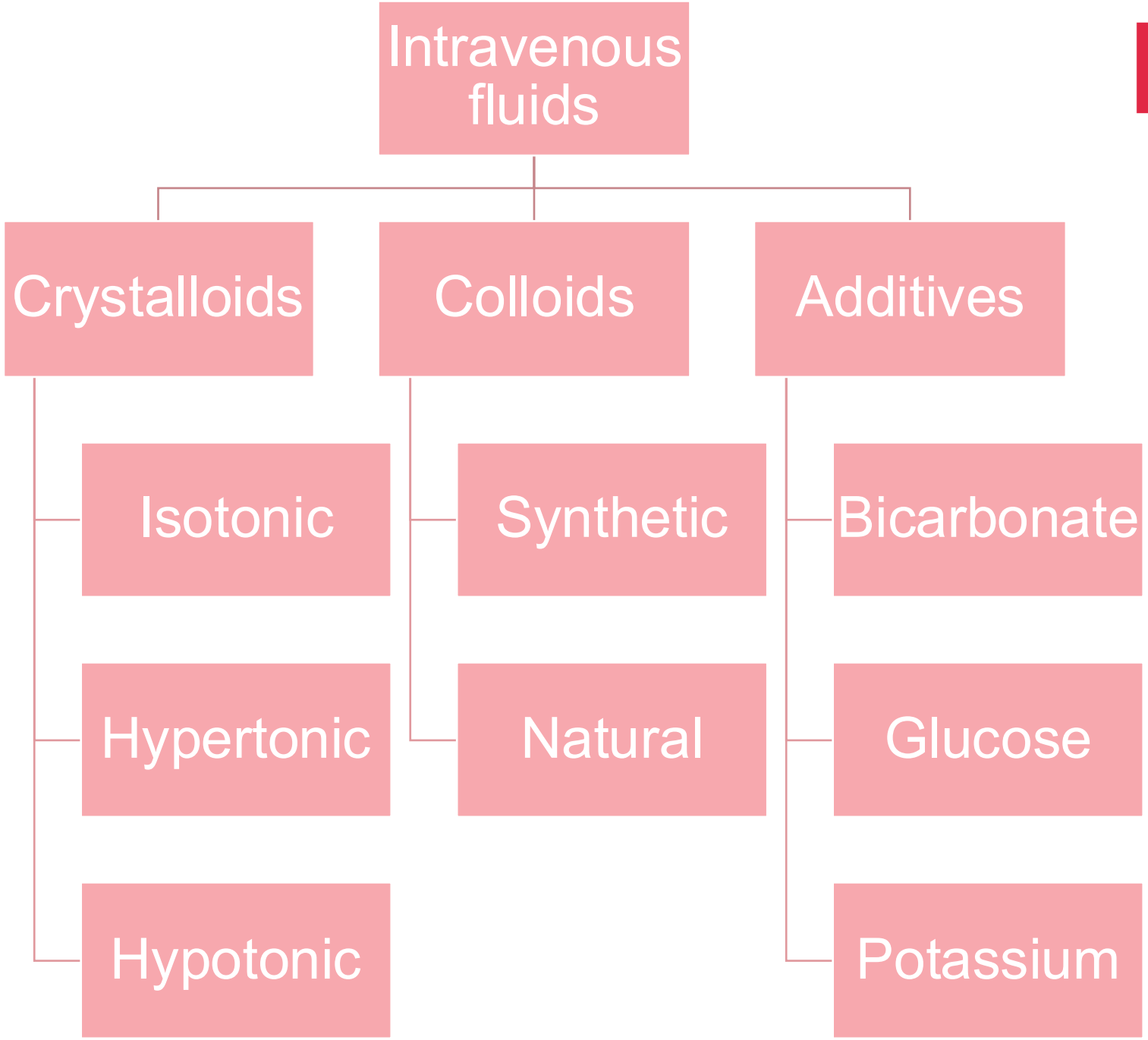
4 broad indications for IV fluid therapy

1. Treat hypovolemic shock
2. Treat dehydration (restore interstitial volume)
3. Provide for maintenance fluid requirements
4. Replace abnormal ongoing losses

Concurrently fluid therapy can be used to address acid-base and electrolyte abnormalities.


LACTATED
RINGER'S
injection, USP
ALBUMIN
injection, USP
6% HETASTARCH
injection, USP
SALINE
injection, USP

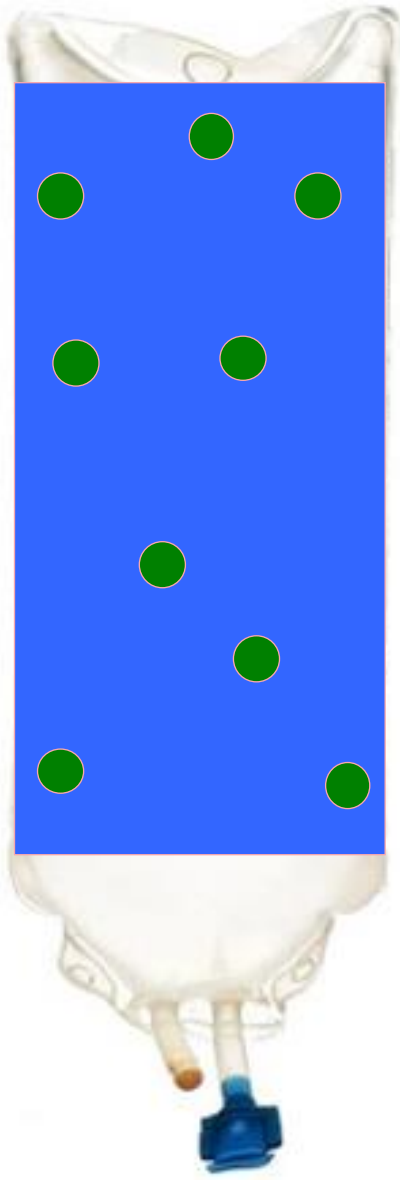
Classification of fluid types



Crystalloid Fluids

WATER

ELECTROLYTES

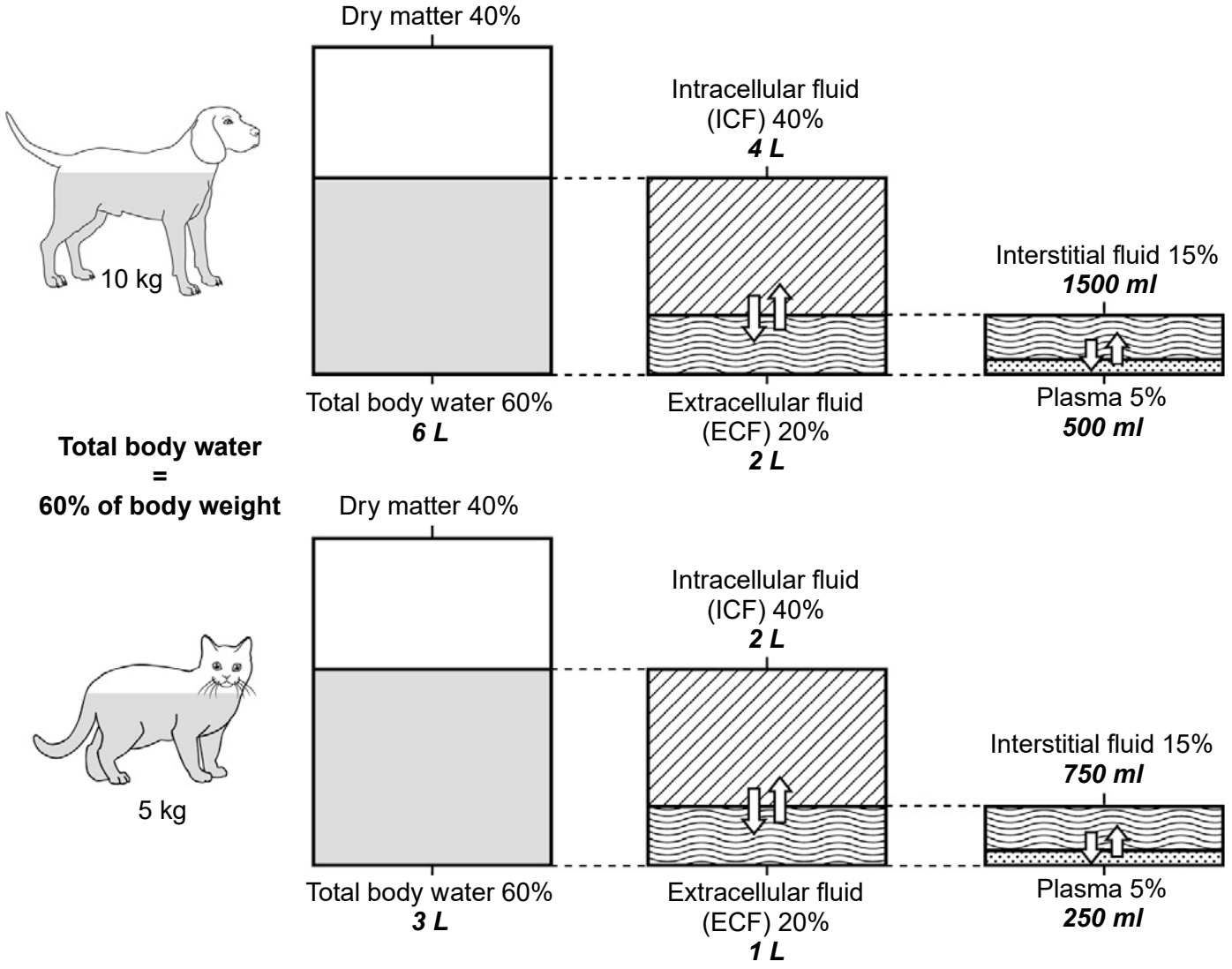


Isotonic Crystalloids

Contain electrolytes (salts) and water only

Isotonic to the ECF (~300 mOsm/L)

- Distribute to the entire ECF
  - Initially within the intravascular space (if given IV)
  - Redistribute to whole ECF over 30-60 min
- Do not affect the ICF



DiBartola Ch1

Isotonic Crystalloids

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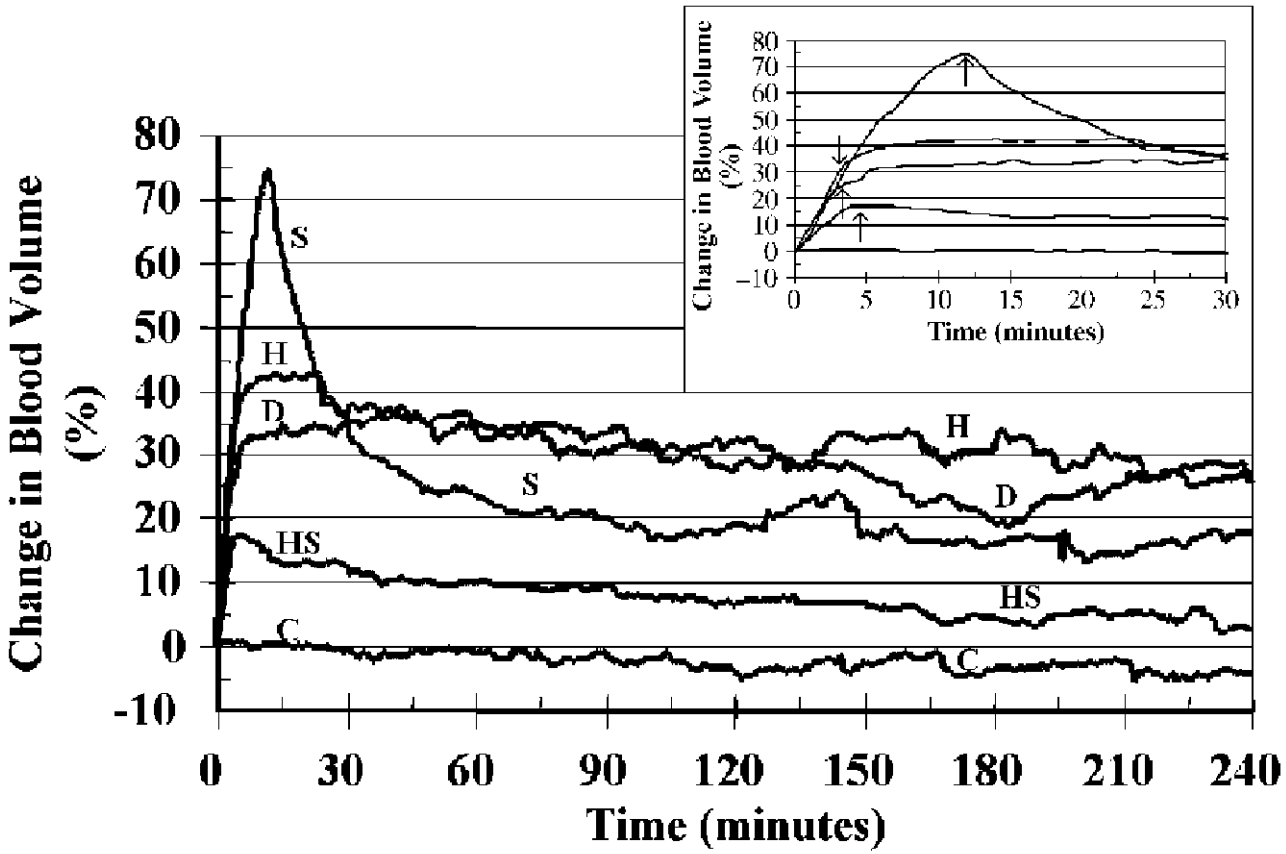


Silverstein D et al. **Assessment of changes in blood volume in response to resuscitative fluid administration in dogs**. JVECC 2003;15(3):185-192.

