

Fluid therapy for ICU patients



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Today's aims



Daily fluid considerations

- ◆ Fluid balance
- ◆ Debates on fluid type



Challenging ICU patients

- ◆ Hypoproteinemia
- ◆ Excessive GI losses
- ◆ Vasopressor dependent
- ◆ CHF with azotemia

Daily fluid balance



- Perfusion parameters
- Interstitial hydration
- POCUS



- Fluid volume in= out
- Weight (5% changes)
- PCV/TP

Cardiovascular



Trending
up?



Hydration parameters



Skin tenting

- BCS
- Age



Eyes

- Tear film
- Sunken eyes

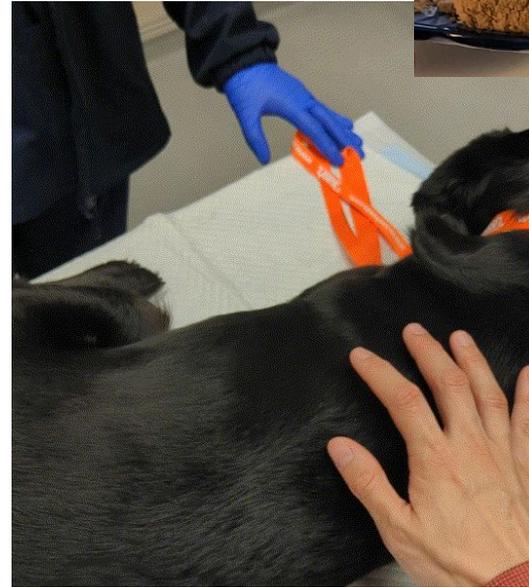


Gum tackiness

- Panting
- Uremia
- Nausea

Daily fluid balance

- Over-estimate dehydration
- Underestimate overhydration
- Best to trend with time

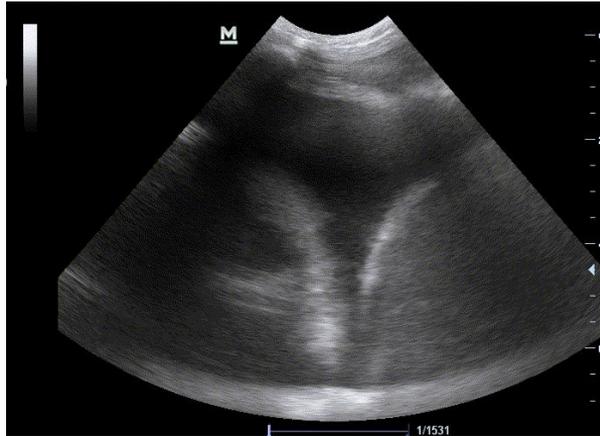


Daily POCUS

Signs of fluid overload



B lines



Pleural effusion



Pericardial effusion

Daily POCUS

Signs of fluid overload



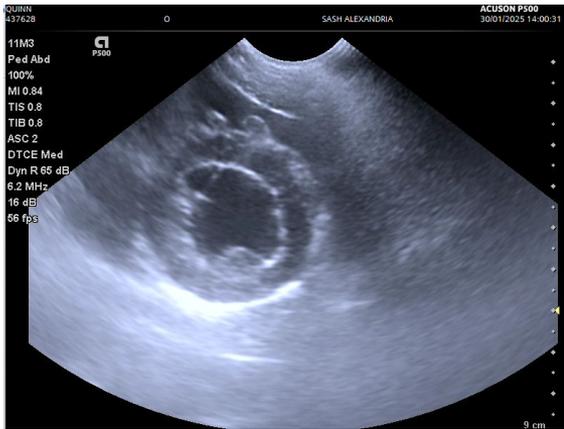
↑ LA:Ao



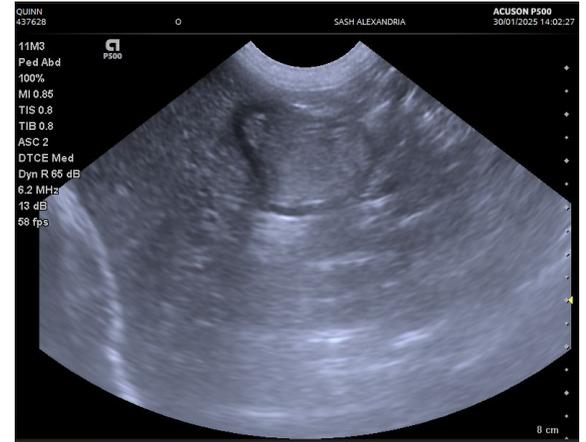
Non-collapsible
vena cava

Daily POCUS

Signs of being underloaded



Inadequate LV filling



GIT losses

Big picture assessment



- Perfusion parameters
- Interstitial hydration
- POCUS



- Fluid volume in= out
- Weight (5% changes)
- PCV/TP

Break

Fluid overload is bad



Longer stay



Mortality

Retrospective evaluation of fluid overload and relationship to outcome in critically ill dogs

Amanda A Cavanagh ¹, Lauren A Sullivan ¹, Bernard D Hansen ²

- **1% ↑ fluid overload**
- **Odds of death ↑ by 8%**

doi: 10.1111/vec.12477

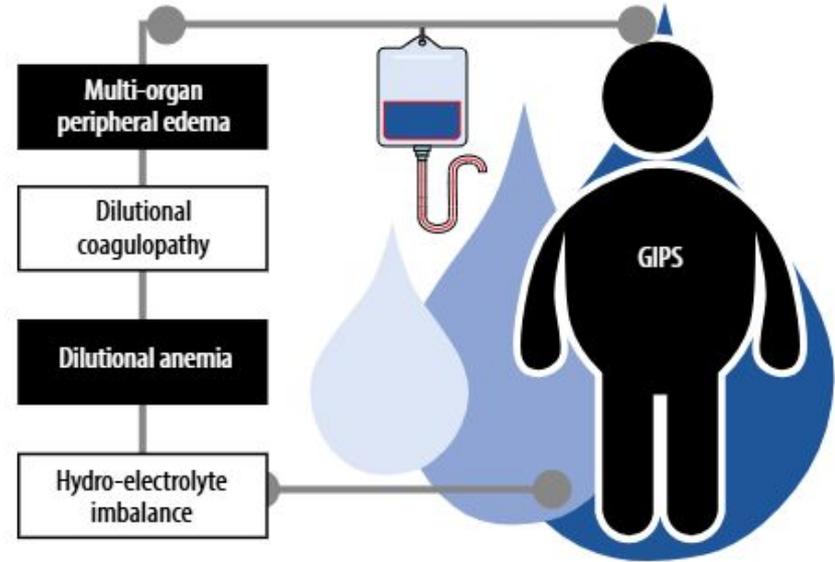
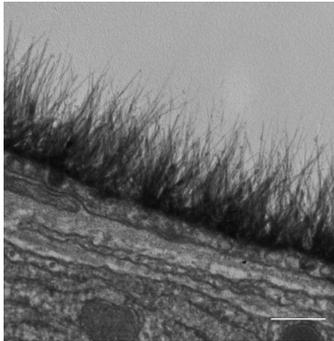
doi: 10.5603/AIT.2014.0060

doi: 10.1097/CCM.0b013e3181feeb15

Fluid overload is bad

- **Multiple organs**
- **Poor GFR**
 - 7.5ml/hr for 5h ↓ perfusion within 5h
- **Intra-abdominal hypertension**

