

CONTROVERSIES IN EMERGENCY AND CRITICAL CARE

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Historical controversies
Heparin, plasma for DIC
Colloids
Indications for ventilation





Fluid therapy controversies

- ? Giving more than twice maintenance IV fluids is no longer recommended for gastro cases
- ? Shock rate fluids must be given more slowly to minimize damage to the glycocalyx
- ? If in doubt it is better to give too little fluids than too much
- ? An appropriate shock bolus is 5ml/kg over 15 minutes
- ? An appropriate shock bolus is 10ml/kg over 15 minutes





Fluid therapy controversies

- ? Hemoabdomens- a shock bolus will blow the clot off
- ? Crystalloids aren't appropriate fluids for severe haemorrhagic shock
- ? A 3ml/kg bolus during surgery is sufficient to rule in or out hypovolemia as a cause of hypotension or tachycardia.
- ? Is it crazy to give IV fluid diuresis to patients who have ingested nephrotoxins.
- ? The kidney is not a toilet, No point attempting to flush it by giving more than maintenance IV fluids





Why did we become so worried about IV fluids?



Best Practice & Research Clinical Anaesthesiology

Volume 28, Issue 3, September 2014, Pages 207-216

1

Evolution of fluid therapy

Table 1. Early solutions and their composition.

Solution	Year	Chemical equivalent (Mmol/l solution)
Latta's solution No 1	1832	Na^+ 106, Cl^- 78, CO_3^{2-} 14
Latta's solution No 2	1832	Na^+ 48–68, Cl^- 39–59, HCO_3^- 9
Latta's solution No 3	1832	Na^+ 107, Cl^- 91, HCO_3^- 16
Latta's solution No 4	1832	Na^+ 134, Cl^- 118, HCO_3^- 16
Ringer's solution	1883	Na^+ 154, K^+ 4.0, Ca^{2+} 2.7, Cl^- 163
0.9% sodium chloride	1883	Na^+ 154, Cl^- 154
Hartmann's solution	1932	Na^+ 131, K^+ 5.0, Ca^{2+} 2.0, Cl^- 111, $\text{CH}_3\text{CHOHCO}_2^-$ (lactate) 29

Ca^{2+} : calcium, Cl^- : chloride, HCO_3^- : bicarbonate, K^+ : potassium, Na^+ : sodium.



The American Journal of Emergency Medicine

Volume 18, Issue 1, January 2000, Pages 108-111



International note

The intravenous use of coconut water

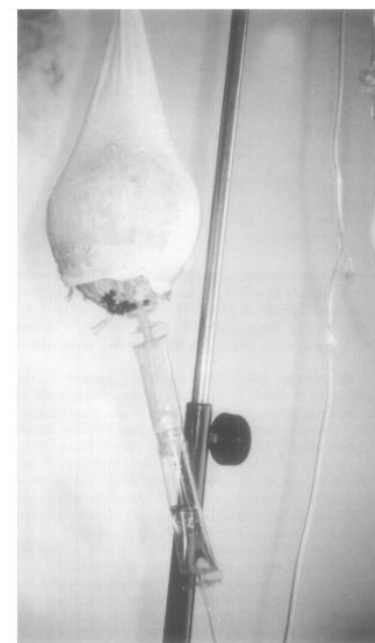
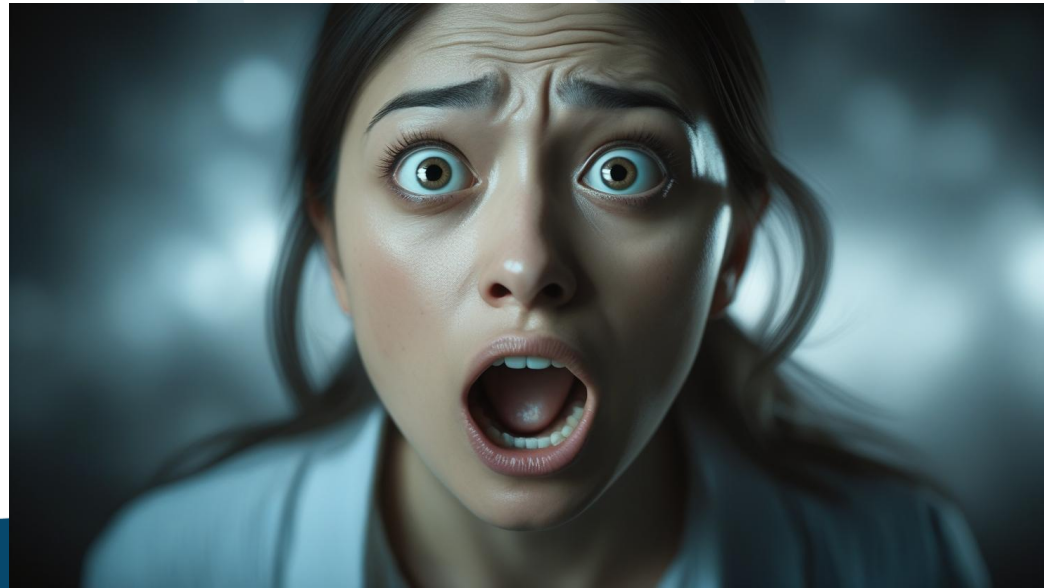


FIGURE 1. Intravenous coconut set-up. The coconut has single-chambered blood transfusion tubing attached, a second needle to equalize intraluminal pressure and is then placed in orthopedic netting.