Isotonic Crystalloids

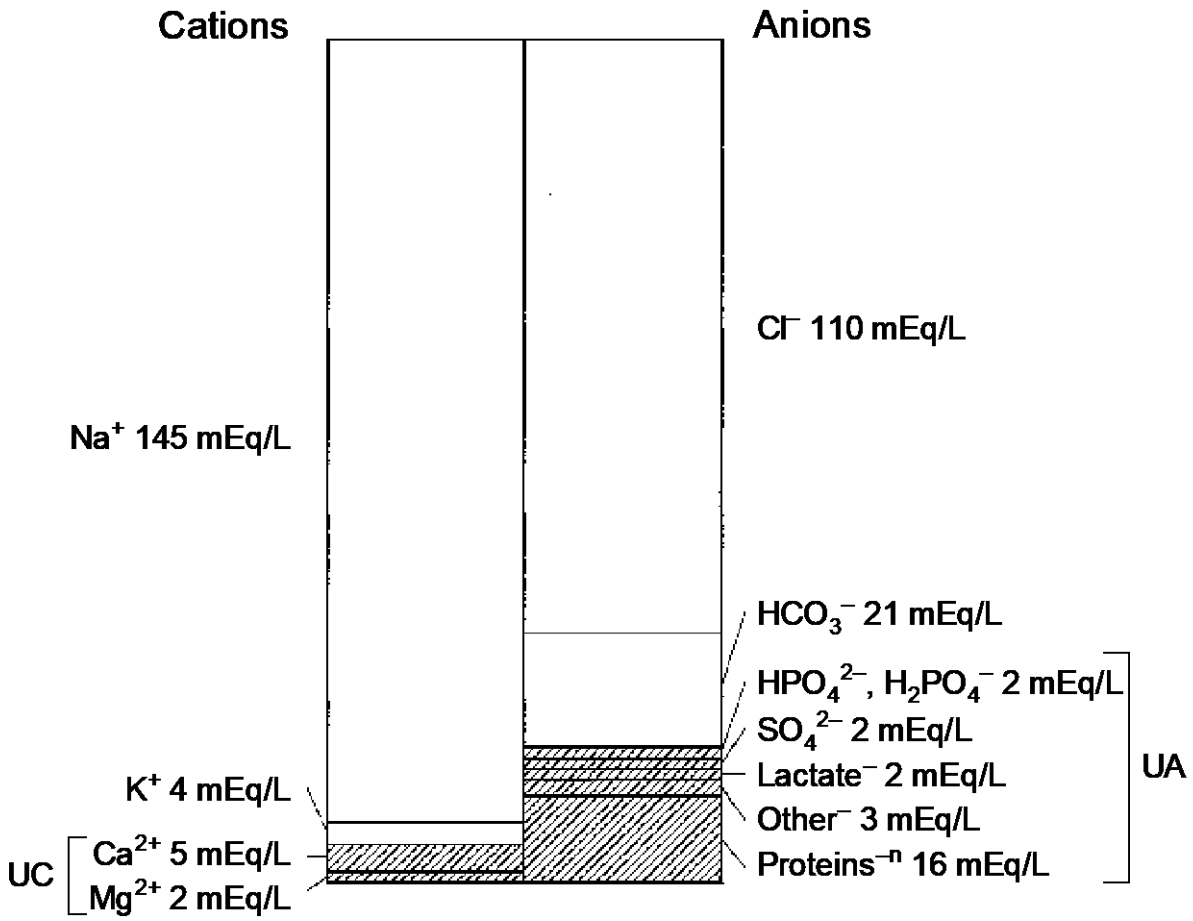
Useful to increase/maintain ECF volume

- Hypovolaemia (1/4 stays in intravascular space)
- Dehydration
- Maintenance
- Excessive losses

Balanced Isotonic Crystalloids

Balanced = electrolyte composition similar to normal ECF

'Gamblegram'



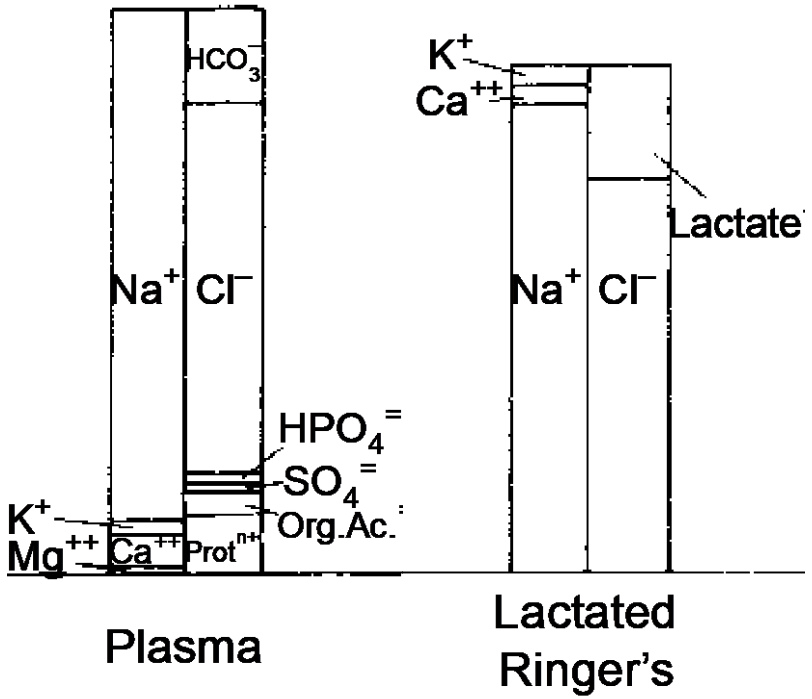
DiBartola Ch1

Hartmann's Solution (Compound Sodium Lactate)
Lactated Ringer's Solution (LRS)

Balanced/buffered isotonic crystalloid

- Actually mildly hypotonic, close enough to be termed isotonic
- Cations: sodium, potassium, calcium
- Anions: chloride, lactate (buffer)

First choice for most indications



DiBartola Ch14

Plasma-Lyte 148
Normosol R

Balanced isotonic crystalloid

- Osmolality closer to ECF – truly isotonic
- Cations: sodium, potassium, magnesium
- Anions: chloride, acetate (buffer), gluconate (buffer?)

More expensive than Hartmann's

Indications

- Magnesium supplementation (small amount only)
- Acetate vs lactate
  - Inability to metabolise lactate?
  - Acetate metabolised more rapidly/effectively
- Avoiding any free water administration (e.g., TBI)

Risk – acetate vasodilation/pro-inflammatory?

Isotonic Sodium Bicarbonate

Useful in severe hyperchloraemic metabolic acidosis non-responsive to balanced crystalloid

Add concentrated $NaHCO_3$ to sterile water

- Isotonic to patient, e.g.
  - $[Na^+]$ = 145 mmol/L
  - $[HCO_3^-]$ = 145 mmol/L
- Use in place of maintenance crystalloid
- Monitor electrolytes/blood gas closely
  - Calculate HCO_3^- deficit
  - Recheck every 25-50% administered
- Make up fresh every day

0.9% Sodium Chloride

Murdoch University

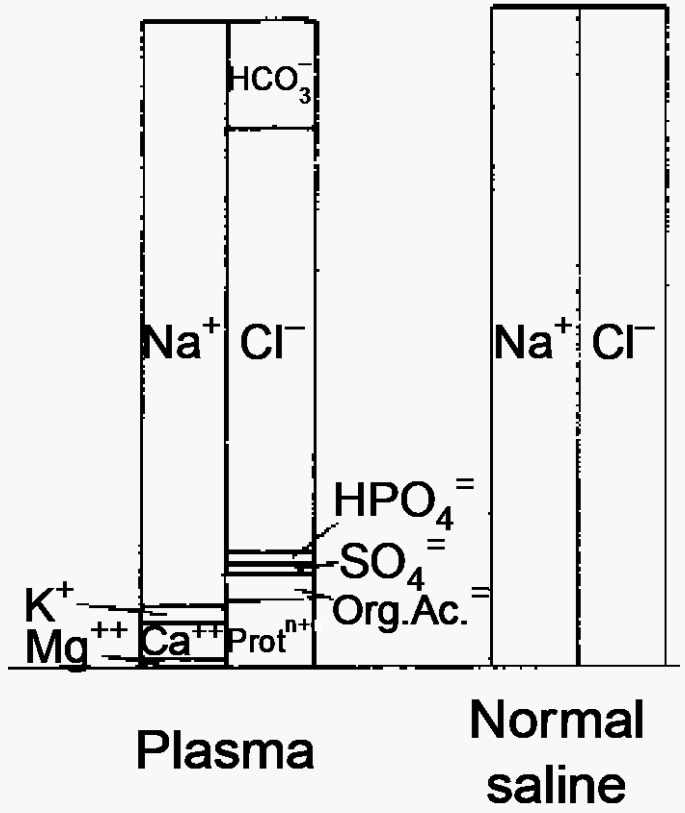
Isotonic crystalloid

Unbalanced/unbuffered with high [Cl^-]

- Cause hyperchloraemic metabolic acidosis
- This can lead to kidney injury

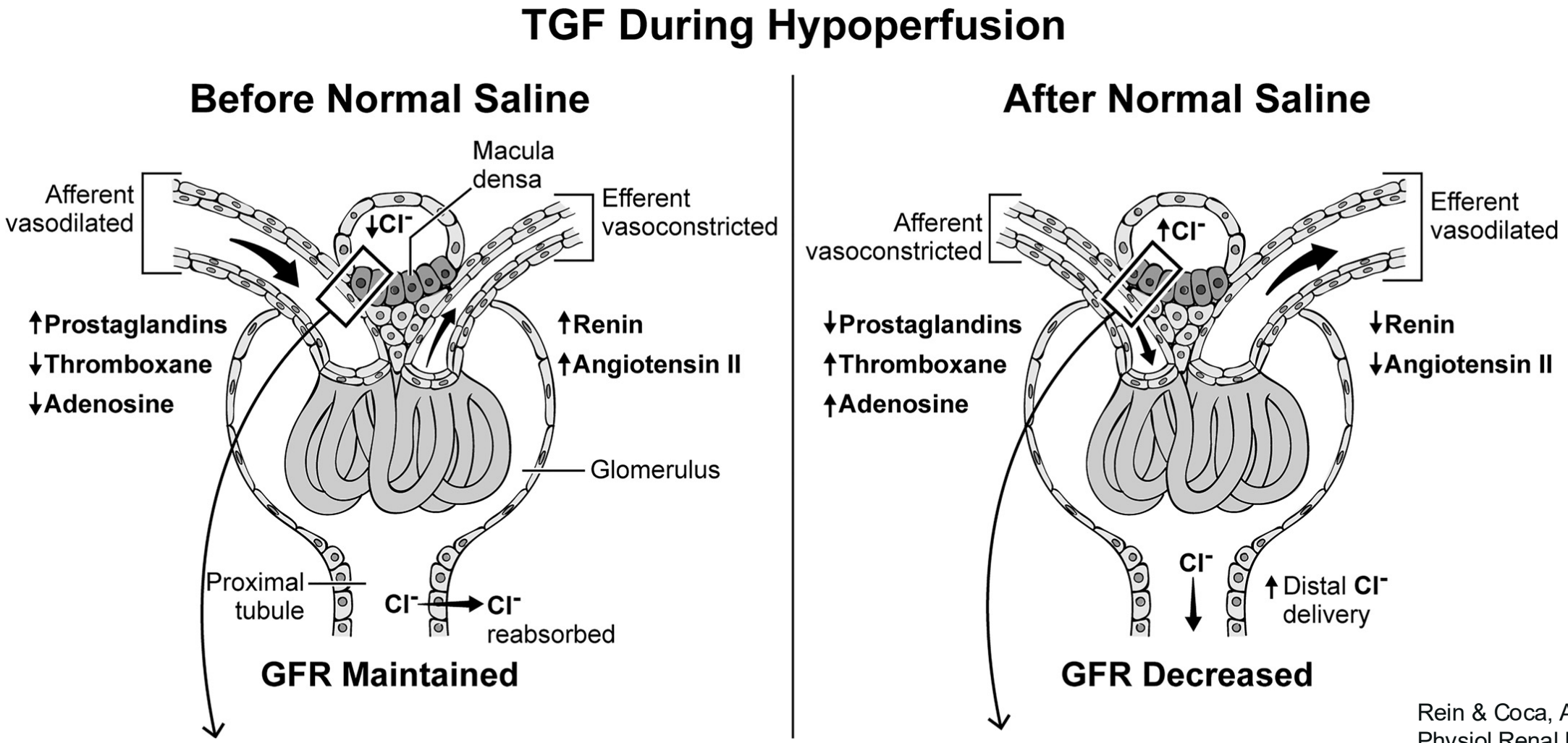
Indications

- Metabolic alkalosis
- Most others not valid



DiBartola Ch14

Chloride and AKI



Rein & Coca, Am J Physiol Renal Physiol 2019; 316:F587-F605

Chloride

Balanced Crystalloids versus Saline in Critically Ill Adults

Table 2. Clinical Outcomes.*

Outcome	Balanced Crystalloids (N = 7942)	Saline (N = 7860)	Adjusted Odds Ratio (95% CI)†	P Value†
Primary outcome				
Major adverse kidney event within 30 days — no. (%)‡	1139 (14.3)	1211 (15.4)	0.90 (0.82 to 0.99)	0.04
Components of primary outcome				
In-hospital death before 30 days — no. (%)	818 (10.3)	875 (11.1)	0.90 (0.80 to 1.01)	0.06
Receipt of new renal-replacement therapy — no./total no. (%)§	189/7558 (2.5)	220/7458 (2.9)	0.84 (0.68 to 1.02)	0.08
Among survivors	106/6787 (1.6)	117/6657 (1.8)		
Final creatinine level ≥200% of baseline — no./total no. (%)§	487/7558 (6.4)	494/7458 (6.6)	0.96 (0.84 to 1.11)	0.60
Among survivors	259/6787 (3.8)	273/6657 (4.1)		
Among survivors without new renal-replacement therapy	215/6681 (3.2)	219/6540 (3.3)		

A Case - Wilson

- **Signalment:** 1 year old, MN, Labradoodle
- **History:**
  - 24 hours of vomiting, progressive lethargy
  - Ate sock 1 week ago but emesis induced successful
  - Yesterday morning vomited a museli bar wrapper but then continued to vomit (10-20x)
- **Physical examination:**
  - 10+% dehydrated
  - Moderate vasoconstrictive shock
  - Tense on abdominal palpation
  - Profound ptyalism