Glycocalyx degradation



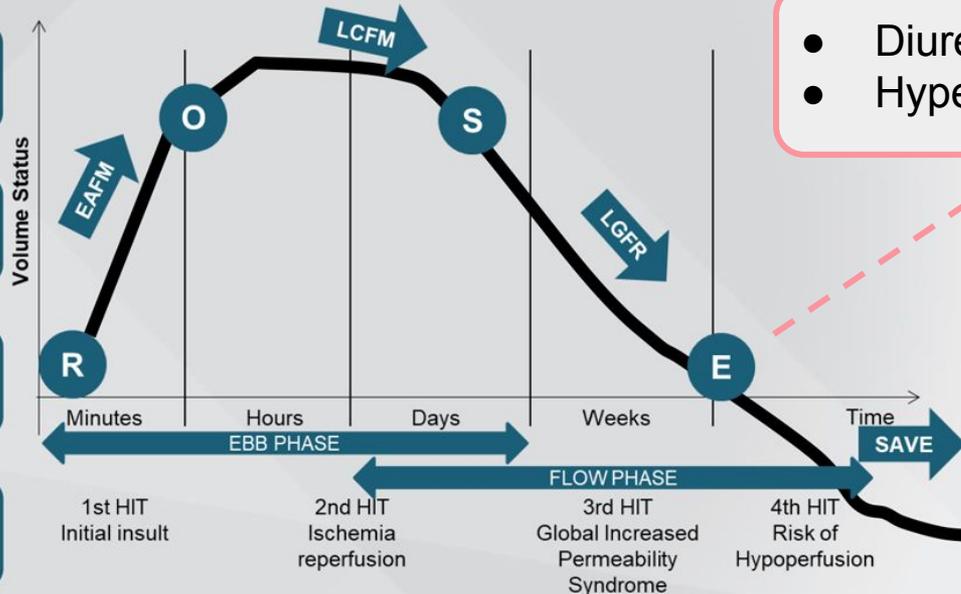
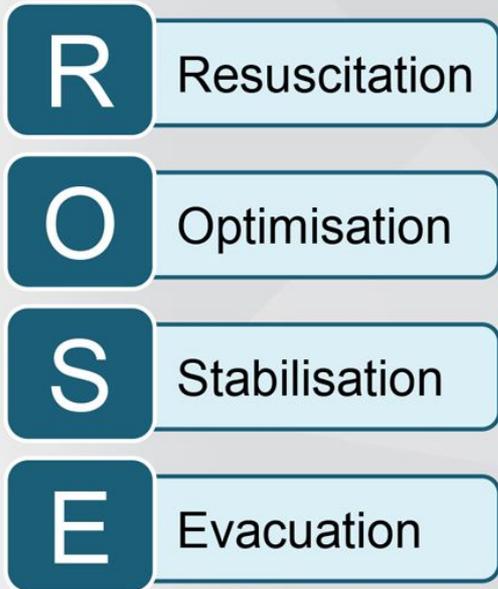
doi: 10.1111/vec.13125

doi: 10.2460/ajvr.75.4.344

doi: 10.5114/ait.2021.105252

SACCM chapter 9: The Endothelial Surface Layer

De-Escalation: The R.O.S.E. Model



- Diuretics
- Hyperoncotic albumin

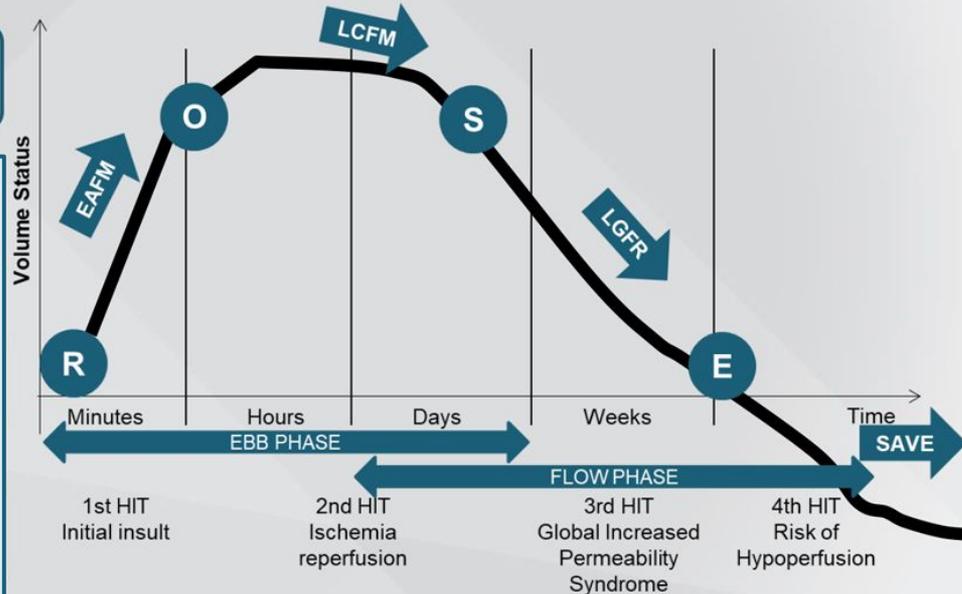
From: *The International fluid academy*

De-Escalation: The R.O.S.E. Model

R

Resuscitation

- Resus to effect
- Restrictive resus



From: The International fluid academy

De-Escalation: The R.O.S.E. Model

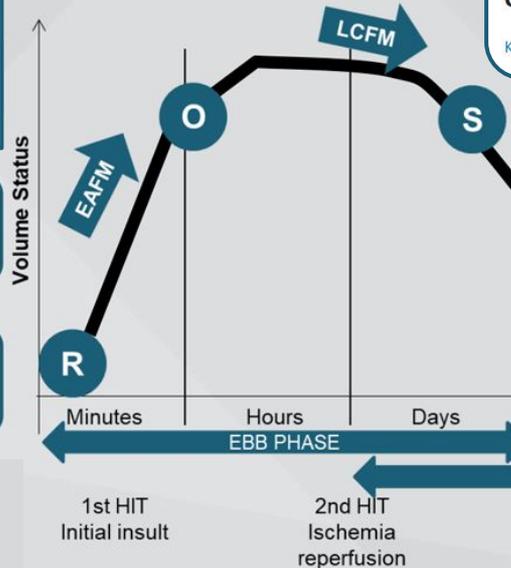
Just enough
maintenance fluids

O

Optimisation

S

Stabilisation



An online survey of small animal veterinarians regarding current fluid therapy practices in dogs and cats