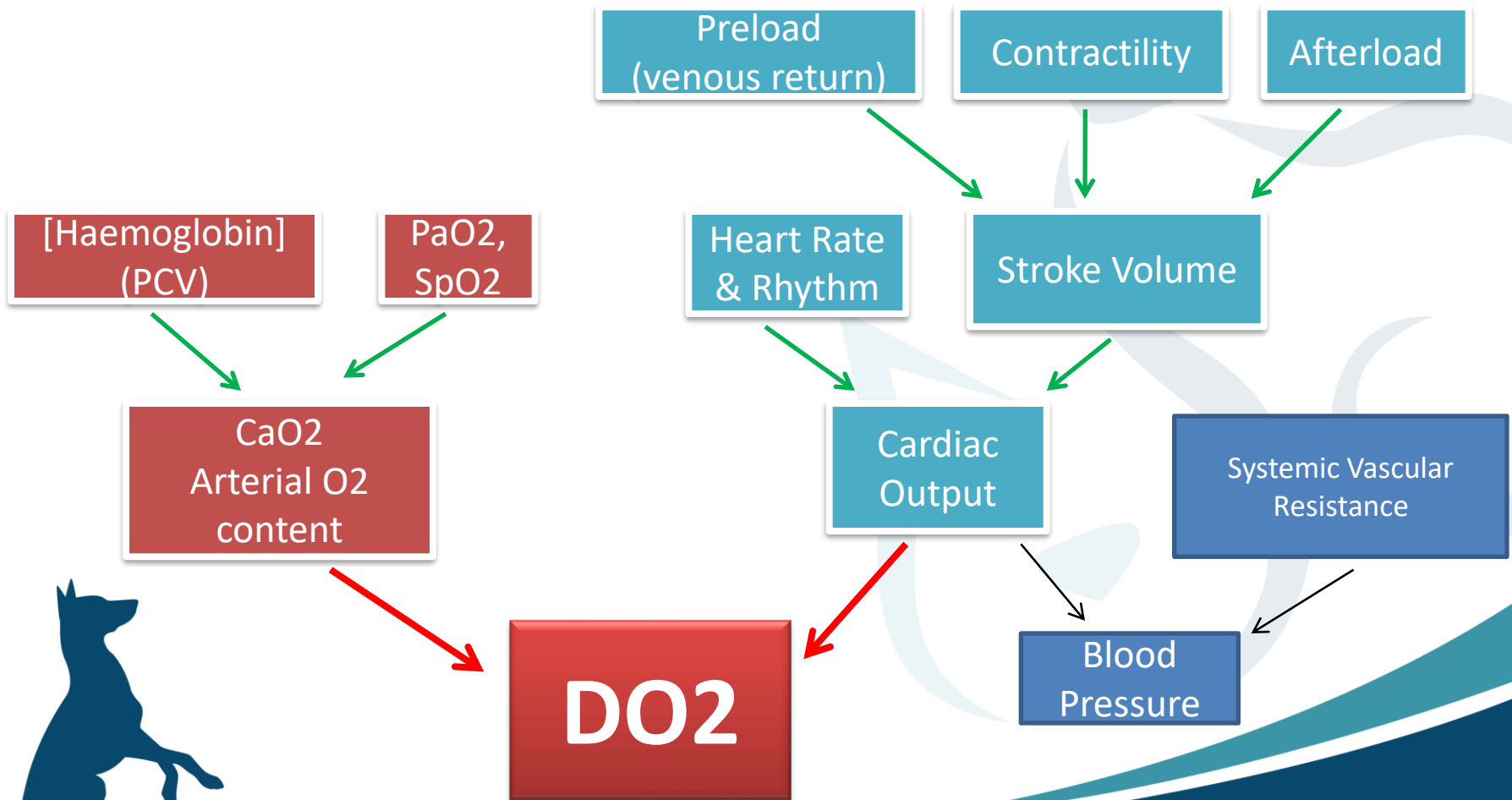
Previous Shock Fluid Rates

- Up to 1 blood volume of replacement crystalloids in 1 hour
 - 90ml/kg dogs
 - 10-30ml/g boluses over 5-10 minutes, repeat as required
 - 60ml/kg cats
 - 10-15ml/kg boluses over 10-15 minutes, repeat as required
- Can a 5ml/kg bolus fix shock?





Shock is inadequate oxygen delivery





What's the worse that can happen if shock is inadequately treated?

- Shock creates an O₂ debt in some tissues - to try to save life
- Compensated shock (mild, moderate)
- Decompensated shock (severe)
- Irreversible shock

A severe oxygen debt at the cellular and tissue level

Cellular damage leads to organ dysfunction

-> organ failure

-> death

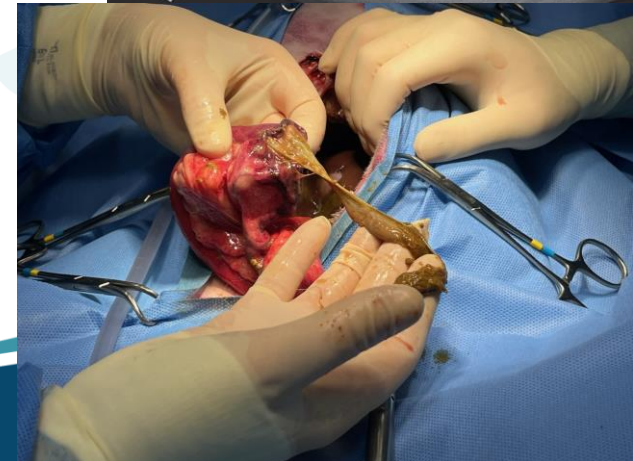
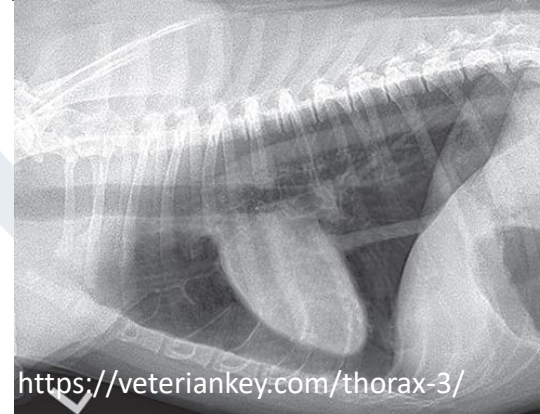
- Inadequate or delayed treatment





Irreversible shock example

- **Davos- 10 year old MN Corgi**
 - Acute collapse
 - HCT=24% (~ 50% of blood in abdomen)
 - Microcardia on radiographs
 - Initial Treatment
 - Opiates + 2xM fluids
 - Referral
 - Outcome:
 - Unconscious on presentation
 - Severe decompensated shock
 - Resuscitated, fluids, blood, surgery
 - Temporary recovery
 - Death 48 hours later
 - Liver failure, gut thromboembolism