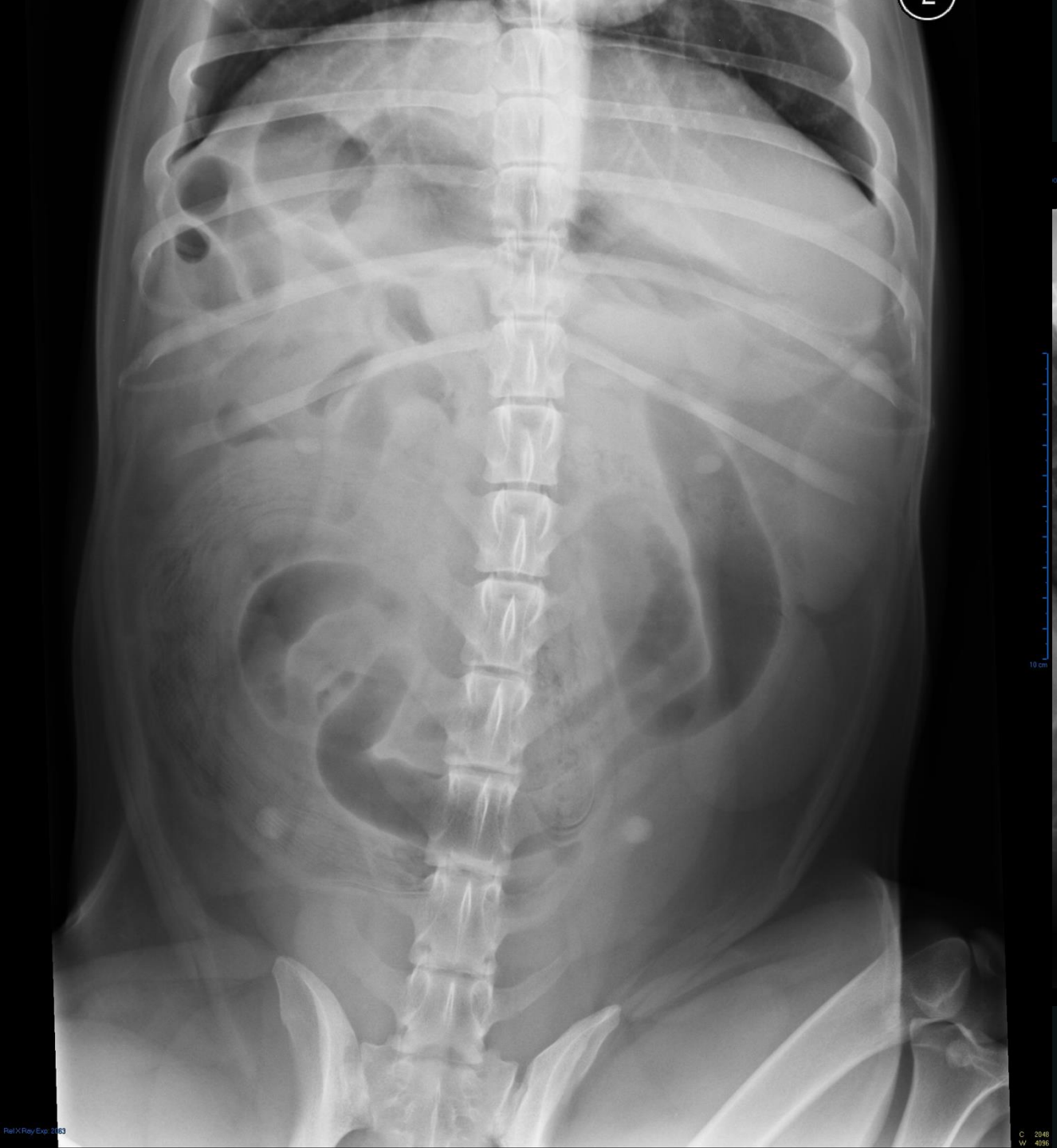
Wilson – PCV/TS, venous blood gas

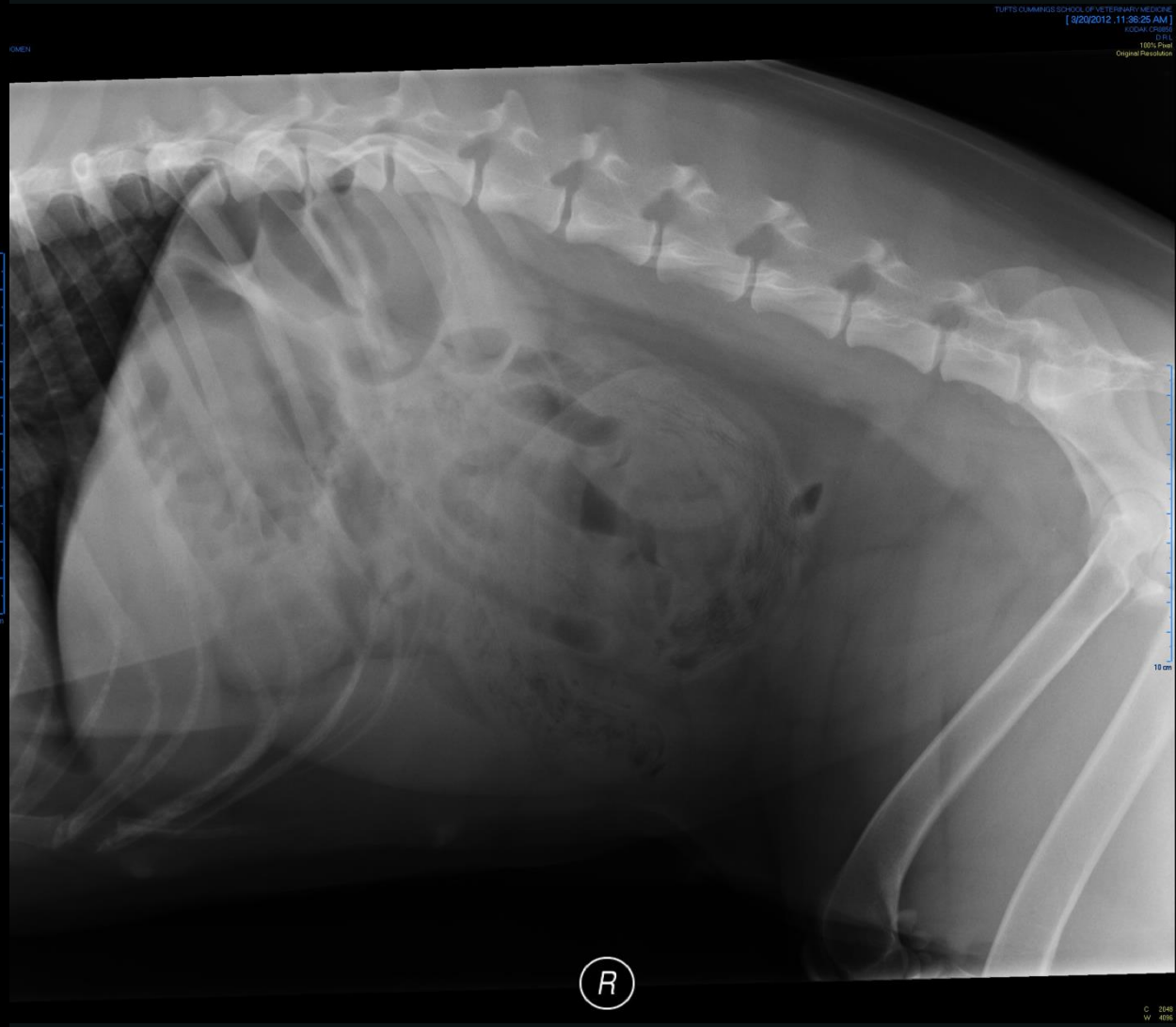
Parameter (units)	Measured value	Reference interval
PCV (%)	**64**	37-55
TSP (g/L)	**92**	60-80
Na (mmol/L)	**136.2**	140-150
K (mmol/L)	**2.9**	3.9-4.9
Cl (mmol/L)	**95**	109-120
iCa (mmol/L)	1.4	1.25-1.5
Gluc (mmol/L)	6.1	3.6-6.2
Lactate (mmol/L)	**5.4**	0.5-2.0
pH	**7.517**	7.34-7.38
pCO2 (mmHg)	**35.9**	40-46
HC03- (mmol/L)	**29.4**	22-24
BE (mmol/L)	**6.3**	-2 to 2
AG (mmol/L)	**11.5**	8-21

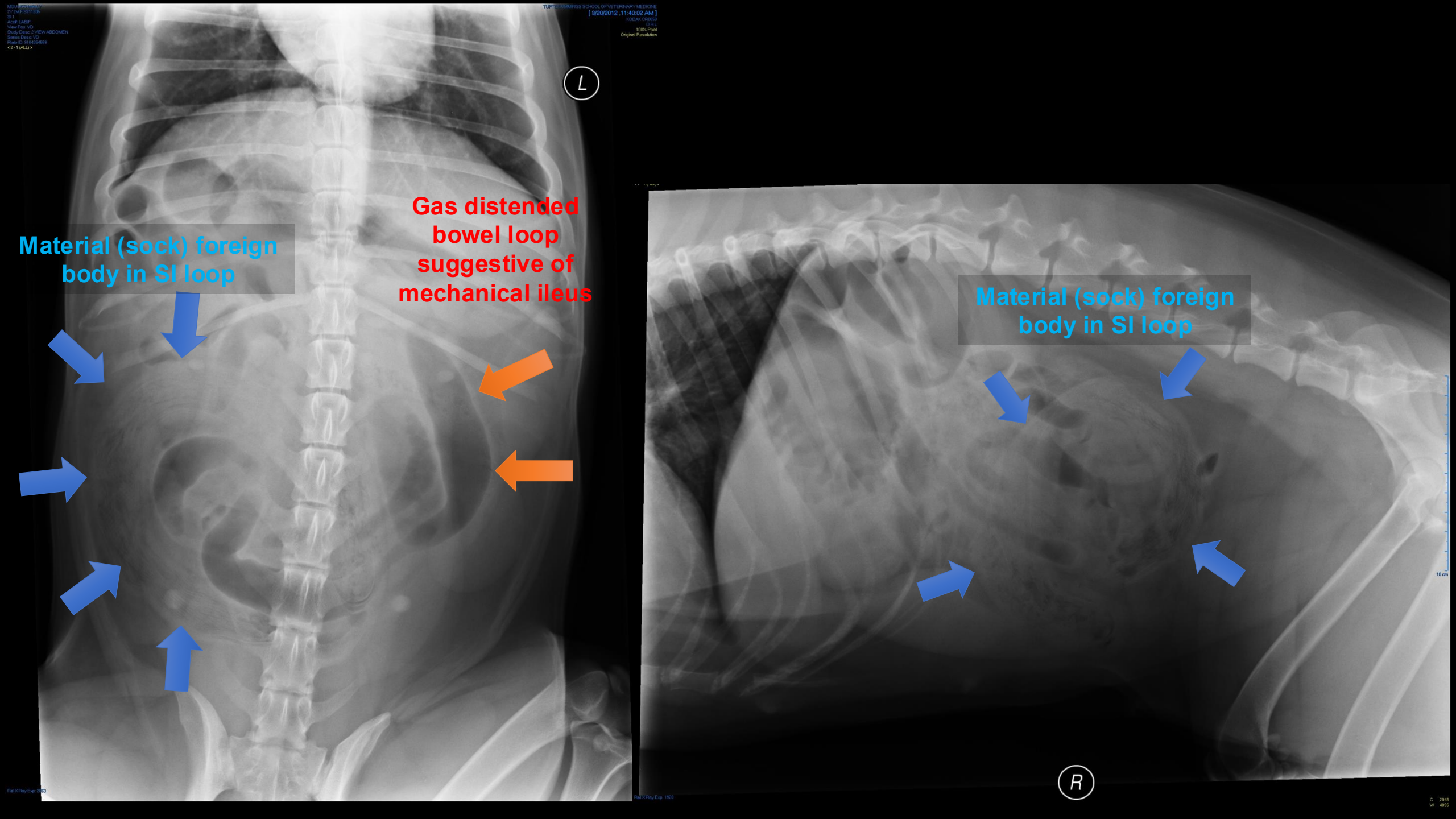
Assessment?

Initial treatment?

Further diagnostics?