Kate Hopper, Alejandro Garcia Rojas, Linda Barter

- 44% 60 ml/kg/day
- 30% 2-4 ml/kg/hr
- Minority indexed to body weight

From: *The International fluid academy*

$$60\text{ml/kg/day} \\ = \\ 62.5\text{ ml/hr}$$

$$2\text{-}4\text{ ml/kg/h} \\ = \\ 50\text{-}100\text{ ml/hr}$$

$$70 \times \text{BW}^{0.75} \\ = \\ 32.5\text{ml/hr}$$



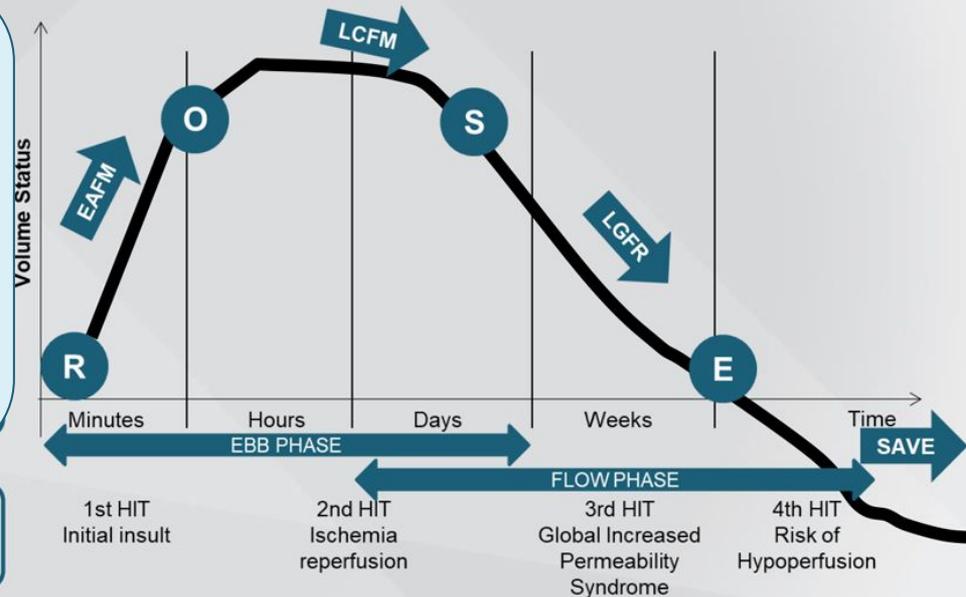
25kg dog

Fluid overload

De-Escalation: The R.O.S.E. Model

Achieving negative fluid balance improves mortality

E Evacuation



Fluid overload



Stop or decrease fluid therapy