Irreversible Shock Example

- **Gladys 2 year old, FN Standard Poodle**

Acute onset bloat, unproductive retching

Methadone, ondansetron

Radiograph confirms GDV

Referred 2 hours later

Presented collapsed and obtunded



- **Treatment**

IV fluid bolus (40ml/kg)

Decompression via trocharisation

GA and surgery required a gastric wall resection

- **Outcome**

Haemorrhagic diarrhoea (shock gut), kidney failure

Death





Avoiding Irreversible Shock

- **Moderate to severe shock causes a cellular oxygen debt**

Primarily affecting gut, liver, kidneys, pancreas and the endothelial glycocalyx

- **Severe shock acts like a tourniquet on essential internal organs.**

The longer and more severe the shock, the greater the chance of irreversible organ damage

- **Fluid boluses to effect can help decrease the chance of irreversible shock developing**

In severe shock it may take 25-50% of blood volume being rapidly replaced by crystalloids to see an appropriate response. Don't be afraid to give it.

- **In acute blood loss it is ideal to replace deficits with blood, but most of the time crystalloids will do the job well.**





Do greater than maintenance fluid rates cause harm?

- ? Do they damage the endothelial glycocalyx
- ? Does they cause the kidneys to swell
- ? Do they cause release of hormones that damage the kidneys or the glycocalyx
- ? Is there a difference in outcomes between overly aggressive large volume fluid rates and bolused fluids titrated to effect
- ? Is there a difference between excessive oral or IV fluids

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☰
Outline

Images

BASIC SCIENCES: ORIGINAL INVESTIGATIONS

Rapid IV versus Oral Rehydration Responses to Subsequent Exercise Heat Stress

KENEFICK, ROBERT W.¹; O'MOORE, KATHLEEN M.²; MAHOOD, NICHOLAS V.²; CASTELLANI, JOHN W.¹



Do high fluid rates damage the kidneys?

Human Maintenance $>1.8\text{L/day}$, Minimum 1L/day





Do high fluid rates damage kidneys?

Human Maintenance $>1.8\text{L/day}$

Minimum 1L/day





Do high fluid rates damage kidneys?

Human Maintenance >1.8L/day

Minimum 1L/day



The Original Cabbage Soup Diet 7-Day Plan

Lose 10-17lbs in 7 days



By
Patty Dotson



Do IV Fluids Damage the Endothelial Glycocalyx (EG)?





Do IV Fluids Damage the Endothelial Glycocalyx (EG)?

- **Causes of EG shedding**

Sepsis, inflammatory response

Ischaemia-reperfusion

Cardiovascular disease, hyperglycemia

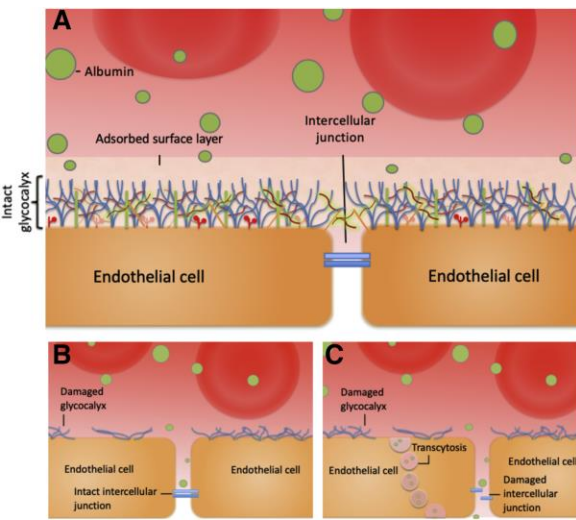
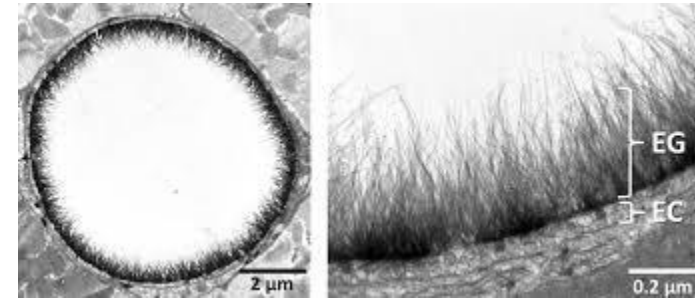
Hypervolemia

Shock

Intense exercise

- **Variable response to studies on IV fluid effects on the EG**

Both hypovolemia and hypervolemia can cause EG damage



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Article | [Open access](#) | Published: 24 May 2022

No association between intravenous fluid volume and endothelial glycocalyx shedding in patients undergoing resuscitation for sepsis in the emergency department

[Stephen Macdonald](#) , [Erika Bosio](#), [Nathan I. Shapiro](#), [Lois Balmer](#), [Sally Burrows](#), [Moira Hibbs](#), [Thomas Jowitt](#), [Lisa Smart](#), [Glenn Arendts](#) & [Daniel Fatovich](#)

[Scientific Reports](#) **12**, Article number: 8733 (2022) | [Cite this article](#)



Using PCV to assess hypovolemia ie AHDS or HGE plus Algebra 😊

- **Works only if the PCV is high**

Assume normal PCV is 50% = 0.5 of the blood volume
Normal dog blood volume is 90ml/kg, body weight is 10kg