L
10 cm
C 2048
W 4096
RadX Rey Exp: 2083


TUFTS CUMMINGS SCHOOL OF VETERINARY MEDICINE
[9/20/2012 , 11:38:25 AM]
KODAK CR850
DR-ML
100% Pixel
Original Resolution
10 cm
R
C 2048
W 4096


Material (sock) foreign body in SI loop
Gas distended bowel loop suggestive of mechanical ileus
L
Material (sock) foreign body in SI loop
R

Wilson - Treatment

- IV fluids with 0.9% NaCl
  - Resuscitate from shock
  - Rapid rehydration
- Aggressive K supplementation
  - CRI 0.5 mmol/kg/h until K > 3.5 mmol/L
  - KCl will also help correct chloride
- Recheck / monitor electrolytes closely

- Exploratory laparotomy
  - Enterotomy for sock foreign body

Hypertonic Crystalloids

Mostly hypertonic saline (NaCl)

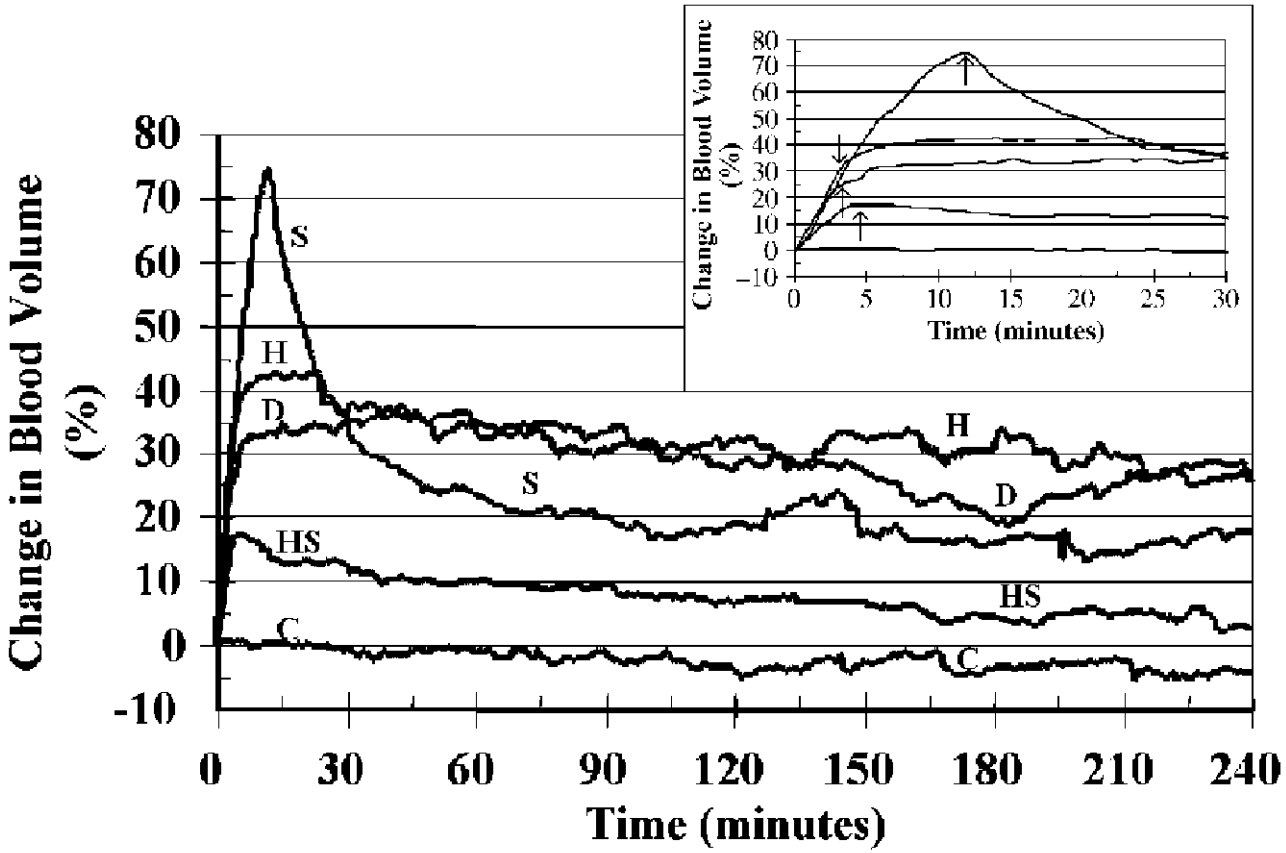
- 3%, **7-7.5%**, 23.4%

Others do exist

- Note that undiluted $NaHCO_3$ also is a hypertonic crystalloid – but will discuss that later

Cause fluid shifts by osmosis

- Interstitial → intravascular space
  - Immediate but short-lived
- Intracellular → extracellular space
  - Slower but longer lasting



Silverstein D et al. **Assessment of changes in blood volume in response to resuscitative fluid administration in dogs**. JVECC 2003;15(3):185-192.

Hypertonic Crystalloids

Dose (7%): 3-5 mL/kg over 5 min

Indications

- Rapid blood volume expansion
  - Especially useful in very large animals
  - Must be followed by another fluid (e.g., balanced isotonic crystalloid) to maintain blood volume expansion
- Treatment of cerebral oedema
  - Useful when concurrent blood volume expansion indicated – e.g., trauma

NOT useful for dehydration/maintenance/ongoing losses

Risks

- Hypernatraemia and hyperchloraemia
- May interfere with coagulation (clinical relevance unclear)

Hypertonic Saline and Chloride

Sadan *et al. Trials* (2018) 19:628
https://doi.org/10.1186/s13063-018-3007-7

Trials

STUDY PROTOCOL Open Access

Low-chloride versus high-chloride hypertonic solution for the treatment of subarachnoid hemorrhage-related complications (The ACETatE trial): study protocol for a pilot randomized controlled trial

Ofer Sadan[1*], Owen Samuels[1], William H. Asbury[2], John J. Hanfelt[3] and Kai Singbartl[4*]

neurocritical care society Neurocrit Care (2011) 15:42–45
DOI 10.1007/s12028-011-9512-0

ORIGINAL ARTICLE

Randomized Controlled Trial Comparing the Effect of 8.4% Sodium Bicarbonate and 5% Sodium Chloride on Raised Intracranial Pressure after Traumatic Brain Injury

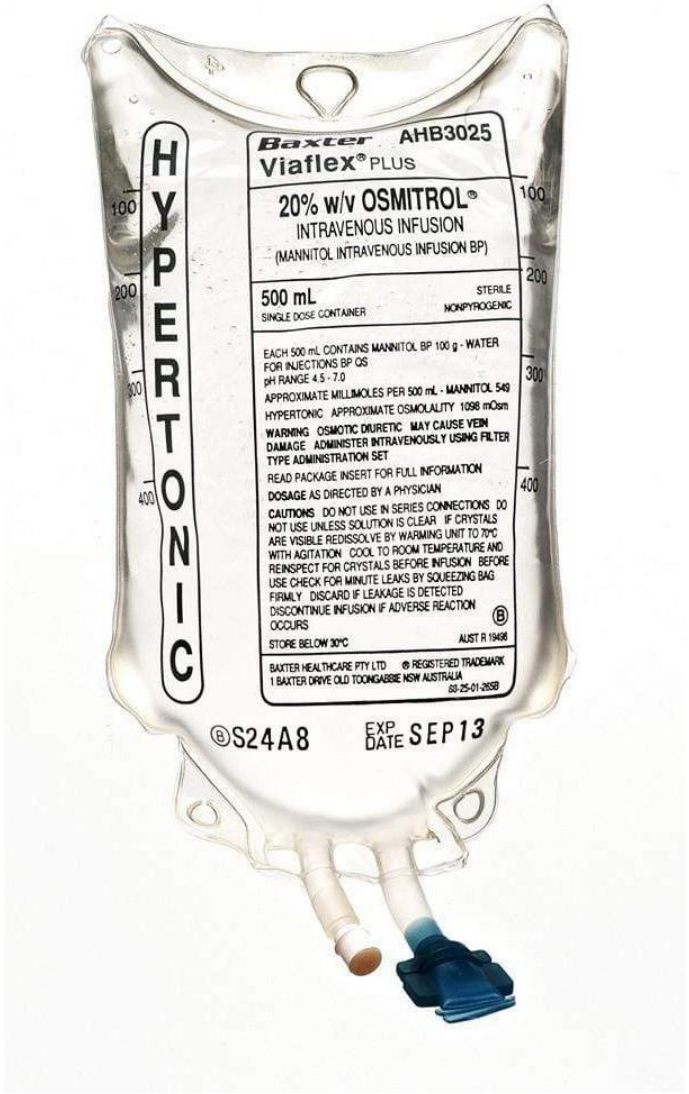
Chris P. Bourdeaux · Jules M. Brown

Mannitol

Mannitol is also a hyperosmolar drug used to treat cerebral oedema

Not usually considered with other fluids

- Osmotic diuretic
- Does not expand blood volume for any meaningful amount of time
- Subsequently decreases blood volume



Hypotonic Crystalloids
AKA ‘Maintenance Crystalloids’

- Contain lower concentration of electrolytes than normal ECF
- Also contain glucose:
  - Pure water cannot be given IV – osmotic red cell injury
  - Glucose moves into cells, leaving water
  - Do NOT use for treatment of hypoglycaemia
- Used when free water source is indicated
- Can be used for long-term maintenance fluid requirements
  - Reflect normal dietary sodium and water intake
  - Risk of hyponatraemia
- Examples:
  - D5W
  - 0.45% NaCl + 2.5% dextrose
  - Plasma-Lyte 56

5% Glucose
AKA D5W = Dextrose 5% in Water

Do NOT use for treatment of hypoglycaemia

- Used in treatment of hypernatraemia (free water deficit)
  - Calculated rate – complex, see critical care textbooks
  - In mild cases, 3.7 mL/kg/hour can be used

A case - Princess

- Signalment:
  - 12 year FS DSH
- History:
  - Known CKD (IRIS Grade II)
- Presenting complaint:
  - Acute vomiting, anorexia
- Physical examination:
  - 7% dehydrated
  - Vitals within normal limits
  - Small, non-painful kidneys on palpation
- Treatment:
  - LRS + 20 mmol KCl/L to correct 7% dehydration over 18 hours, and provide for maintenance

Parameter (units)	Measured value	Reference interval
PCV (%)	27	24-45
TSP (g/L)	83	54-78
Na (mmol/L)	150	142-156
K (mmol/L)	3.4	3.9-5.2
Cl (mmol/L)	120	115-128
iCa (mmol/L)	1.19	1.12-1.4
BG (mmol/L)	10.0	3.7-9.3
Lactate (mmol/L)	1.1	0.5-2.0

A case - Princess

Day 2

- Frequent urination overnight
- Physical examination normal

What's happened?

Treatment changes?

Further diagnostics?

Parameter (units)	Day 1	Day 2	Reference interval
PCV (%)	27	25	24-45
TSP (g/L)	83	77	54-78
Na (mmol/L)	150	165	142-156
K (mmol/L)	3.4	3.7	3.9-5.2
Cl (mmol/L)	120	133	115-128
iCa (mmol/L)	1.19	1.23	1.12-1.4
BG (mmol/L)	10.0	7.1	3.7-9.3
Lactate (mmol/L)	1.1	0.9	0.5-2.0

A case - Princess

Day 2

- Frequent urination overnight
- Physical examination normal

USG 1.004

Urinary free water loss due to CKD

Requires free water replacement

D5W @ 3.7mL/kg/h for 15 hours

Continue LRS

Parameter (units)	Day 1	Day 2	Reference interval
PCV (%)	27	25	24-45
TSP (g/L)	83	77	54-78
Na (mmol/L)	150	165	142-156
K (mmol/L)	3.4	3.7	3.9-5.2
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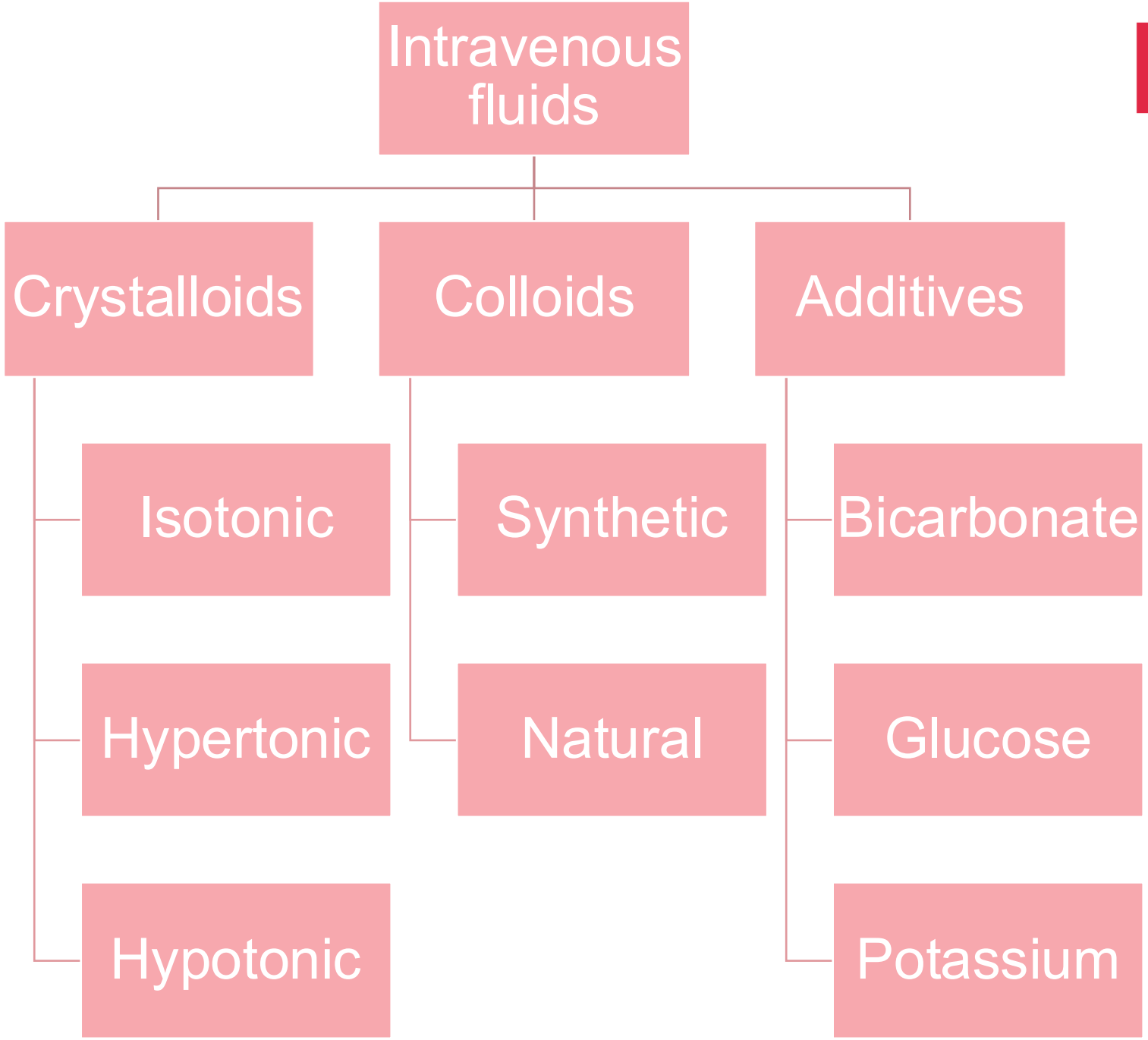
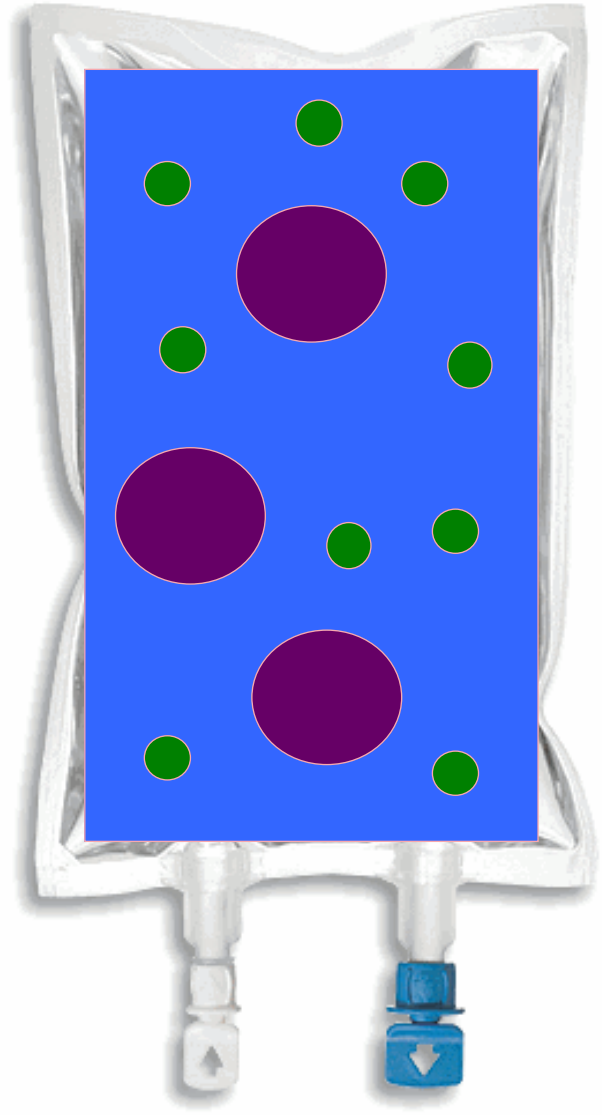
Classification of fluid types