Frusumide

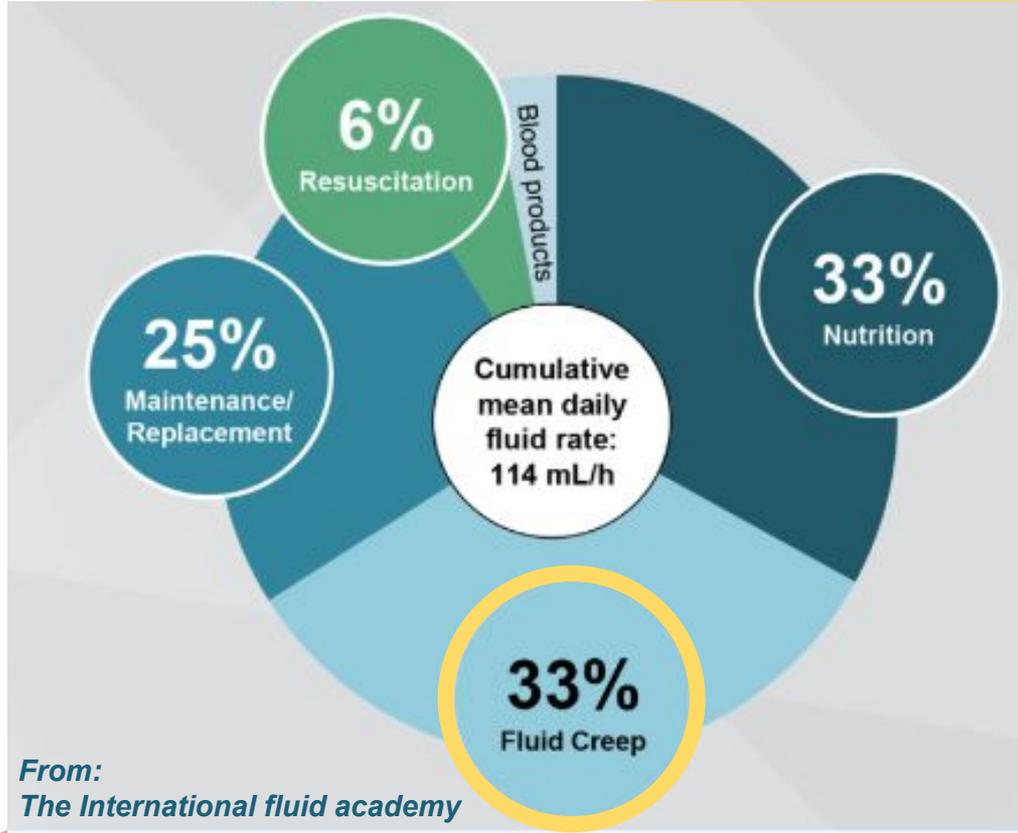


- Up to 20mg total over 3 days
- 5-40 mg total + CRI



- 0.2- 0.5mg/kg, up to 1 mg/kg
- Single dose or q 6-8h

Fluid creep

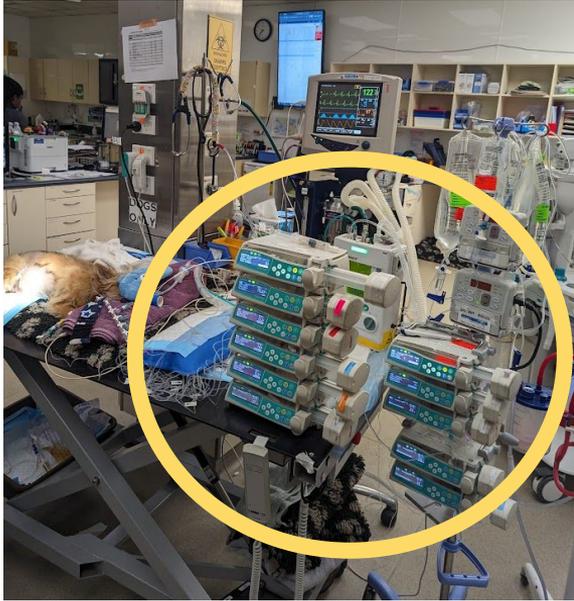


From:
The International fluid academy

- Diluents, flushes
- Contributes to large sodium and chloride load

doi: 10.1007/s00134-018-5147-3
doi: 10.1097/CCM.0000000000003276

Fluid creep

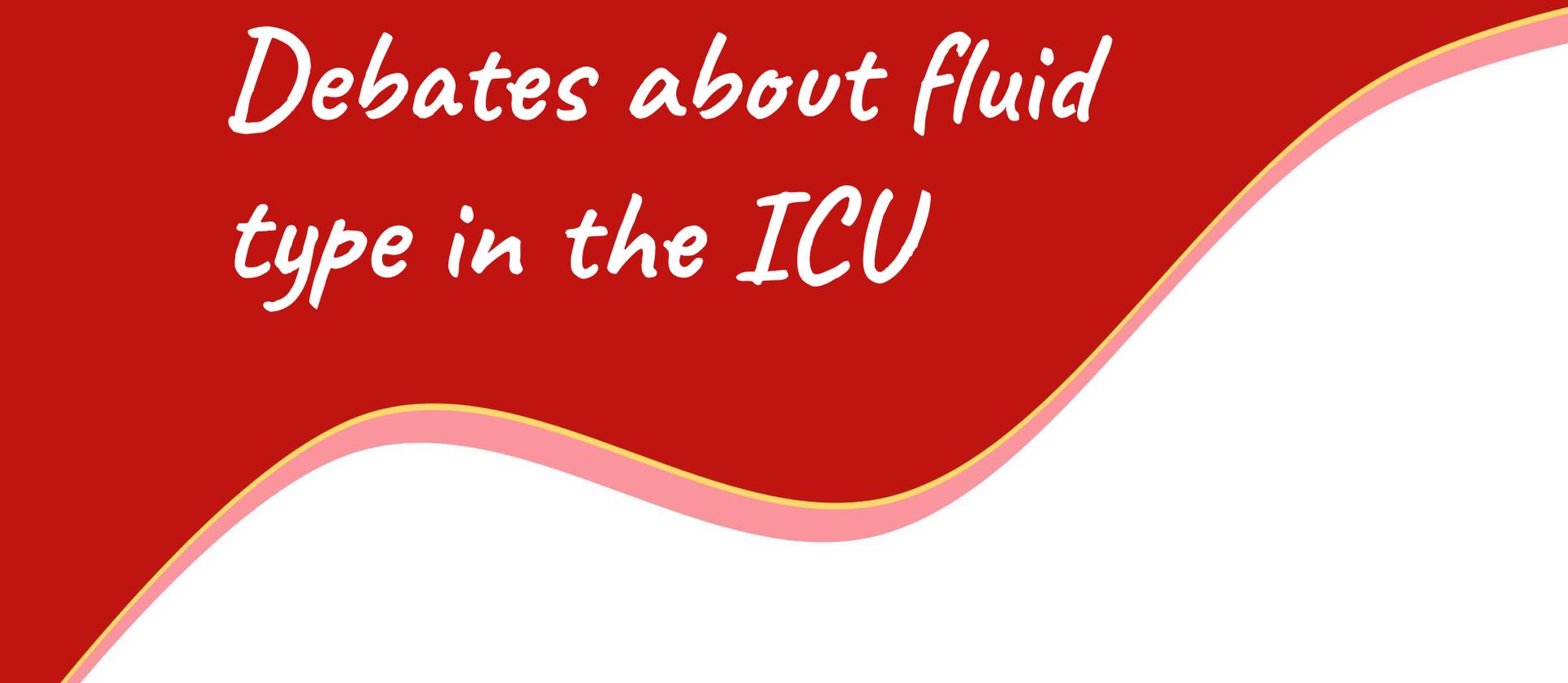


Easy to exceed daily maintenance requirements

- Less diluted drugs
- Use sterile water or NaCl 0.45%?