Patients PCV is now 60% = 0.6
X is the new blood volume

$$0.5 \times BV (90 \times BW) = 0.6 \times \mathbf{X}$$

$$0.5 \times 900 = 450 = 0.6 \times \mathbf{X}$$

$$\mathbf{X} = 450 / 0.6$$

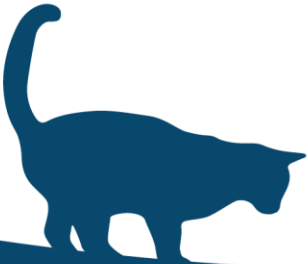
$$\mathbf{X} = 750 \text{ml}$$

$$\text{Patients volume deficit} = (90 \times BW) - 750 = 900 - 750 = 150$$

Volume deficit is 150ml or 15ml/kg

Appropriate bolus is 15ml/kg

Appropriate rehydration maintains PCV in normal range





Using PCV to assess hypovolemia

- **Works only if the PCV is high**

10kg dog, Patients PCV = 70

$$0.5 \times (BV) = 0.7 \times X$$

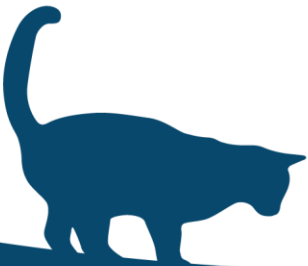
$$0.5 \times 900 = 0.7 X$$

$$450 = 0.7 X$$

$$X = 450/0.7 = 642$$

Volume deficit = $900 - 642 = 258 = 26\text{ml/kg}$

Appropriate bolus is 26ml/kg





Using PCV to assess hypovolemia

- **Works only if the PCV is high**

10kg dog

Patients PCV = 80

$0.5 \times (BV) = 0.8 \text{ X}$

$0.5 \times 900 = 0.8 \text{ X}$

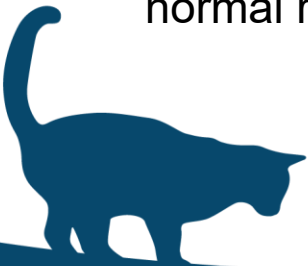
$450 = 0.8 \text{ X}$

$\text{X} = 450 / 0.8 = 562$

Volume deficit = $900 - 562 = 338 = 34\text{ml/kg}$

Appropriate bolus is 34ml/kg, not 10ml/kg then twice maintenance

If appropriately replacing ongoing losses PCV should decrease into normal range

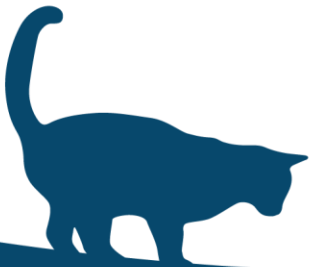




Using PCV to assess hypovolemia

- Works only if the PCV is elevated or baseline known

Patients PCV	Blood volume ml/kg	Volume Deficit ml/kg
50	90	0
55	82	8
60	75	15
65	69	21
70	64	25
75	60	30
80	56	34





IRIS Acute Kidney Injury Staging

Kidney injury from toxins occurs via

- Haemodynamic changes
- Filtration
- Tubular interstitial injury
- Outflow obstruction

Grade I kidney injury

creatinine increase >26umol/L

Table 1: IRIS AKI Grading Criteria

AKI Grade	Blood Creatinine	Clinical Description
Grade I	<1.6 mg/dl (<140 µmol/l)	Nonazotemic AKI: a. Documented AKI: (historical, clinical, laboratory, or imaging evidence of AKI, clinical oliguria/anuria, volume responsiveness†) and/or b. Progressive nonazotemic increase in blood creatinine: ≥ 0.3 mg/dl (≥ 26.4 µmol/l) within 48 h c. Measured oliguria (<1 ml/kg/h)# or anuria over 6 h
Grade II	1.7 – 2.5 mg/dl (141 – 220 µmol/l)	Mild AKI a. Documented AKI and static or progressive azotemia b. Progressive azotemic: increase in blood creatinine; ≥ 0.3 mg/dl (≥ 26.4 µmol/l) within 48 h), or volume responsiveness† c. Measured oliguria (<1 ml/kg/h)# or anuria over 6 h
Grade III	2.6 – 5.0 mg/dl (221 – 439 µmol/l)	
Grade IV	5.1 – 10.0 mg/dl (440 – 880 µmol/l)	Moderate to Severe AKI: a. Documented AKI and increasing severities of azotemia and functional renal failure
Grade V	>10.0 mg/dl (>880 µmol/l)	

(†Volume responsive is an increase in urine production to >1 ml/kg/h over 6 h; and/or decrease in serum creatinine to baseline over 48 h)

International Renal Interest Society
best practice consensus guidelines for
the diagnosis and management of
acute kidney injury in cats and dogs

Gilad Segev^a, Stefano Cortellini^b, Jonathan D. Foster^c, Thierry Francey^d,
Catherine Langston^e, Leonel Londoño^f, Ariane Schweighauser^d,

Fluids

Statement: Hypovolemia should be corrected within 1–2 h of detection. Dehydration should be corrected within 6 h of detection, in the absence of contraindication for rapid fluid administration (e.g. cardiac disease). If there is a concern for cardiac disease, consider slower fluids administration (correction over 12–24 h). All veterinary patients need to be monitored and serially reassessed during fluid administration (i.e. avoiding volume overload, hypertension, pulmonary edema, and pleural effusion) (100% agreement).



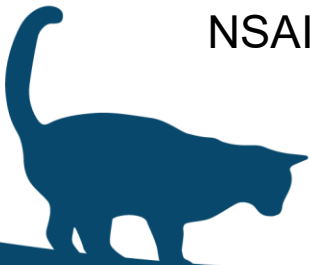
Nephrotoxins & IV Diuresis

- **Toxicology Consensus**

- Every toxicology textbook and critical care textbook written by a boarded specialist in toxicology recommends 48 to 72 hours fluid diuresis (2-3xM) for nephrotoxins including lilies, grapes & non-steroidal anti-inflammatory drugs
- Excludes ethylene glycol (antifreeze) for which diuresis alone is useless

- **Opinion of a small number of criticalists**

- ? Is pre-emptive diuresis unnecessary or potentially dangerous to the kidneys
- ? Is there no evidence of therapeutic benefit for IV fluid therapy for NSAIDs, Lily's, Grapes & Sultanas etc.





How are nephrotoxins identified?