Colloid Fluids



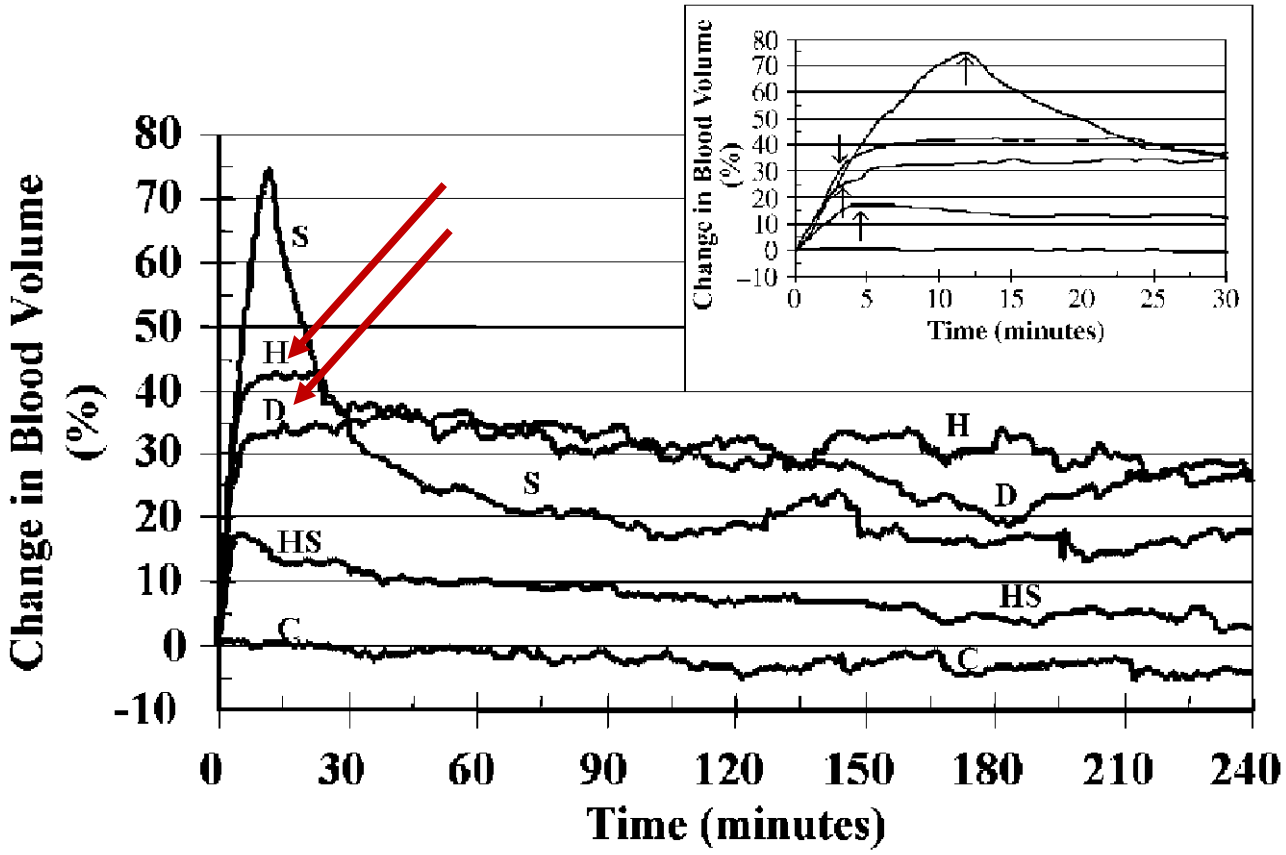
WATER

ELECTROLYTES

LARGE MOLECULES

Stay within INTRAVASCULAR space

Colloid Fluids



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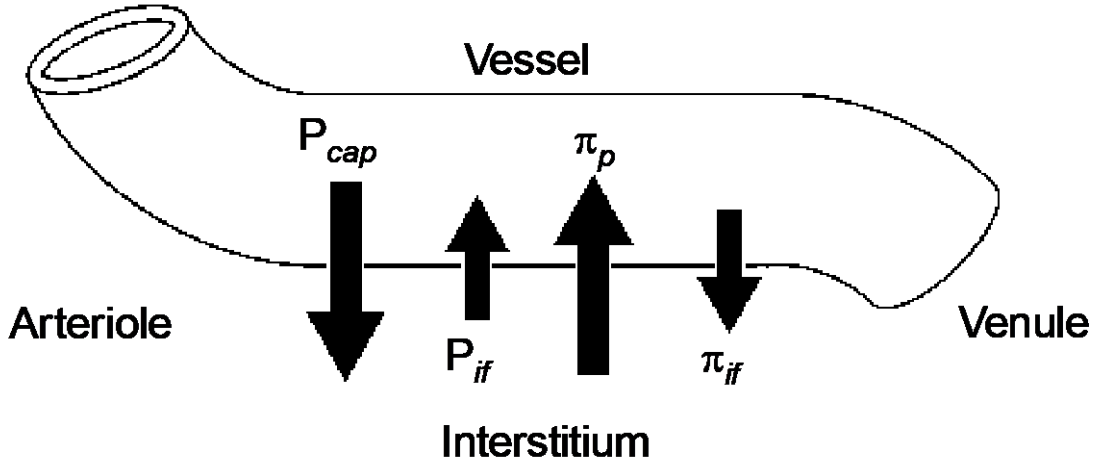
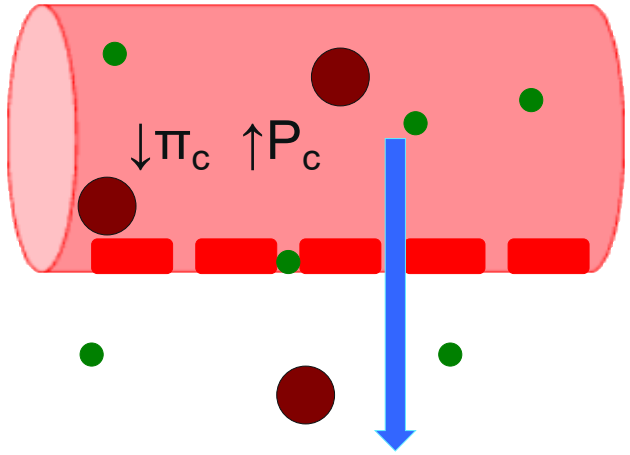
Colloid Fluids

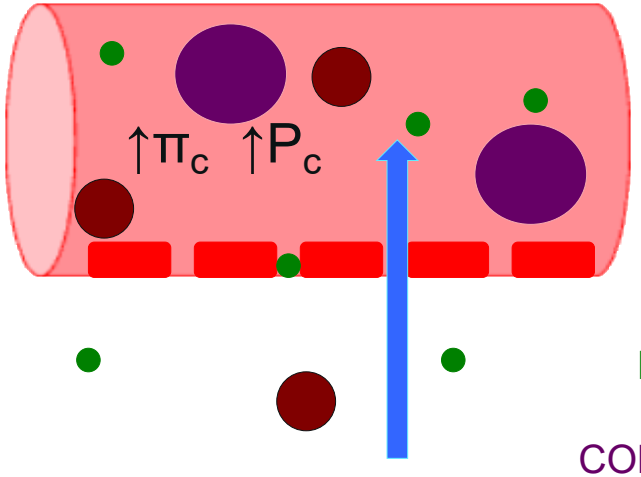


Crystalloid fluid, eg Hartmann's



ELECTROLYTES
ALBUMIN

Colloid fluid, eg Voluven



ELECTROLYTES
ALBUMIN
COLLOID MOLECULES

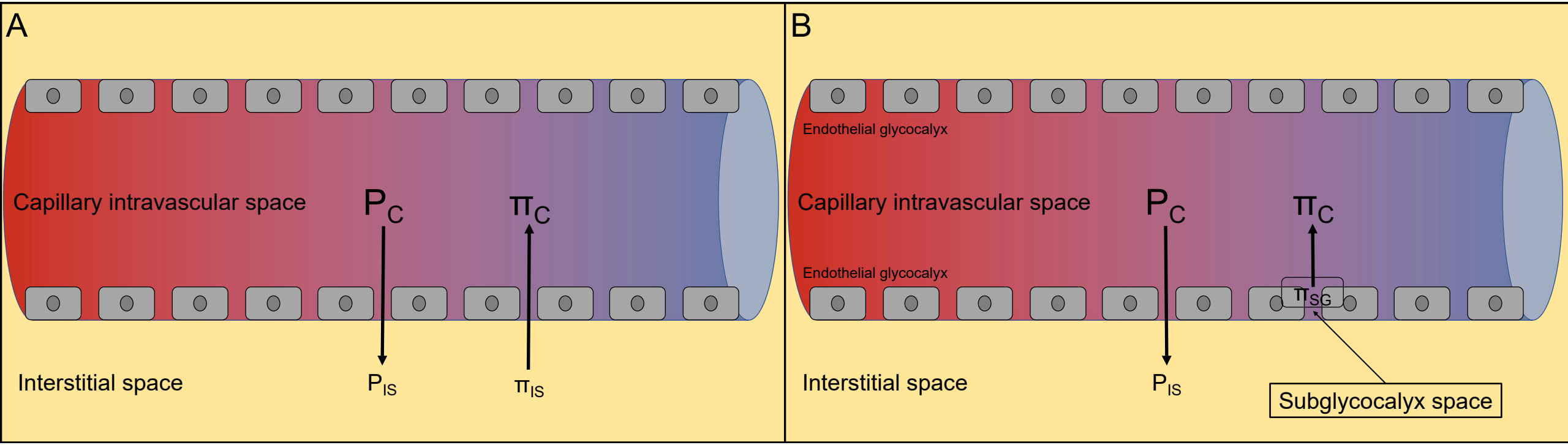
The Endothelial Glycocalyx

Are the traditional assertions true?

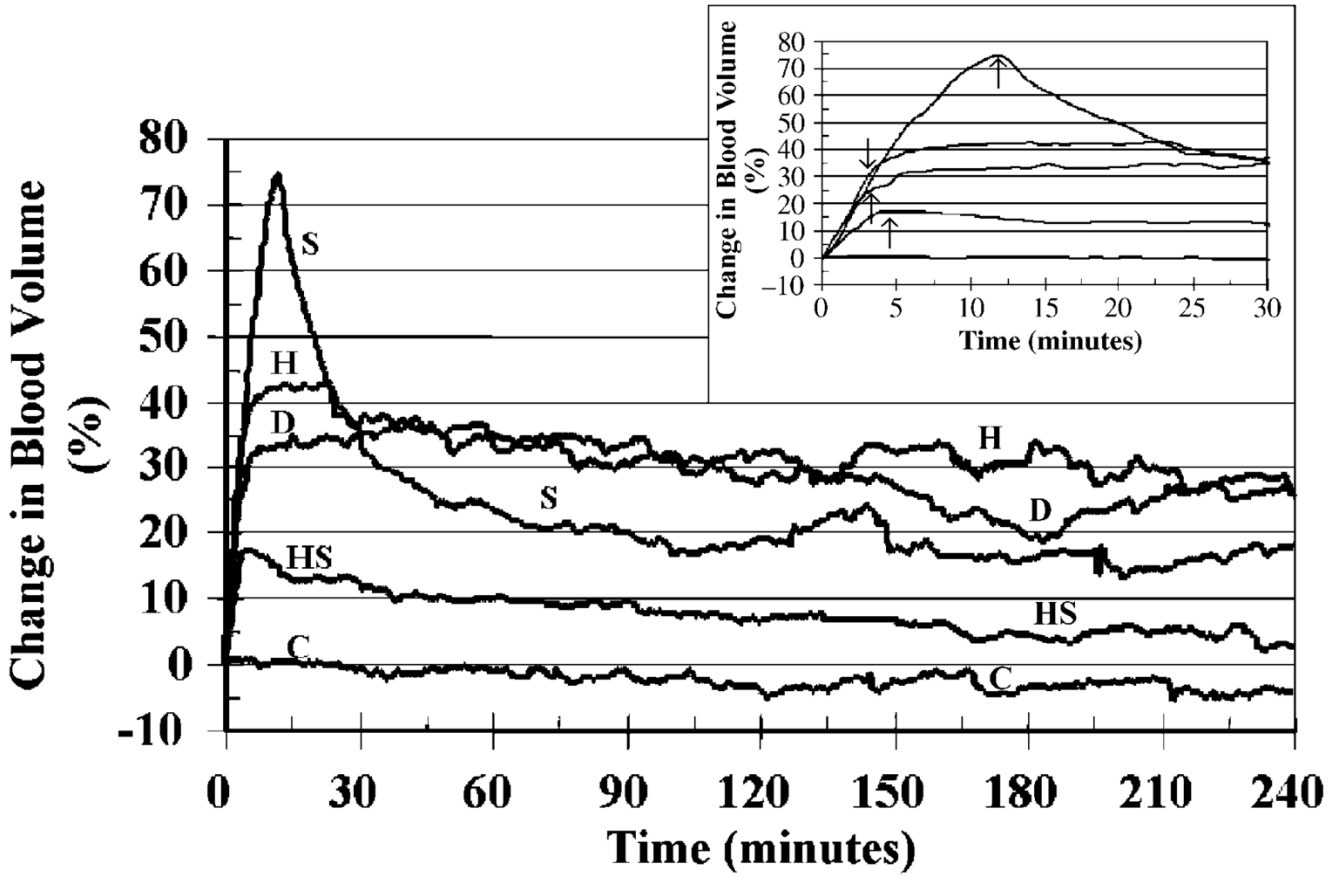
Some new assertions:

- The COP effect on fluid extravasation is modulated by the endothelial glycocalyx
- An intact glycocalyx is necessary for the COP effect to work
- Therefore, crystalloids should be prioritized

Revised Starling Principle



Revised Starling Principle Consequences



Silverstein et al. JVECC 2005; 15:185-192

Human Clinical Studies

Crystalloid:Colloid

1.0 to 1.5

DOI: 10.1111/vec.13056

ORIGINAL STUDY

Veterinary Emergency Critical Care WILEY

Prospective randomized controlled blinded clinical trial evaluating biomarkers of acute kidney injury following 6% hydroxyethyl starch 130/0.4 or Hartmann's solution in dogs

Corrin J. Boyd BSc, BVMS(Hons), GradDipEd, MVetClinStud, MANZCVS, DACVECC | Claire R. Sharp BSc, BVMS, MS, DACVECC | Melissa A. Claus DVM, DACVECC | Anthea L. Raisis BVSc, MVetClinStud, DVA, PhD | Giselle Hosgood BVSc(Hons), MS, PhD, FANZCVS, DACVS | Lisa Smart BVSc(Hons), PhD, DACVECC

1.1

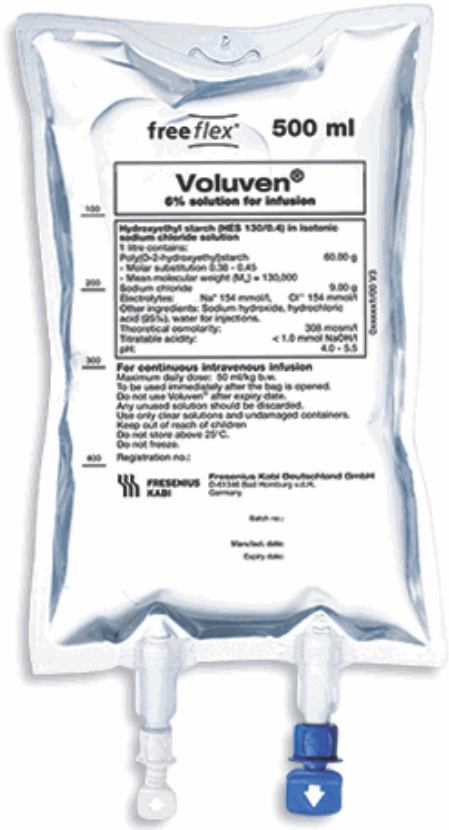
Types of Colloid Fluid

Synthetic

- Hydroxyethyl starch (HES)
  - Most common
  - E.g., Voluven, Vetstarch
- Gelatin
  - Increasing use in some countries
  - E.g., Gelofusine
- Dextrans
  - No longer widely available except in Denmark

Natural

- Albumin
  - Canine – not widely available
  - Human – risk of hypersensitivity
- Plasma can be considered as a natural colloid



Canine Albumin

The ideal colloid for dogs?

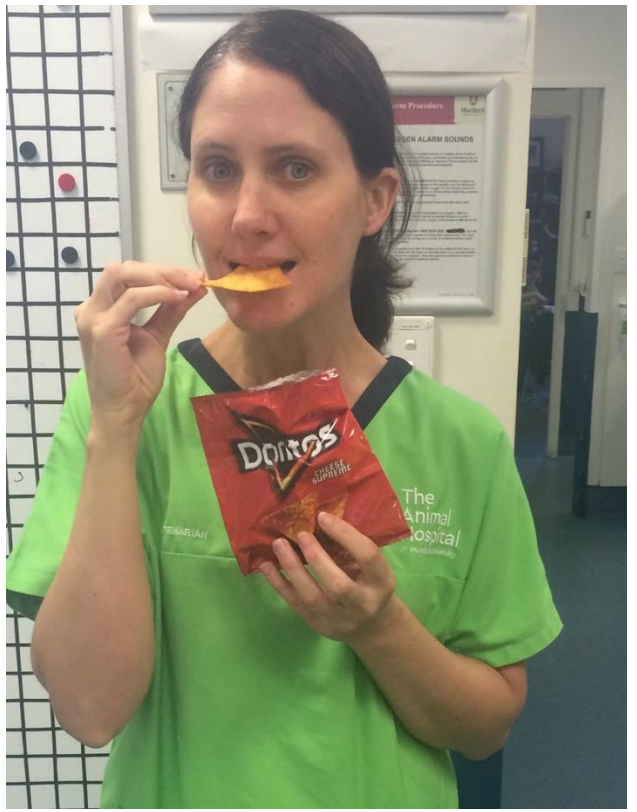
- Expensive and limited availability
- Only small clinical studies

Hydroxyethyl Starch

Hydroxethyl substitution of amylopectin derived from waxy maize, potato, or sorghum

- Heterogenous
- Newer = lower MW, degree of substitution
- Changes aimed at reducing adverse effects

Concerns include coagulopathy and AKI



Hydroxyethyl Starch

Colloids versus crystalloids for fluid resuscitation in critically ill people (Review)

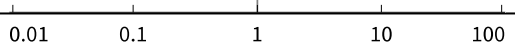
Lewis SR, Pritchard MW, Evans DJW, Butler AR, Alderson P, Smith AF, Roberts I

Cochrane Library
Cochrane Database of Systematic Reviews

Link with increased transfusion requirement in human medicine

Analysis 1.4. Comparison 1 Starches vs crystalloid, Outcome 4 Transfusion of blood product.

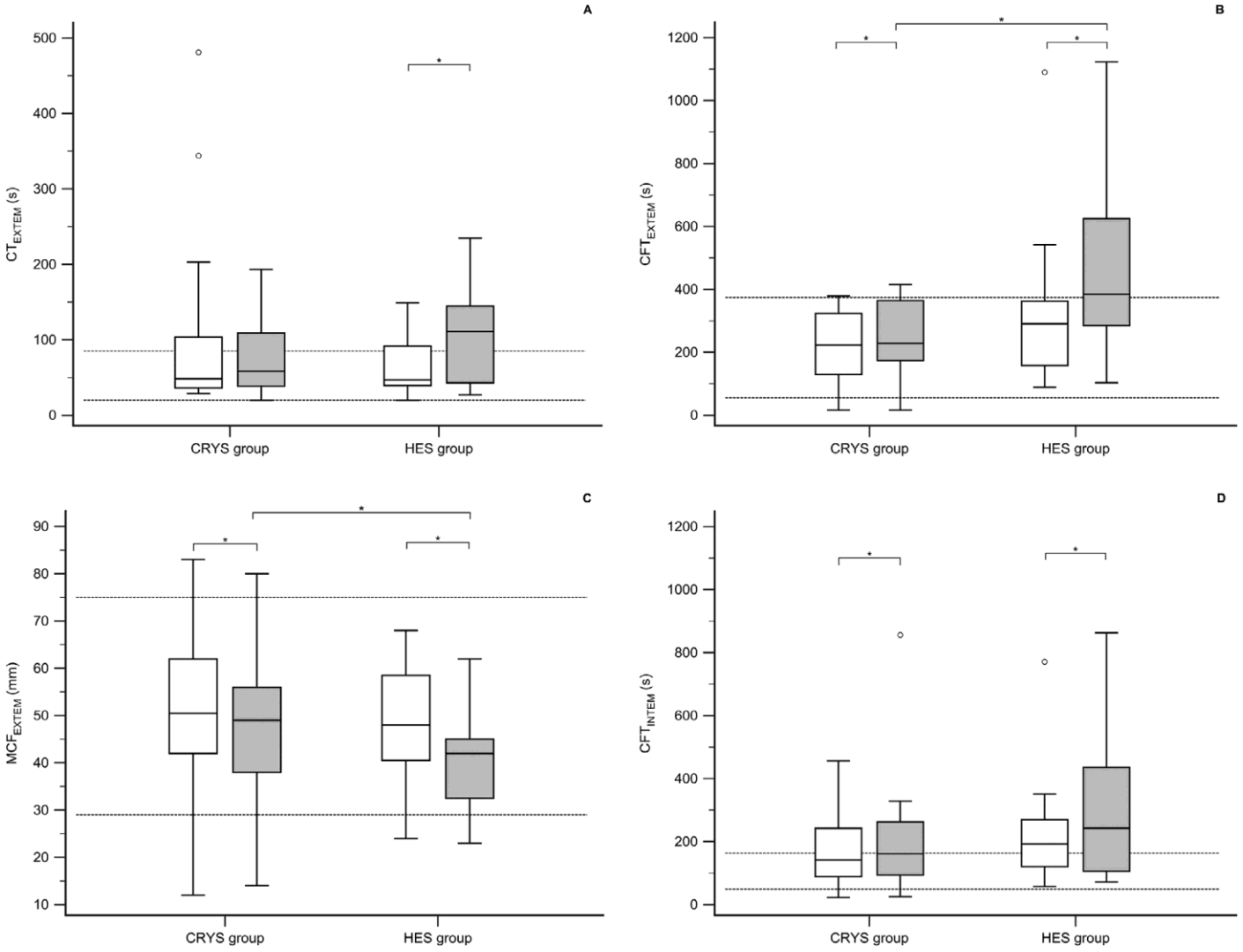
Study or subgroup	Starch n/N	Crystalloid n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Brunkhorst 2008	199/262	189/275		61.33%	1.11[1,1.23]
Cifra 2003	1/10	3/13		0.53%	0.43[0.05,3.57]
Guidet 2012	29/100	20/96		8.66%	1.39[0.85,2.29]
McIntyre 2008	10/21	5/19		2.98%	1.81[0.75,4.35]
Nagy 1993	11/21	10/20		6.14%	1.05[0.58,1.91]
Perner 2012	84/397	59/400		19.89%	1.43[1.06,1.94]
Vlachou 2010	0/12	0/14			Not estimable
Wills 2005	1/129	3/128		0.47%	0.33[0.03,3.14]
Total (95% CI)	**952**	**965**		**100%**	**1.19[1.02,1.39]**
Total events: 335 (Starch), 289 (Crystalloid)					
Heterogeneity: Tau^2=0.01; Chi^2=6.95, df=6(P=0.33); I^2=13.63%					



Favours starches

Favours crystalloids

Hydroxyethyl Starch



DOI: 10.1111/vec.13018

ORIGINAL STUDY

Journal of Veterinary Emergency and Critical Care | WILEY

A prospective randomized open-label trial on the comparative effects of 6% hydroxyethyl starch 130/0.4 versus polyionic isotonic crystalloids on coagulation parameters in dogs with spontaneous hemoperitoneum

Claudia Iannucci Dr med vet, DACVECC[1] | Daniel Dirkmann Dr med PD[2] | Judith Howard Dr med vet, DACVIM[3] | Katja N. Adamik Dr med vet PD, DACVECC, DECVECC[1]

Hydroxyethyl Starch

Colloids versus crystalloids for fluid resuscitation in critically ill people (Review)

Lewis SR, Pritchard MW, Evans DJW, Butler AR, Alderson P, Smith AF, Roberts I

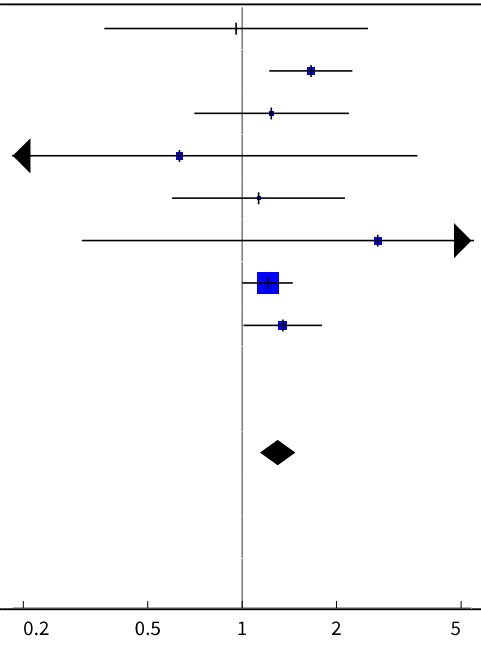
Cochrane Library

Cochrane Database of Systematic Reviews

Link with AKI well established in human medicine

Analysis 1.5. Comparison 1 Starches vs crystalloid, Outcome 5 Renal replacement therapy.