Break

*Debates about fluid
type in the ICU*



***Balanced
crystalloids***

Fluid image

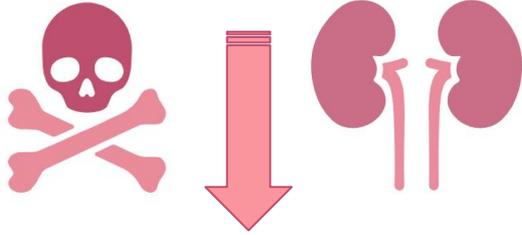
VS

NaCl 0.9%

Fluid image

The NEW ENGLAND JOURNAL of MEDICINE

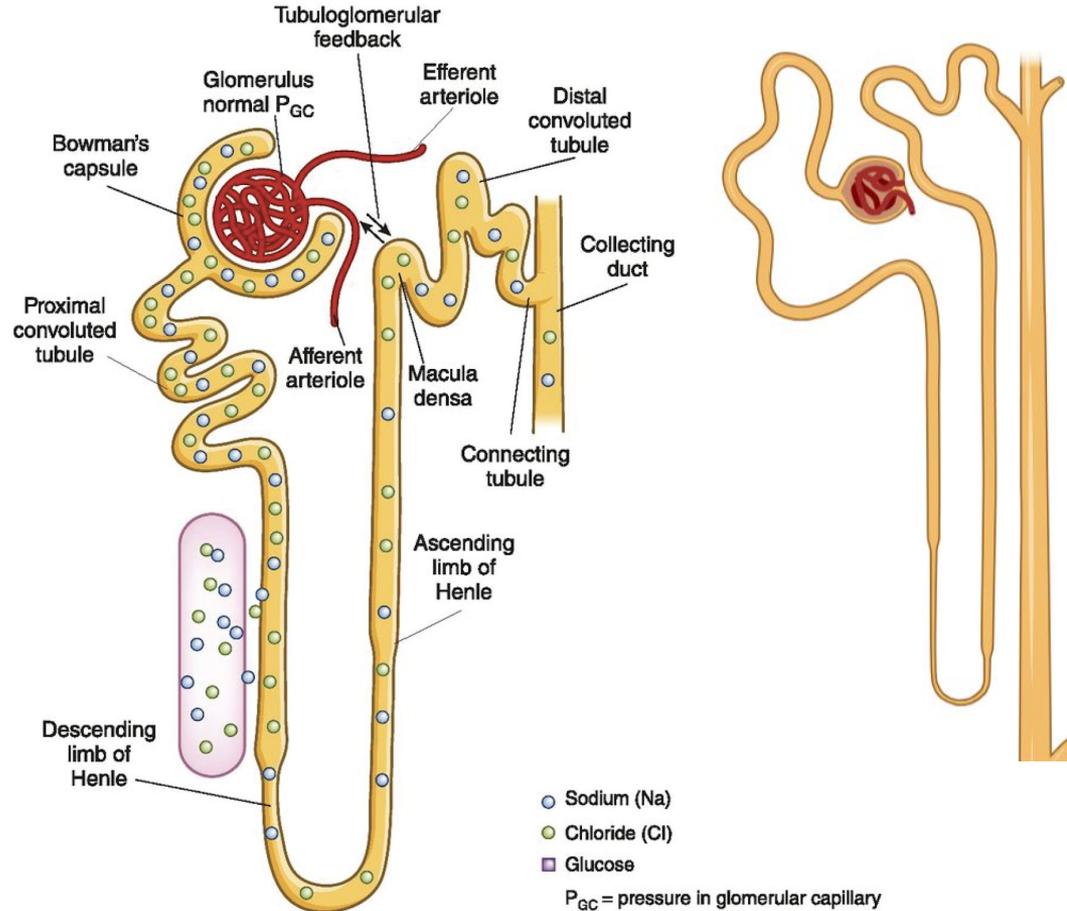
Balanced Crystalloids versus Saline in Critically Ill Adults



2018

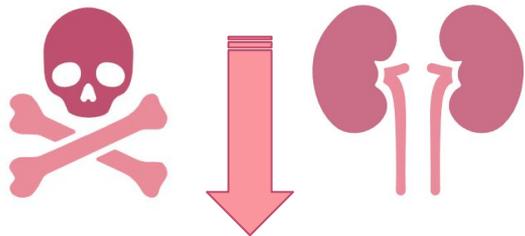
The NEW ENGLAND JOURNAL of MEDICINE

Balanced Crystalloids versus Saline in Noncritically Ill Adults



The NEW ENGLAND JOURNAL of MEDICINE

Balanced Crystalloids versus Saline
in Critically Ill Adults



2018

The NEW ENGLAND JOURNAL of MEDICINE

Balanced Crystalloids versus Saline
in Noncritically Ill Adults



2021

JAMA

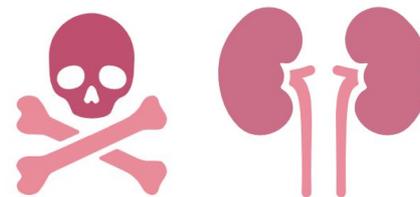
Effect of Intravenous Fluid Treatment With
a Balanced Solution vs 0.9% Saline Solution
on Mortality in Critically Ill Patients
The BaSICS Randomized Clinical Trial



2022

The NEW ENGLAND JOURNAL of MEDICINE

Balanced Multielectrolyte Solution versus Saline in
Critically Ill Adults



No difference

doi: 10.1056/NEJMoa1711584

doi: 10.1056/NEJMoa1711586

doi:10.1001/jama.2021.11684

doi: 10.1056/NEJMoa2114464

What to do?

***Balanced
crystalloids
preferred***

NaCl 0.9%

- *Limited stocks*
- *Metabolic alkalosis*

*Isotonic
crystalloids*

Fluid image

VS

*Hypotonic
NaCl 0.45%*

Fluid image

Isotonics

*High Na load +
fluid overload*

NaCl 0.45%

- + 2.5% dextrose (iso-osmolar)
- Risk of hyponatremia due to non-osmotic ADH release
 - RAAS activation in states of hypovolemia
 - SIADH
 - Children + adults

What to do w NaCl 0.45%?

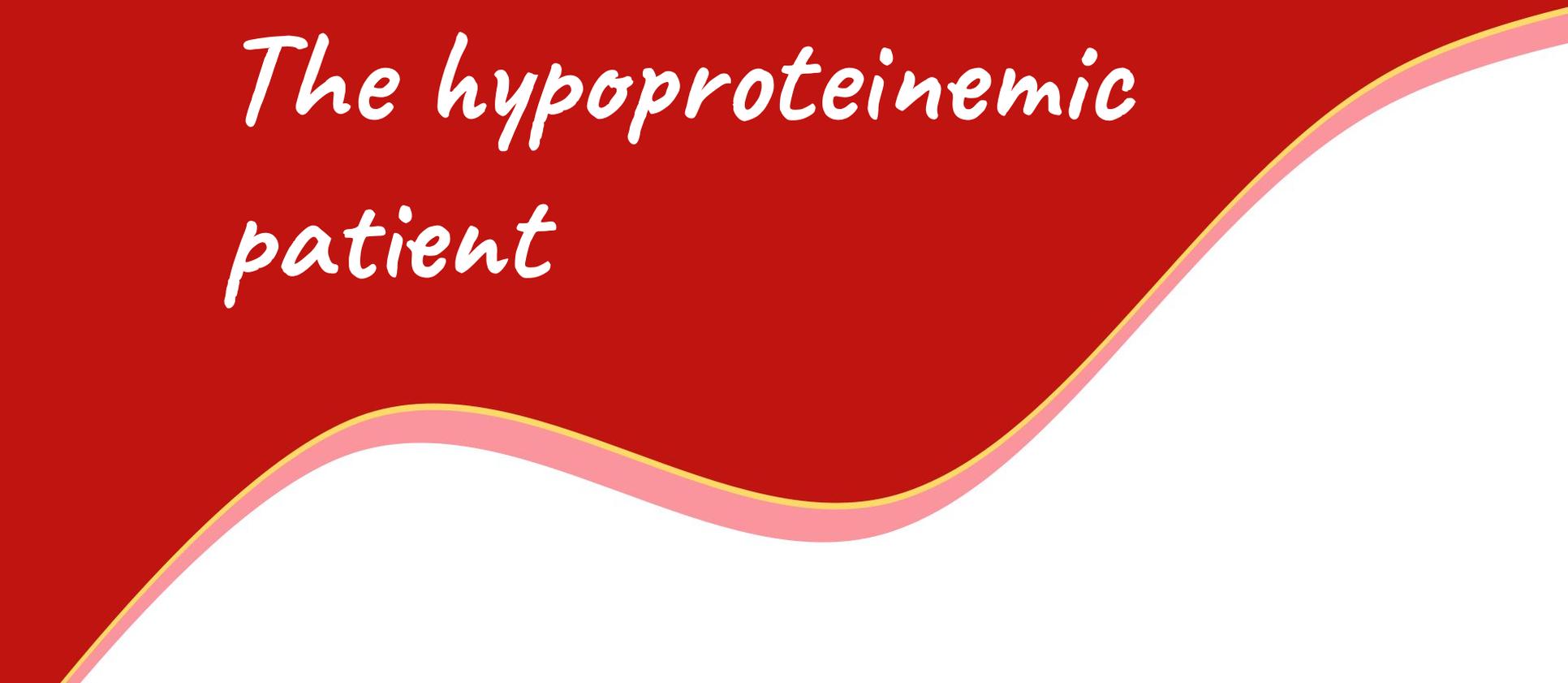
Use

- Maintenance fluids only
- HyperNa tx
- Can't tolerate Na load
 - CHF or renal dz
- Minimize fluid overload