- New nephrotoxins are identified by case clusters
- Poisons control centers regularly publish treatment updates

The collage features several logos for animal poison control services:

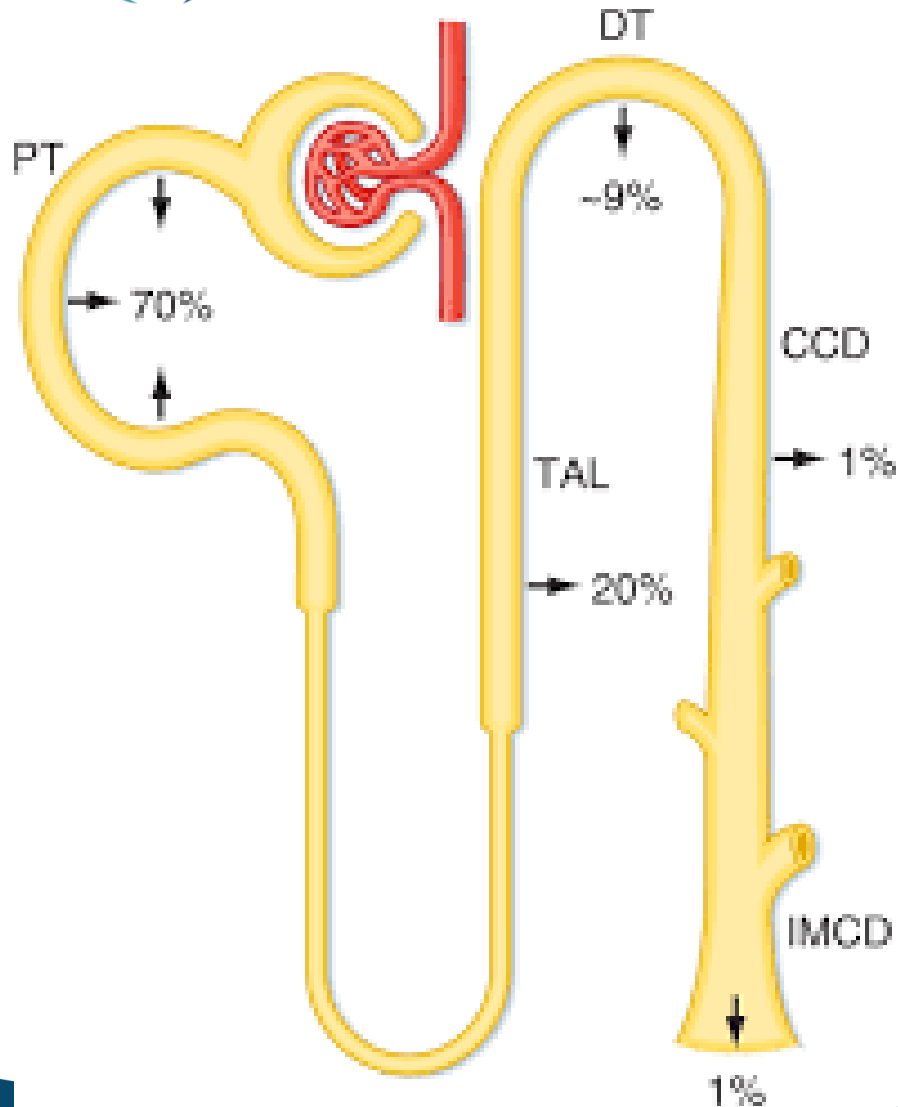
- Veterinary Poisons Information Service:** A circular logo with a black paw print and a white cross, surrounded by the text "VETERINARY POISONS INFORMATION SERVICE".
- Animal POISONLine:** A red speech bubble logo with a white cross, containing the text "Animal POISONLine" and the phone number "01202 509000". A small black circle above it says "24hr advice for owners".
- American Board of Veterinary Toxicology (ABT):** A circular logo with a yellow background and a blue border, featuring a white caduceus and the text "AMERICAN BOARD OF VETERINARY TOXICOLOGY".
- ABT American Board of Toxicology:** A white hexagonal logo with the text "ABT" and "American Board of Toxicology" on a dark blue background.
- ASPCA Animal Poison Control Center:** A logo with the ASPCA name in large letters and "ANIMAL POISON CONTROL CENTER" below it, with the phone number "888.426.4435".
- PET POISON HELPLINE:** A logo with a blue paw print and the text "PET POISON HELPLINE" and the phone number "800.213.6680", with the website "www.petpoisonhelpline.com" below it.
- australian animal poisons helpline:** A logo with the text "australian animal poisons helpline" and the phone number "1300 TOX PET".
- Animal Poisons Helpline:** A photo of a woman in a white lab coat talking on a phone, with the text "Animal Poisons Helpline" and the phone number "UNITED STATES (917) 722-5958" below it.

Free* emergency poisons advice for pet owners 9am-5pm 7 days a week
*after-hours from \$75

WellPet Vets



The kidneys aren't passive in response to fluid loading



- 98-99% of GFR is reabsorbed by tubules
- Most nephrotoxins reported to be responsive to IVF cause proximal tubular (PT) injury
- 65% filtrate reabsorbed in proximal tubule (PT)
- In fluid excess there is less reabsorption by PT.
- Fluid diuresis may compensate for vasodilation, decreased perfusion pressure, or fluid losses associated with polyuria



Lily's & IVF Diuresis



First reports early 1990's
>400 references so far

J Vet Diagn Invest 12:566-568 (2000)

Acute renal failure in a cat secondary to Tiger Lily (*Lilium tigrinum*) toxicity.

Journal article: [Feline Practice](#), 1997, Vol. 25, No. 5/6, 38-39 ref. 10

Authors: [L. Gullledge](#), [D. Boos](#), [R. Wachsstock](#)

Nephrotoxicosis in a cat following ingestion of Asiatic hybrid lily (*Lilium* sp.)

Mark A. Brady, Evan B. Janovitz

Case Reports

> [J Am Vet Med Assoc](#). 2002 Jan 1;220(1):49-52, 36.

doi: 10.2460/javma.2002.220.49.

J Vet Diagn Invest 16:527-541 (2004)

Acute renal failure caused by lily ingestion in six cats

[Cathy E Langston](#)¹



A comprehensive study of Easter lily poisoning in cats

Wilson K. Rumbeiha¹, Jayaraj A. Francis, Scott D. Fitzgerald, Muraleedharan G. Nair, Kate Holan, Kwasi A. Bugyei, Heather Simmons

> [J Am Anim Hosp Assoc](#). 2011 Nov-Dec;47(6):386-90. doi: 10.5326/JAAHA-MS-5629.