Study or subgroup	Starch n/N	Crystalloid n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Bechir 2013	6/23	6/22		1.79%	0.96[0.36,2.52]
Brunkhorst 2008	81/261	51/272		17.91%	1.66[1.22,2.25]
Guidet 2012	22/100	17/96		5.22%	1.24[0.7,2.19]
James 2011	2/56	3/53		0.55%	0.63[0.11,3.63]
Mahrous 2013	13/30	10/26		4.17%	1.13[0.6,2.13]
McIntyre 2008	3/21	1/19		0.36%	2.71[0.31,23.93]
Myburgh 2012	235/3352	196/3375		49.97%	1.21[1,1.45]
Perner 2012	87/398	65/400		20.03%	1.35[1.01,1.8]
Vlachou 2010	0/12	0/11			Not estimable
Total (95% CI)	**4253**	**4274**		**100%**	**1.3[1.14,1.48]**
Total events: 449 (Starch), 349 (Crystalloid)					
Heterogeneity: $Tau^2=0$; $Chi^2=4.77$, df=7(P=0.69); $I^2=0\%$					
Test for overall effect: Z=3.93(P<0.0001)					



Hydroxyethyl Starch

Original Study

Journal of Veterinary Emergency and Critical Care **00**(0) 2015, pp 1–6
doi: 10.1111/vec.12412

Retrospective cohort study on the incidence of acute kidney injury and death following hydroxyethyl starch (HES 10% 250/0.5/5:1) administration in dogs (2007–2010)

Associated with composite AKI/death outcome

Galina Hayes, PhD, DVM, DACVECC, DACVS; Leontine Benedicenti, DVM and Karol Mathews, DACVECC, DVSc

Journal of Veterinary Internal Medicine
Open Access
ACVIM

Standard Article

J Vet Intern Med 2017;31:434–441

Changes in Serum Creatinine Concentration and Acute Kidney Injury (AKI) Grade in Dogs Treated with Hydroxyethyl Starch 130/0.4 From 2013 to 2015

Duration associated with AKI

N.E. Sigrist, N. Kälin, and A. Dreyfus

Journal of Veterinary Internal Medicine
Open Access
ACVIM

Standard Article

J Vet Intern Med 2017;31:1749–1756

Effects of Hydroxyethyl Starch 130/0.4 on Serum Creatinine Concentration and Development of Acute Kidney Injury in Nonazotemic Cats

No association with AKI

N.E. Sigrist, N. Kälin, and A. Dreyfus

Retrospective Study

Journal of Veterinary Emergency and Critical Care **00**(0) 2016, pp 1–10
doi: 10.1111/vec.12483

Retrospective evaluation of the effects of administration of tetrastarch (hydroxyethyl starch 130/0.4) on plasma creatinine concentration in dogs (2010–2013): 201 dogs

No association with AKI

Ivayla D. Yozova, Dr med vet; Judith Howard, DVM, DACVIM and Katja-Nicole Adamik, Dr med vet, DACVECC, DECVECC

Original Article

Journal of Feline Medicine and Surgery
2017, Vol. 19(10) 1073–1079

DOI: 10.1177/1098612X16677460
journals.sagepub.com/home/jfm

Effect of tetrastarch (hydroxyethyl starch 130/0.4) on plasma creatinine concentration: a clinical and retrospective analysis (2010–2015)

No association with AKI

SAGE

Ivayla D Yozova[1], Judith Howard[2] and Katja N Adamik[1]

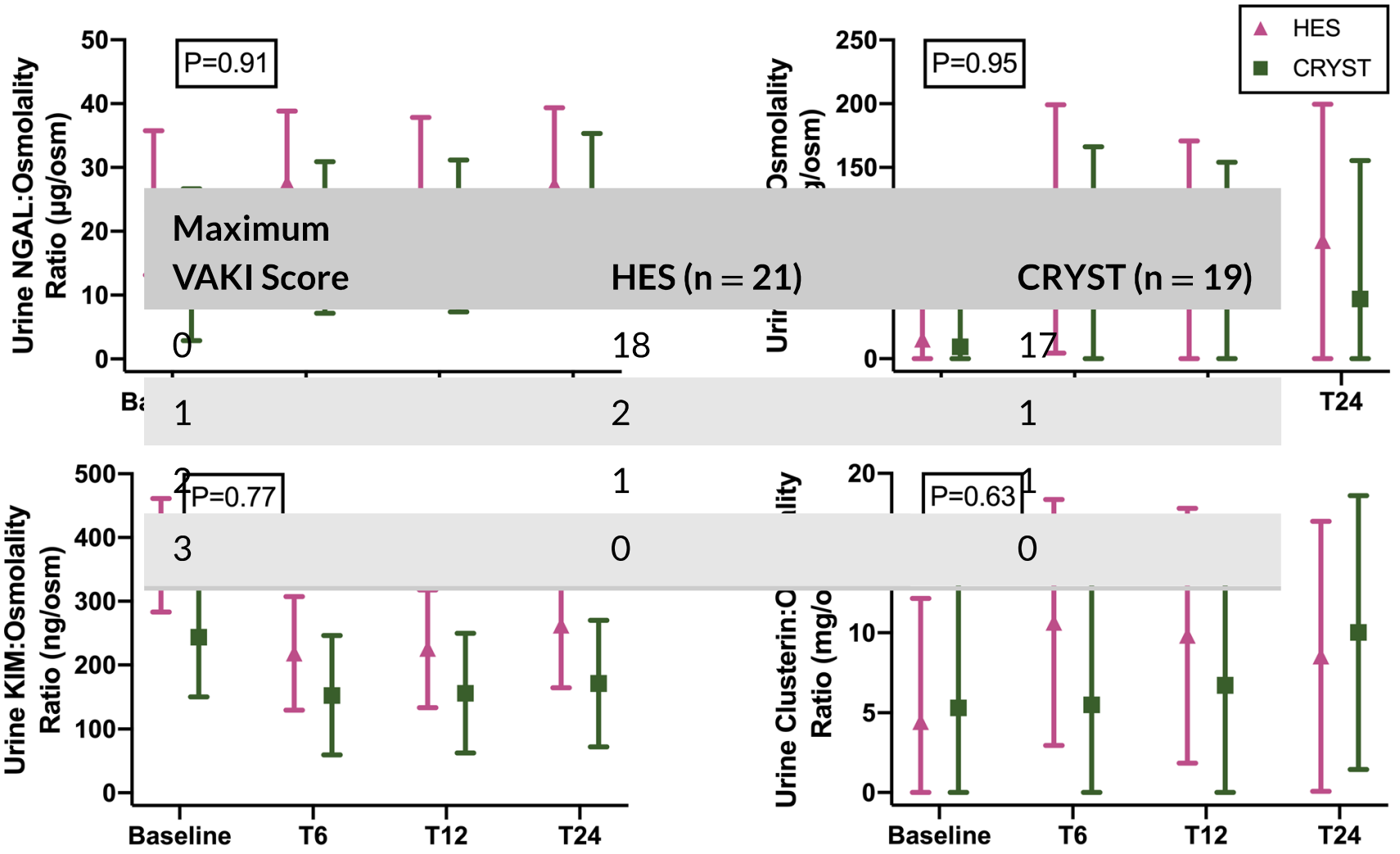
Hydroxyethyl Starch

DOI: 10.1111/vec.13056

ORIGINAL STUDY

Prospective randomized controlled blinded clinical trial evaluating biomarkers of acute kidney injury following 6% hydroxyethyl starch 130/0.4 or Hartmann's solution in dogs

Corrin J. Boyd BSc, BVMS(Hons), GradDipEd, MVetClinStud, MANZCVS, DACVECC | Claire R. Sharp BSc, BVMS, MS, DACVECC | Melissa A. Claus DVM, DACVECC | Anthea L. Raisis BVSc, MVetClinStud, DVA, PhD | Giselle Hosgood BVSc(Hons), MS, PhD, FANZCVS, DACVS | Lisa Smart BVSc(Hons), PhD, DACVECC



Gelatin

Bovine collagen derived, chemically modified

- Succinylated, urea-linked, oxypolygelatin

Lower MW than HES

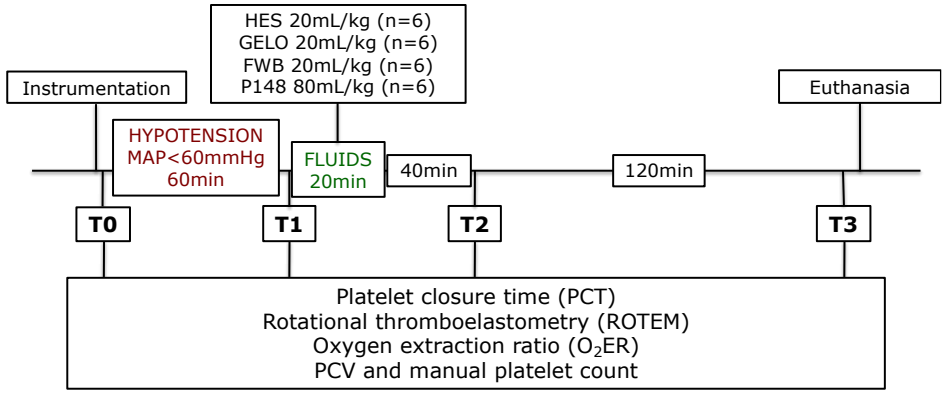
- Freely filtered, minimal metabolism
- Short half-life

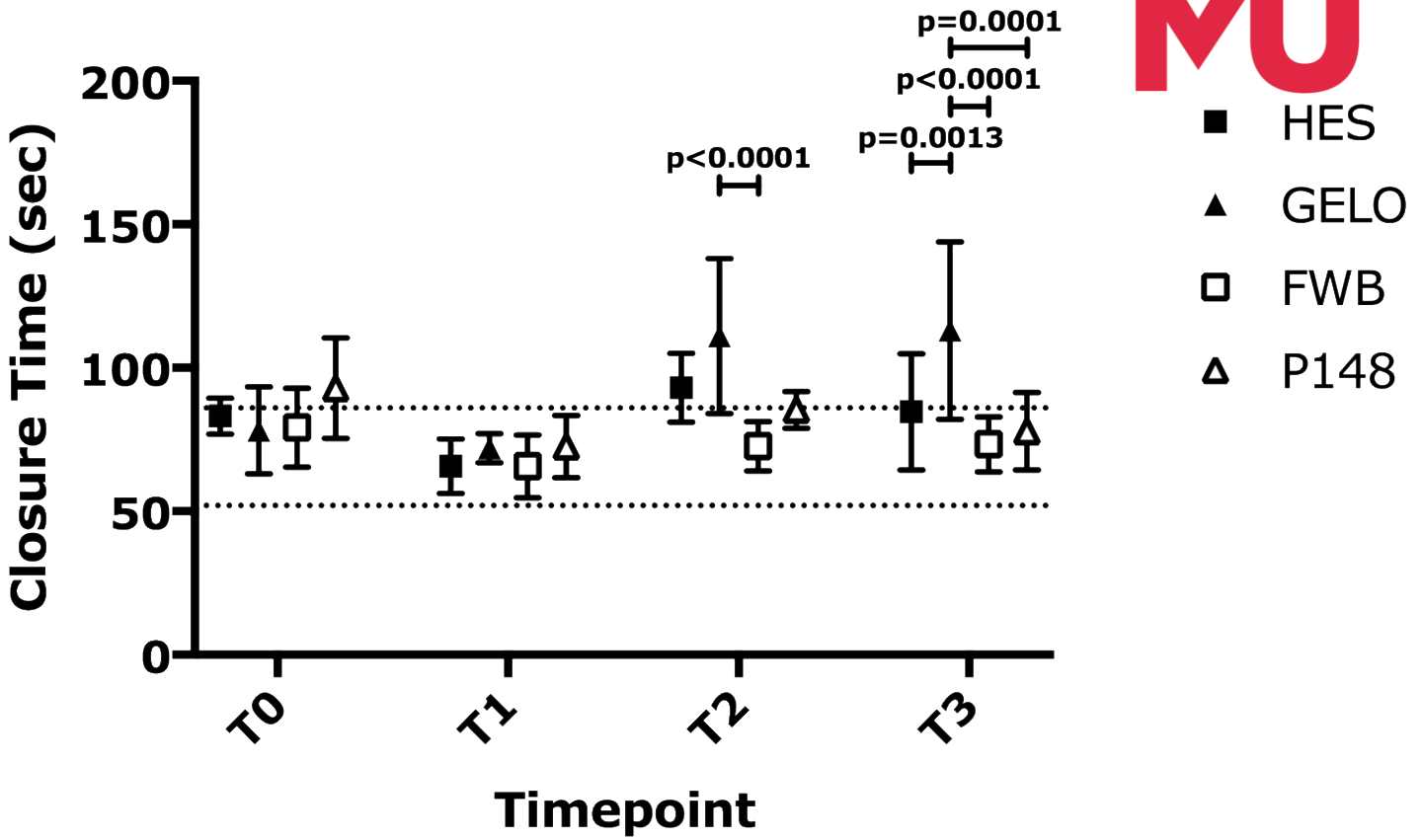
Like HES, concerns include coagulopathy and AKI

Gelatin

Hypocoagulability and Platelet Dysfunction Are Exacerbated by Synthetic Colloids in a Canine Hemorrhagic Shock Model