Avoid

- In hypoNa
- Patients at risk of hypoNa
 - SIADH
 - Repeated RAAS activation

Break



*The hypoproteinememic
patient*

Hypoalbuminemia

GIT losses

AHDS

Parvovirus

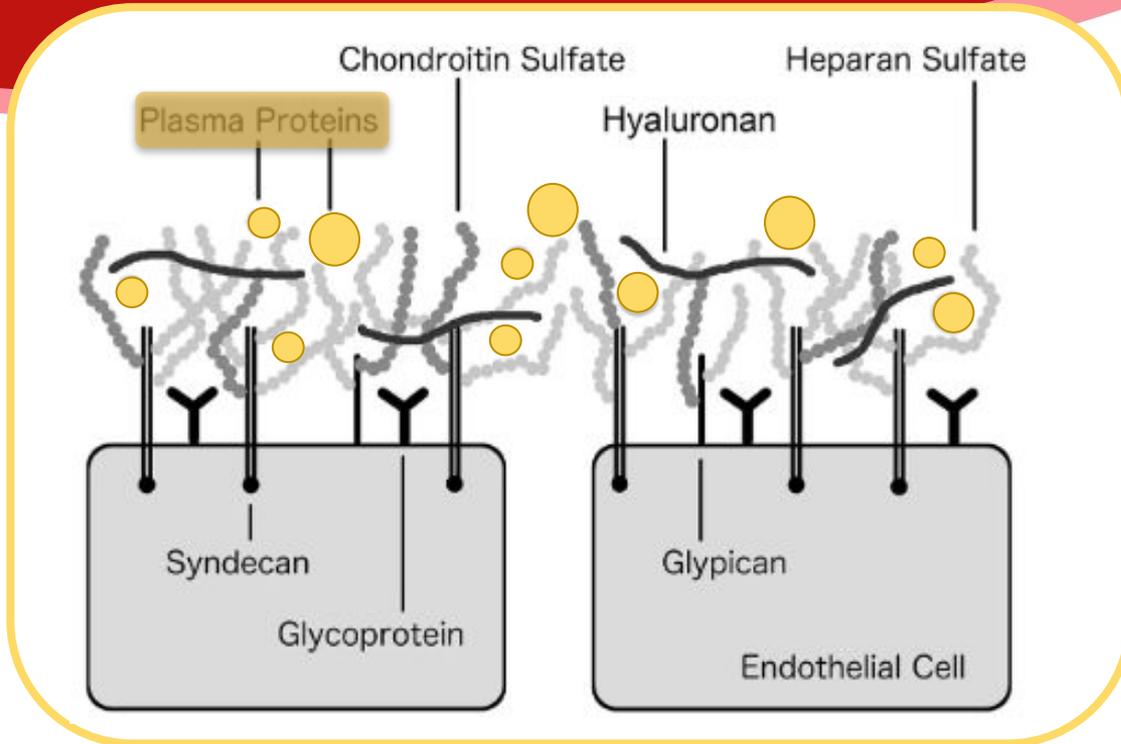
PLE

Hemorrhage

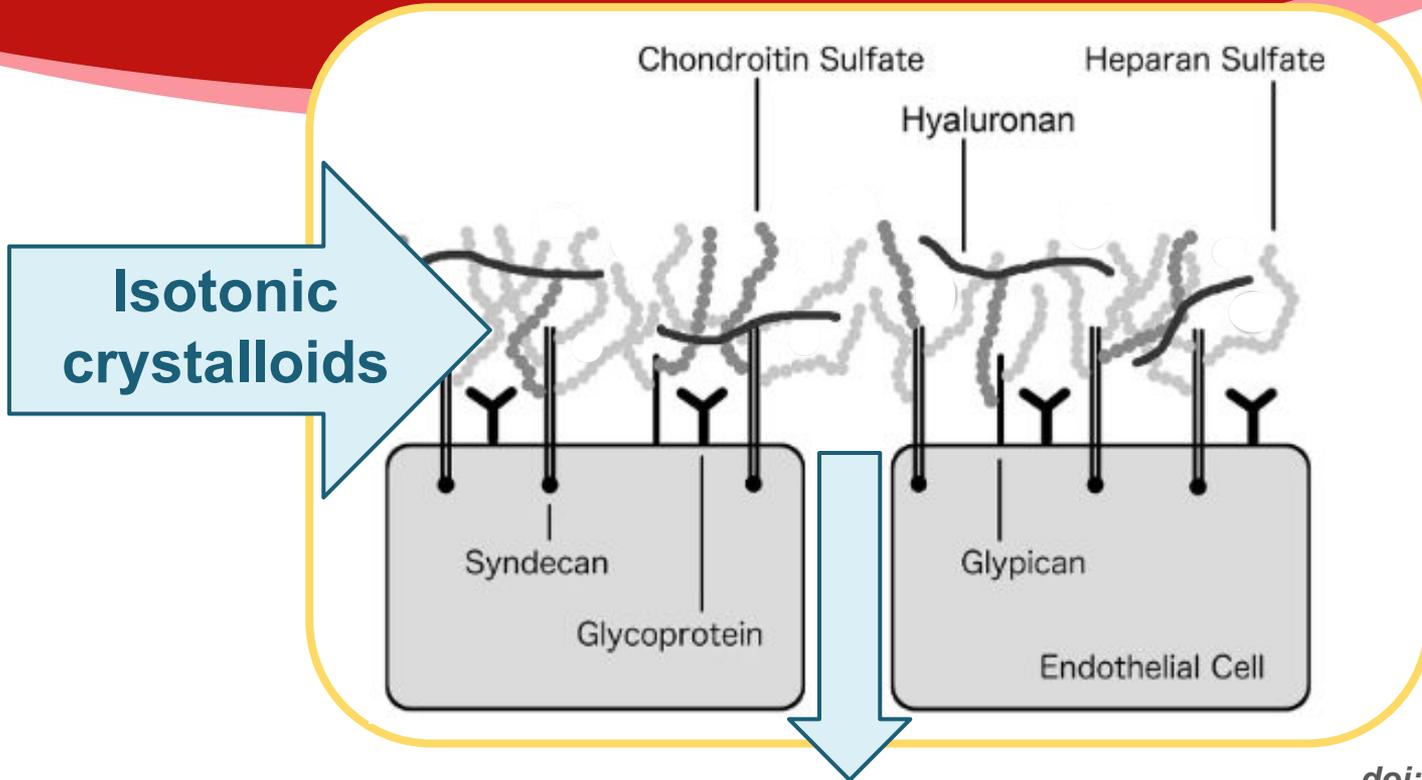
**Inflammatory
processes**

**Dilutional
effect from
fluids**

Hypoalbuminemia



Hypoalbuminemia



Colloid support: when?