Exposure circumstances and outcomes of 48 households with 57 cats exposed to toxic lily species

[Slater](#)¹, [Sharon Gwaltney-Brant](#)

Outcome following gastrointestinal tract
decontamination and intravenous fluid diuresis in
cats with known lily ingestion: 25 cases (2001-2010)

[Alice J Bennett](#)¹, [Erica L Reineke](#)

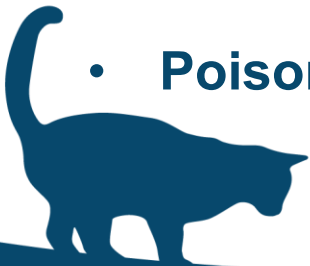
Early IV fluid diuresis prevents kidney failure





Lilies & IVF diuresis

- Original reports cats presenting azotemic and dying
- Gavage study proved water soluble liliun component nephrotoxic
- **Clinical signs**
 - Salivation Vomiting
 - Anorexia Depression
 - Polyuria Dehydration
 - Anuria (24-48 hours)
 - Death (3-7 days)
- **Multiple toxicology studies showed survival and prevention of renal failure with early IVF diuresis**
- **Poisons info centres have 1000's of documented cases**





Lilies & IVF Diuresis

- **Why does IV diuresis help?**

Salivation, vomiting, polyuria predisposes to dehydration and renal hypoperfusion
Nephron tubular cells slough leading to tubular obstruction which decreases GFR

? Unknown if there is increased excretion of toxin BUT decontamination and IVF diuresis have definitively been shown to help survive toxicity

Without fluids 50-100% mortality, with fluids 0 to 7% mortality

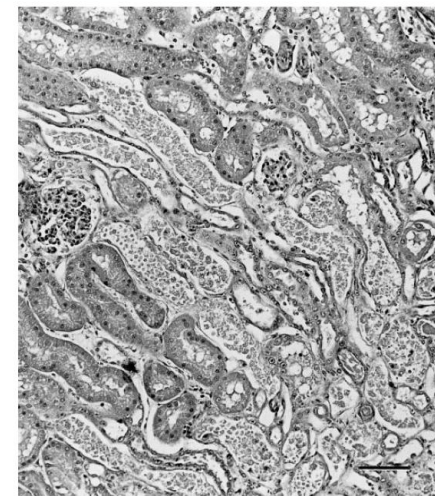
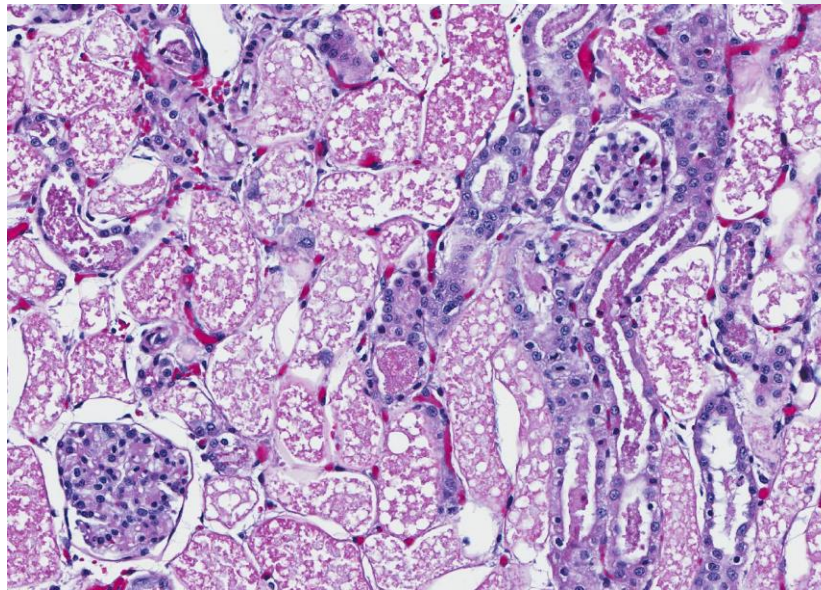
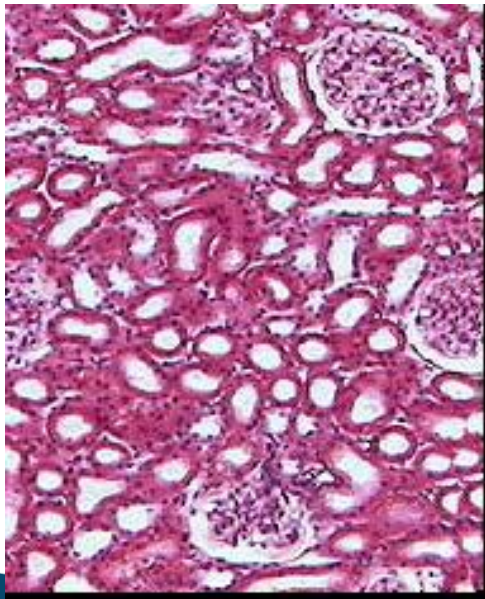


Figure 9. Photomicrograph of renal cortex from a cat that received aqueous flower extract. Note the widespread degeneration and necrosis of epithelial cells lining the proximal convoluted tubules but sparing the distal convoluted tubules and collecting ducts. HE stain. Bar = 100 μ m.