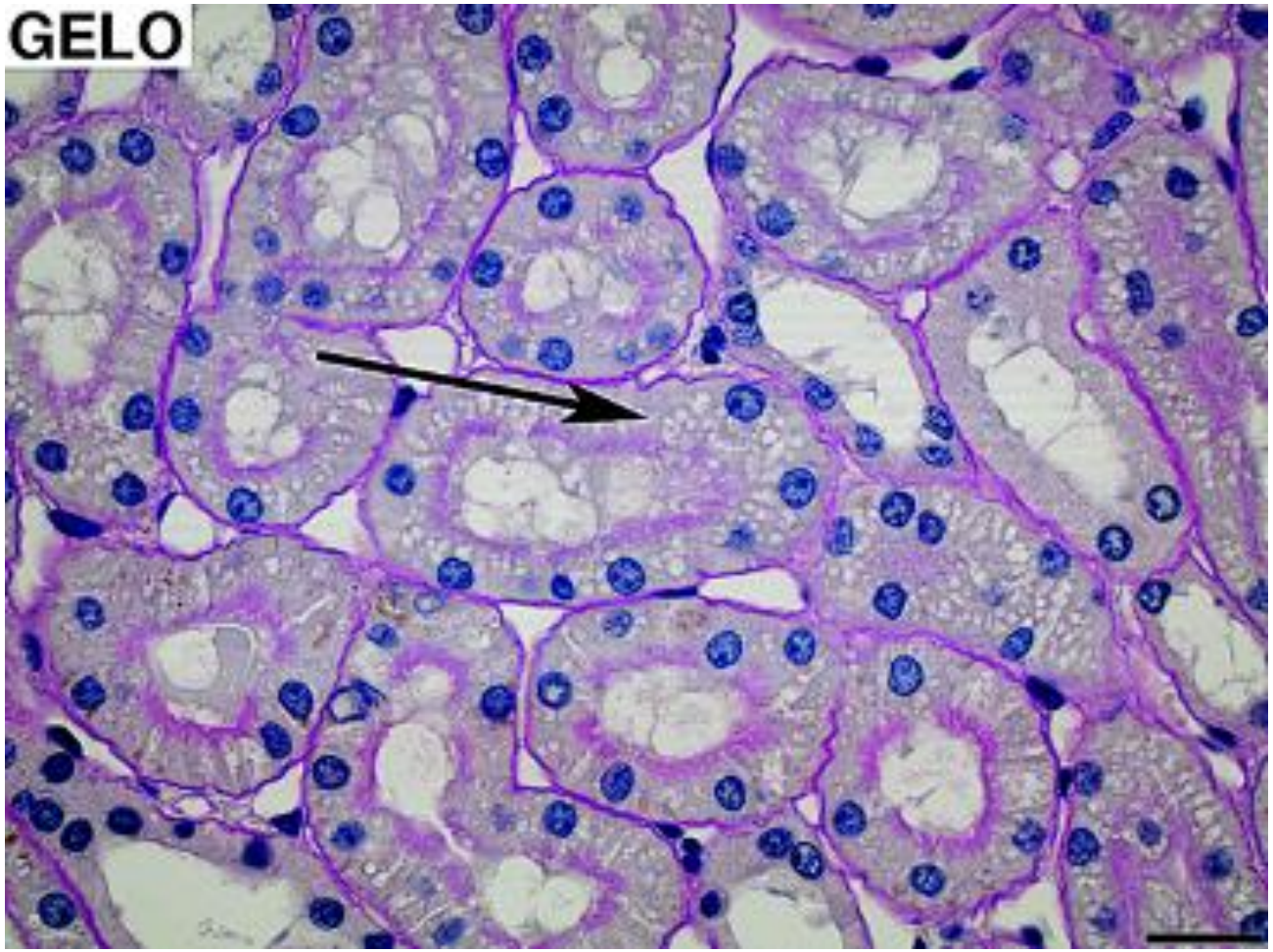
Corrin J. Boyd, Melissa A. Claus, Anthea L. Raisis, Giselle Hosgood, Claire R. Sharp and Lisa Smart*





Less evidence than HES, but some links to increased hemorrhage in human medicine

Gelatin



ORIGINAL STUDY

WILEY Journal of Veterinary Emergency and Critical Care

Evaluation of biomarkers of kidney injury following 4% succinylated gelatin and 6% hydroxyethyl starch 130/0.4 administration in a canine hemorrhagic shock model

Corrin J. Boyd BSc, BVMS(Hons), GradDipEd, MVetClinStud, MANZCVS, DACVECC[1] | Melissa A. Claus DVM, DACVECC[1] | Anthea L. Raisis BVSc, MVetClinStud, PhD, MANZCVS, DVA[1] | Rachel Cianciolo VMD, PhD, DACVP[2] | Erika Bosio BSc(Hons), PhD[3,4] | Giselle Hosgood BVSc(Hons), MS, PhD, FANZCVS, DACVS[1] | Mary Nabity DVM, PhD, DACVP[5] | Trevor Mori BSc(Hons), PhD[6] | Anne Barden BSc, PhD[6] | Claire R. Sharp BSc, BVMS, MS, DACVECC[1] | Lisa Smart BVSc(Hons), DACVECC[1,3,4]

J Vet Emerg Crit Care. 2019;29:132–142.

Human studies primarily in cardiac surgery with mixed findings

Colloid Indications

Remain within intravascular space

- Only useful for hypovolaemia
- May be more effective than crystalloids in some situations
    - Especially when low colloid osmotic pressure (COP) is a problem
        - Hypoalbuminaemia

NOT useful for dehydration/maintenance/ongoing losses

Can be considered in cases where there is evidence of hypovolaemia and low plasma colloid osmotic pressure is believed to be contributing to an inadequate response to isotonic crystalloids

- Generally follows an attempt at crystalloid resuscitation

Colloid Recommendations

Controversial

- There is definitely no consensus amongst the veterinary ECC/anaesthesia/medicine fields

Only consider in hypovolaemia

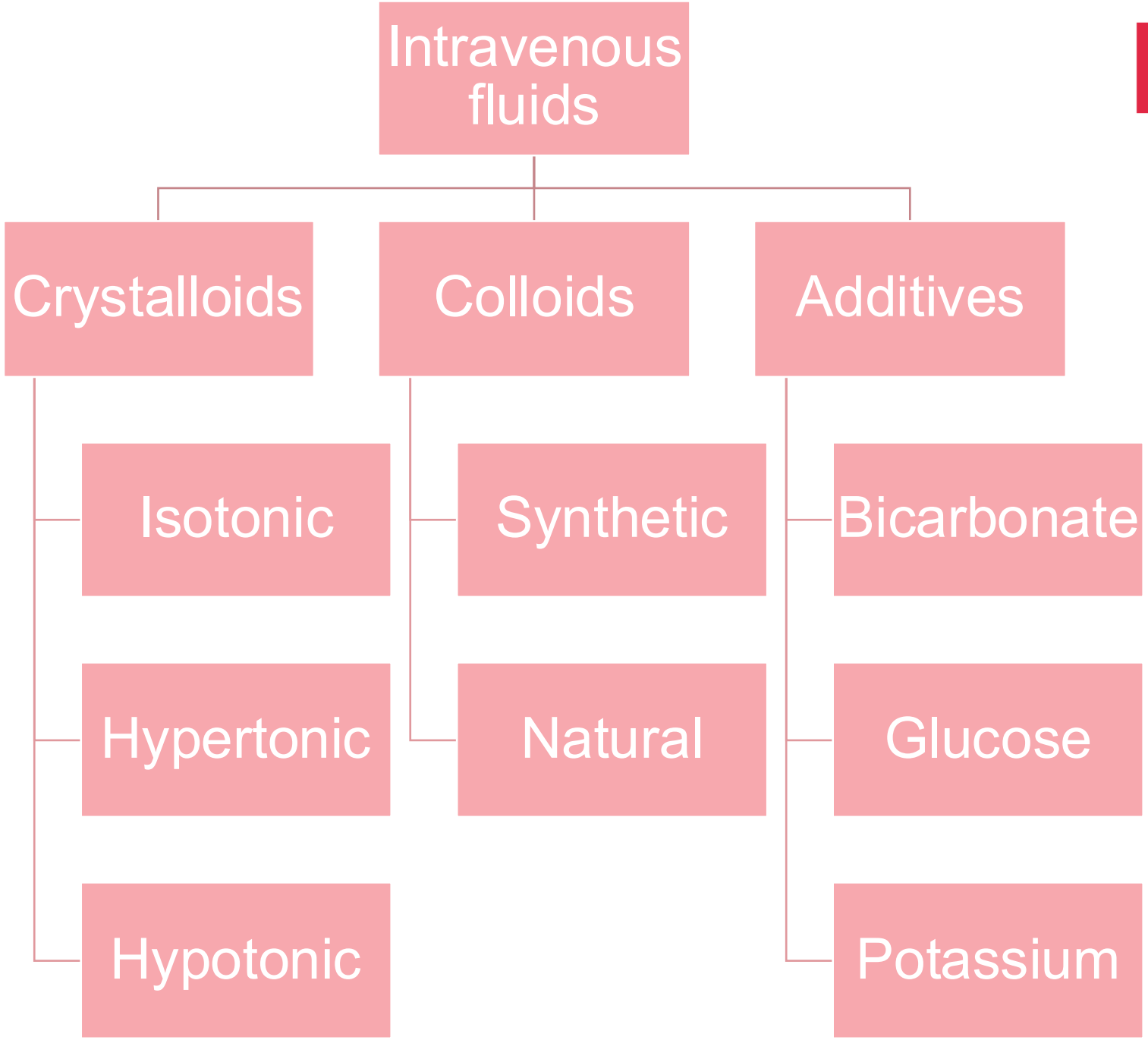
- Balanced isotonic crystalloid is first line therapy
- Consider colloids in situation where:
  - Confident it is truly hypovolaemia
  - Reasonable volumes of crystalloid have been tried (e.g., 30 mL/kg in dog)
  - Response to crystalloid is transient
  - Reason to believe response to colloid would be more sustained (hypoalbuminaemia)

Colloid Recommendations

If considering colloids

- Don’t use synthetic colloids if active bleeding/high bleeding risk
  - Blood products (including plasma) likely the best choice here
- Use extreme caution if at high risk of kidney injury
- If using a synthetic colloid, prefer HES (e.g., Voluven)
  - Less research on gelatin
  - Gelatin causes profound platelet dysfunction
  - A little more evidence for kidney injury with Gelatin
- If using a synthetic colloid, use the lowest effective dose
  - Titrate 3-5 mL/kg boluses to effect
- Colloid CRIs probably do more harm than good

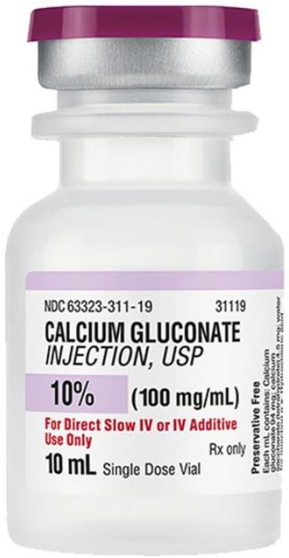
Classification of fluid types



Glucose and Electrolyte Supplements

May be added to a crystalloid or administered as a standalone bolus/CRI

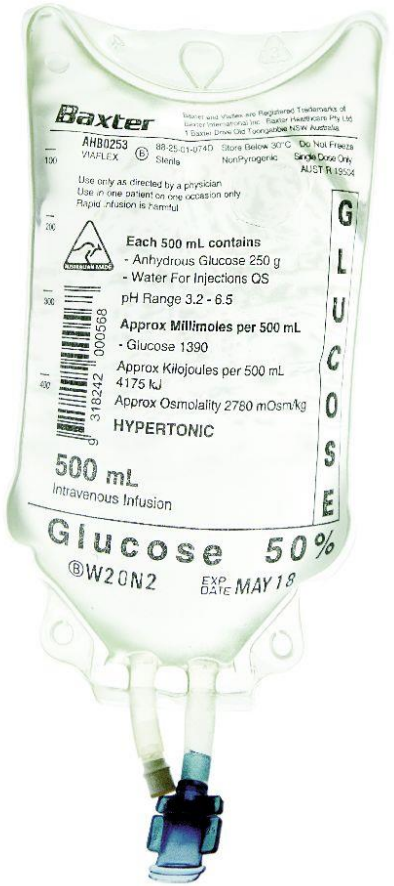
- Differs from electrolyte to electrolyte



50% Glucose

Used for treatment of hypoglycaemia

- Bolus
  - Dilute at least 1:1 with isotonic crystalloid or water for injection (unless using central line)
  - Give 0.25-1 g/kg glucose as bolus
    - 1 g/kg = 2 mL/kg of undiluted 50% = at least 4 mL/kg after dilution
- Supplement in fluids (constant infusion)
  - Add to isotonic crystalloid to make a 2.5% or 5% supplemented solution
    - 2.5% = 25 g glucose in 1L bag crystalloid
      - Remove 50 mL of crystalloid and add 50 mL of 50% glucose
    - 5% = 50 g glucose in 1L bag crystalloid
      - Remove 100 mL of crystalloid and add 100 mL of 50% glucose



Potassium

Most common electrolyte to supplement

- To treat or prevent hypokalaemia
- Usually potassium chloride (KCl)
  - Can contribute to hyperchloraemia
- Usually add to crystalloid fluid
- MIX WELL
- CARE with administration rate
  - Risk of arrhythmia including asystole
  - DO NOT EXCEED 0.5 mEq/kg/hour
- Occasionally CRI (central line)
- NEVER BOLUS

Table 51-1 Guidelines for Routine Intravenous Supplementation of Potassium in Dogs and Cats[30]

Serum Potassium Concentration (mEq/L)	mEq KCl to Add to 250 ml Fluid*	mEq KCl to Add to 1 L Fluid	Maximal Fluid Infusion Rate† (ml/kg/hr)
<2.0	20	80	6
2.1 to 2.5	15	60	8
2.6 to 3.0	10	40	12
3.1 to 3.5	7	28	18
3.6 to 5.0	5	20	25

*It is essential to shut off the flow valve to the patient and that the fluid container contents are thoroughly mixed during and after adding potassium to the parenteral fluids.
†So as not to exceed 0.5 mEq/kg/hr.

Silverstein and Hopper, Small Animal Critical Care Medicine 2nd Edition

Learning outcomes

- At the end of this lecture you will be able to :

1. Describe the features of hypotonic crystalloids such as 0.45% NaCl and D5W, and how they may be used to correct a free water deficit manifesting as hypernatremia.
2. Describe the features of hypertonic crystalloids such as 7.5% NaCl, and how they may be used where hyperosmolar therapy is indicated, such as to reduce intracranial pressure in patients with traumatic brain injury.
3. Describe the features of synthetic colloid fluids, and how our understanding of their effects has changed over time with the revised Starling principle and studies suggesting the potential for harm.
4. Explain the role of fluid additives such as 50% glucose, potassium, and bicarbonate, in fluid therapy.