Start receiving colloids

TP ~4.0g/dL

Albumin 15-20 g/dL

Reasons

- **Refractory hypotension**
- **Refractory hypovolemia**
- **Interstitial edema**

doi: 10.1016/j.vaa.2024.07.005

doi: 10.1111/vec.12834

doi: 10.1111/vec.13286

Colloid support: what?

Synthetic
colloids

Natural colloids



Colloid support: what?

Synthetic
colloids

Aim

- *Not specific alb level*
- *CVS stability*
- *↓ crystalloid use*

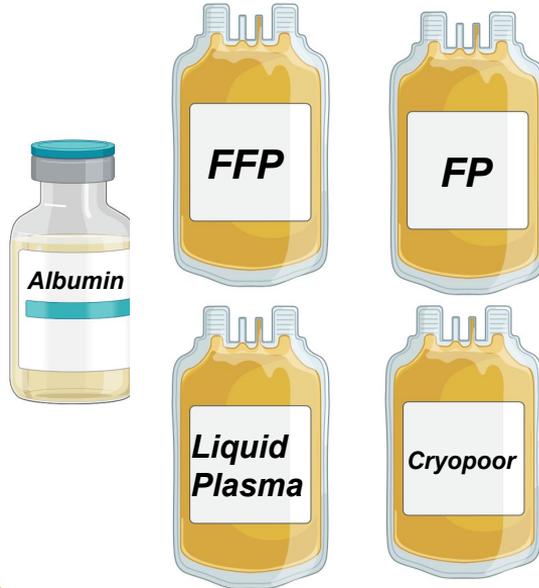
Natural colloids



Colloid support: how?

- 2 ml/kg/hr
- Median 0.72 g/kg

Natural colloids



- 4-8 ml/kg bolus 20mins, 1-2 ml/kg/h CRI
- 10-20 ml/kg over 2-4h
- Maintenance fluid
- 50% crystalloid + 50% colloid

doi: 10.1111/vec.12834

doi: 10.1111/vec.12834

Colloid support: how?

Natural colloids



Colloid support: how?



Natural colloids



TO USE, TURN AT NOTCH
500 mL NDC 0409-4162-03

Aminosyn® II
8.5%
Sulfite-Free
AN AMINO ACID INJECTION



(01) 0 030409 416203 4

Each 100 mL contains: Total amino acids approx. 8.5 g. Contains sodium hydroxide for pH adjustment. **Essential Amino Acids/100 mL:** Isoleucine 561 mg; leucine 850 mg; lysine (as acetate salt) 893 mg; methionine 146 mg; phenylalanine 253 mg; threonine 340 mg; tryptophan 170 mg; valine 425 mg. **Nonessential Amino Acids/100 mL:** N-acetyl-L-tyrosine 230 mg; alanine 844 mg; arginine 865 mg; glycine 425 mg; proline 614 mg; histidine 255 mg; serine 450 mg; L-aspartic acid 595 mg; L-glutamic acid 627 mg. **Electrolytes (mEq/Liter):** Sodium 32 (from pH adjustment); acetate 61. pH 5.8 (5.0 to 6.5). Specific Gravity = 1.03. 706 mOsmol/Liter.

Single dose container. The overwrap is a moisture and oxygen barrier. Do not remove unit from overwrap until ready for use. Visually inspect overwrap for tears or holes. Discard unit if overwrap is damaged. Use unit promptly when overwrap is opened. Store at 20° to 25°C (68° to 77°F). [See USP Controlled Room Temperature.] Protect from freezing. After removing the overwrap, check for minute leaks by squeezing container firmly. If leaks are found, discard solution as sterility may be impaired.

COLOR VARIATION FROM PALE YELLOW TO YELLOW IS NORMAL AND DOES NOT ALTER EFFICACY

The future?

scientific reports

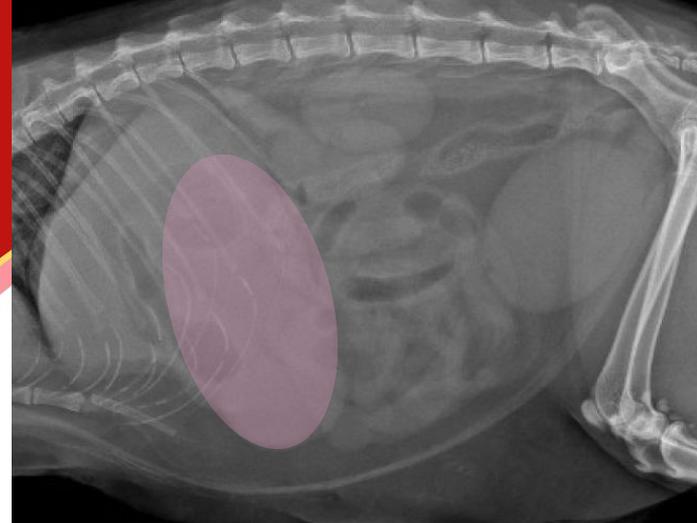
 Check for updates

OPEN **Polyoxazoline-conjugated porcine serum albumin as an artificial plasma expander for dogs**

Wataru Okamoto¹, Tomone Usui¹, Mai Hasegawa¹, Tatsuhiko Kobayashi¹, Junya Fujisawa¹, Kazuaki Taguchi², Kazuaki Matsumoto², Mitsutomo Kohno³, Masayuki Iwazaki⁴, Shotaro Shimano⁵, Itsuma Nagao⁵, Hiroto Toyoda⁵, Naoki Matsumura⁵, Hirotaka Tomiyasu⁵, Ryota Tochinai⁶ & Teruyuki Komatsu^{1D-4}

Break

Excessive fluid losses



When to stop pushing?