NSAID Toxicity

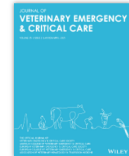
- Decrease/ abolish renal compensatory response to hypoperfusion
- At low doses cause GI irritation/ulcers resulting in vomiting, diarrhoea ie fluid losses that predispose to hypovolemia and dehydration
- Risk of nephrotoxicity at moderate to high doses well reported
- All toxicologists recommend IV fluid diuresis for nephrotoxic doses based on case experience + toxicology services follow up on cases

JOURNAL OF VETERINARY EMERGENCY & CRITICAL CARE

 Full Access

Management of Acetaminophen and Ibuprofen Toxicoses in Dogs and Cats

Jill A. Richardson DVM



Volume 10, Issue 4
December 2000
Pages 285-291

 References  Related  Informa

Received: 16 March 2022 | Accepted: 23 November 2022

DOI: 10.1111/jvim.16603

STANDARD ARTICLE

Journal of Veterinary Internal Medicine

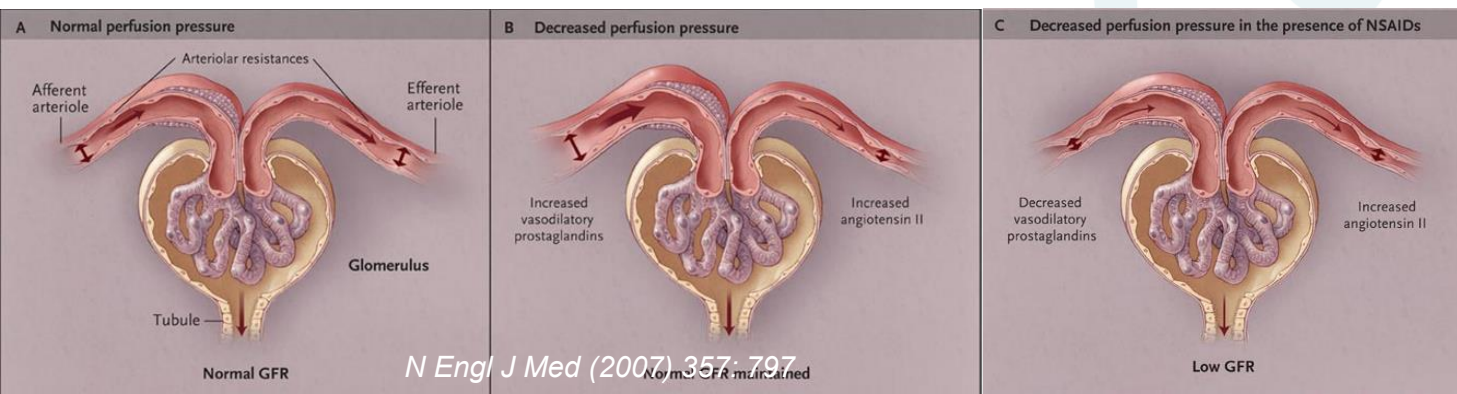
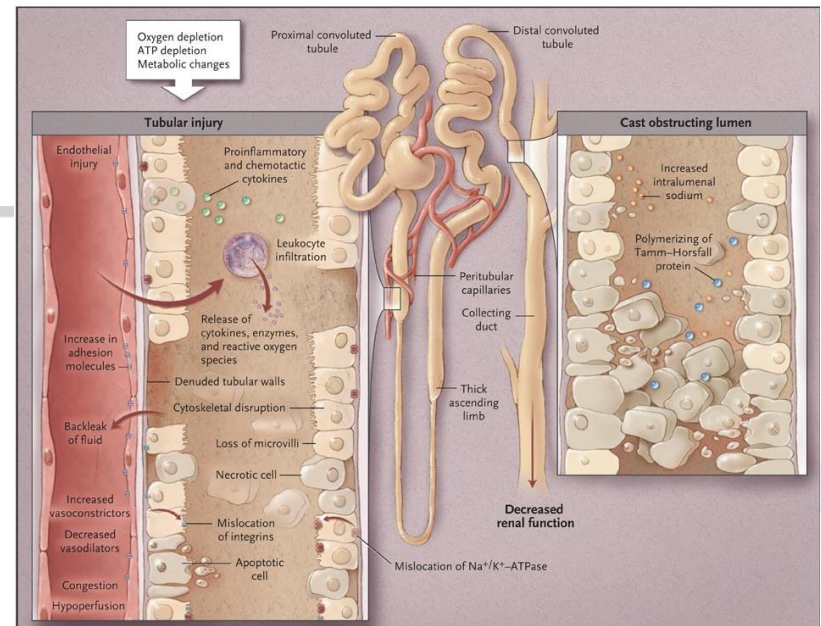
Open Access



Outcomes of 434 dogs with non-steroidal anti-inflammatory drug toxicosis treated with fluid therapy, lipid emulsion, or therapeutic plasma exchange