Recurrent hypovolemia from losses

Normal plasma protein

- **Isotonic boluses**

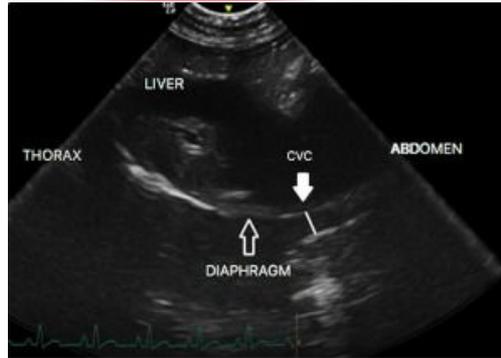
Low plasma protein

- **Consider colloids**

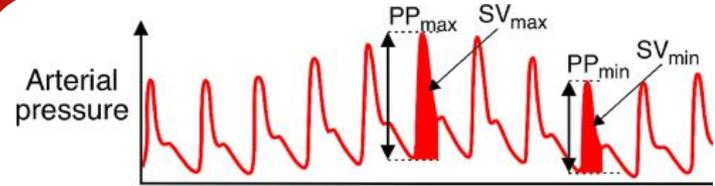
Fluid responsiveness



LV filling



Vena cava collapsibility



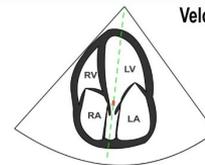
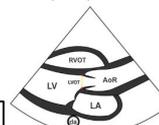
$$PPV (\%) = \frac{PP_{max} - PP_{min}}{\frac{PP_{max} + PP_{min}}{2}} \cdot 100 (\%) > 11-16\%$$

Pulse pressure variation

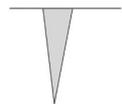
Cross-sectional area (CSA)



$$CSA = (LVOTd)^2 \times 0.785$$



Velocity-time integral (VTI)



$$SV = CSA \times VTI$$

$$CO = SV \times HR$$

Velocity time integral

Vasopressor dependent

Persistent despite fluids

Hypotension

↑ lactate

**Altered
perfusion
parameters**

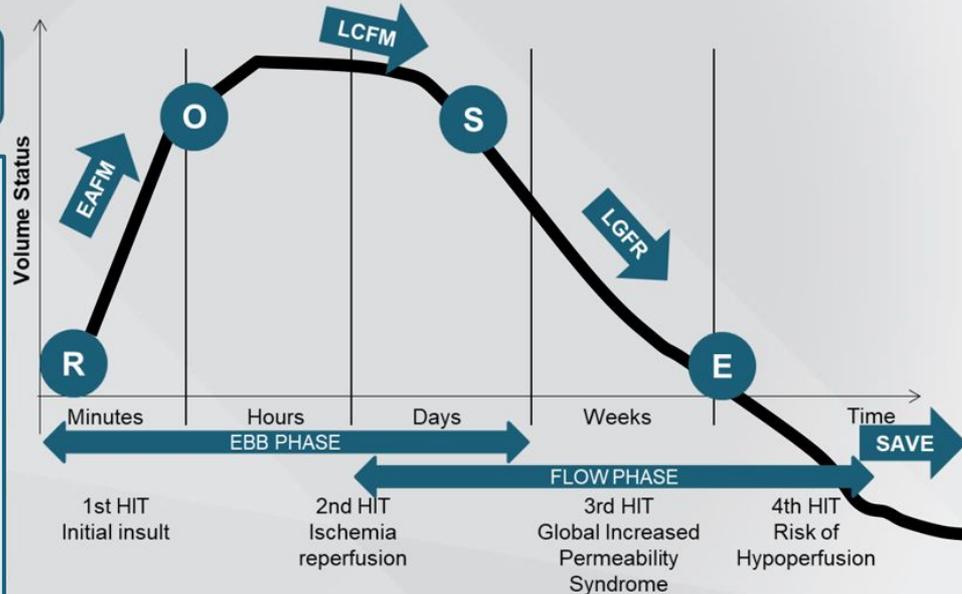
**Not fluid
responsive on
POCUS**

De-Escalation: The R.O.S.E. Model

R

Resuscitation

- Resus to effect
- Restrictive resus



From: The International fluid academy

Early pressors

- 2019 CENSER trial
- ↑ shock control at 6h

Restrictive fluids

- CLASSIC + CLOVERS
- No improvement in mortality

Pressor push

- Phenylephrine + epinephrine
- Critical hypotension + peri-sx
- Effective + safe
- More studies needed

Early vasopressin + hydrocortisone

- Earlier shock reversal
- Less time on NE

doi: 10.1164/rccm.201806-1034OC

doi: 10.1016/j.ajem.2022.08.055

doi: 10.1056/NEJMoa2212663

doi: 10.1056/NEJMoa2202707

doi: 10.1016/j.ajem.2021.05.007

CHF with azotemia

CHF with azotemia



doi:10.1111/jvim.17254

doi: 10.1111/jvim.16571

CHF with azotemia

↑ **RAAS + Na/water retention**



doi:10.1111/jvim.17254

doi: 10.1111/jvim.16571

CHF with azotemia

**NG tube
water**

0.5-1 x M

**NaCl 0.45%
or LRS**

0.5-1 x M

1-2 ml/kg/hr

**3%
replacement**

Over 24-48h

Highlights

Daily fluid balance
($70 \times \text{BW}^{0.75}$)

**Hypoproteinemia +
plasma products**

**Beware of fluid
creep**

**Don't overdo fluids
when vasopressors
needed**

**Balanced
crystalloids**

VetUpdates

STAY IN THE LOOP



- Monthly lit newsletters
- Guidelines/Reviews
- Lit quizzes
- And more!

Journal Of Veterinary Emergency And Critical Care

- Assessment of change in end-tidal CO2 after fluid challenge as a marker of fluid responsiveness as measured by the aortic velocity time integral in healthy anesthetized mechanically ventilated dogs.
Tarragona L, Donati PA, ... Otero PE. J Vet Emerg Crit Care (San Antonio) - (Epub 2024 Dec 5) [E29](#)

Frontiers In Veterinary Science

- Utilization of peripheral glucose and lactate differences in the diagnosis of thromboembolism: a multi-center study.
Yee M, Cuillaumin J, ... Walton R. Front Vet Sci - 2024 Dec 4 - [Open access](#) [E29](#)

REVIEW HIGHLIGHTS



Feline Aortic Thromboembolism
Recent Advances & Future Prospects



According to recent literature..

atupdates.org

In a retrospective study evaluating dogs treated with **angiotensin-converting enzyme inhibitors**, which of the following were **risk factors** for **worsening renal function** after treatment?

- A- Proteinuria, spironolactone treatment
- B- Steroid use, hypertension
- C- Concurrent furosemide, pre-existing azotemia

vetupdates.org

Questions?