NSAID Toxicity

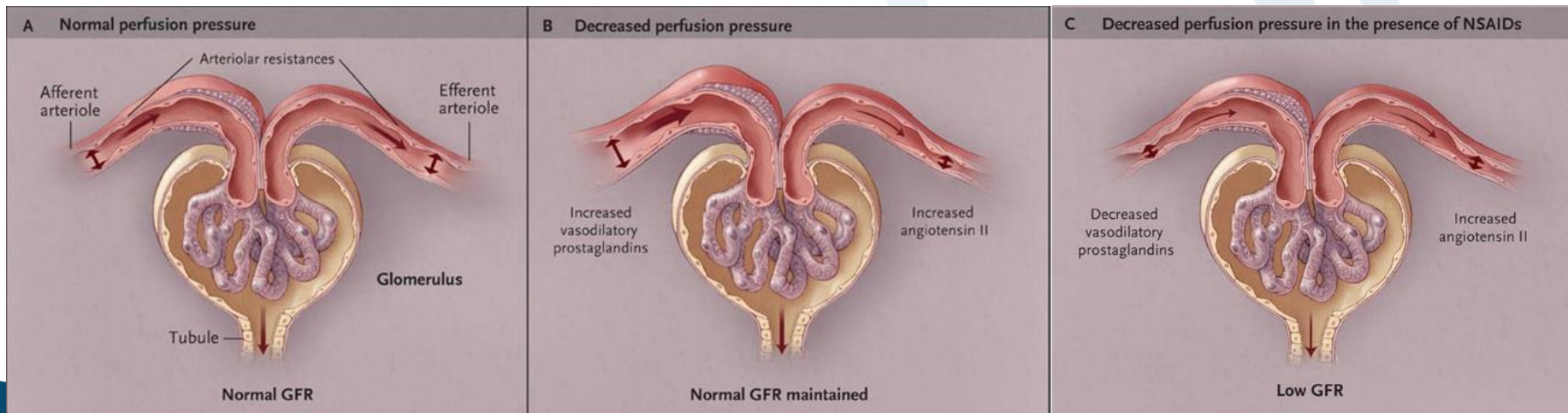
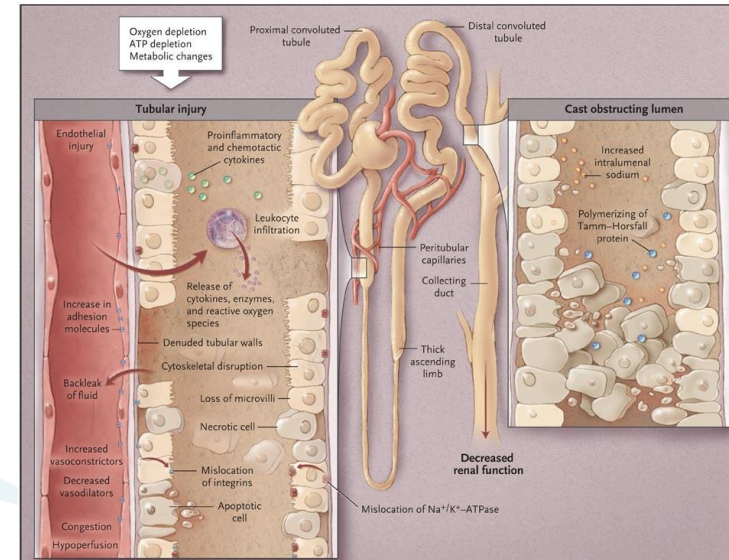
- Low doses: GI irritation/ulceration
 - Vomiting, diarrhoea, nausea
 - Dehydration + hypovolemia
- High doses : GI + Nephrotoxicity
 - Decreased vasodilatory prostaglandins
 - Decreased GFR
 - Natriuresis, polyuria may occur causing hypovolemia
 - Interstitial nephritis
 - Tubular damage which predisposes to tubular obstruction
- Difficult to accurately detect mild hypovolemia or dehydration





NSAID Toxicity

- Difficult to detect mild hypovolemia or dehydration.
- All cause GI distress before nephrotoxicity
- Highly protein bound drugs
- Once albumin binding sites saturated, increase in free drug which is filtered by the kidneys
- Diuresis not required below nephrotoxic dose ie
>175mg/kg ibuprofen
> 40mg/kg carprofen





Nephrotoxic NSAID & IVF diuresis

- Historical clinical case toxicology reports determined nephrotoxic dose
- Toxicologist clinical experience and published case series conform efficacy of IVF diuresis
- Clinical experience confirms safety of IVF diuresis and efficacy in preventing azotemia
- Before standard of care changes - it is important to prove no adverse effects





Grapes, Raisins & Sultana Toxicity

First recognized in 1999

Received: 14 August 2018 | Revised: 31 May 2019 | Accepted: 29 June 2019
DOI: 10.1111/vec.13025

RETROSPECTIVE STUDY



Retrospective evaluation of *Vitis vinifera* ingestion in dogs presented to emergency clinics in the UK (2012–2016): 606 Cases

Rachel Croft MA, VetMB^{1,*} | Elisabetta Clementi DVM, PGCertSAECC^{2,*} |
Helen Farmer BVM, BVSc, PGDipVCP³ | Rachel Whalley BVM, BVSc³ | Mark Dunning MA,
VetMB, PhD, DECVIM⁴ | Ava Firth DVM, MVS, DACVECC, DECVCC⁵

> *J Small Anim Pract*. 2022 Jun;63(6):447–453. doi: 10.1111/jsap.13483. Epub 2022 Feb 8.

Incidence of *Vitis* fruit-induced clinical signs and acute kidney injury in dogs and cats

M A Dijkman¹, R G van Roemburg², D W De Lange¹, S Hugen², J H Robben²



Acute renal failure associated with raisin or grape ingestion in 4 dogs

E. M. Mazzaferro MS, DVM, PhD, DACVECC, P. A. Eubig DVM, T. B. Hackett DVM, MS, DACVECC,
M. Legare DVM, C. Miller DVM, DACVIM, W.E. Wingfield DVM, MS, DACVS, DACVECC ... See all authors



RETROSPECTIVE STUDY | Free Access

Retrospective evaluation of the clinical course and outcome following grape or raisin ingestion in dogs (2005–2014): 139 cases

Colin F. Reich DVM, DACVECC | Mallory C. Salcedo DVM, DACVECC,
Amy M. Koenigshof DVM, MS, DACVECC, Molly M. Hopp DVM ... See all authors



References | Related | Information



This article also appears in:
Veterinary Clinical Digest: a free publication highlighting the latest research published by Wiley's veterinary journals - Volume 11, Issue 44

References | Related | Information

J Vet Intern Med 2005;19:663–674

Acute Renal Failure in Dogs After the Ingestion of Grapes or Raisins: A Retrospective Evaluation of 43 Dogs (1992–2002)

Paul A. Eubig, Melinda S. Brady, Sharon M. Gwaltney-Brant, Safdar A. Khan, Elisa M. Mazzaferro, and Carla M.K. Morrow

Factors influencing outcome of *Vitis vinifera* (grapes, raisins, currants and sultanas) intoxication in dogs

Sutton, N M; Bates, N; Campbell, A. *The Veterinary Record*; London Vol. 164, Iss. 14, (Apr 4, 2009): 430.
DOI:10.1136/vr.164.14.430

Received: 9 September 2021 | Revised: 4 March 2022 | Accepted: 12 March 2022
DOI: 10.1111/vec.13234

CASE SERIES



Acute kidney injury in dogs following ingestion of cream of tartar and tamarinds and the connection to tartaric acid as the proposed toxic principle in grapes and raisins

Colette A. Wegenast DVM, DABT¹ | Irina D. Meadows DVM, DABT¹ |
Rachele E. Anderson DVM, CCRP² | Teresa Southard DVM, PhD, DACVP³ |
Cristy Rocío González Barrientos DVM³ | Tina A. Wismer DVM, MS, DABVT, DABT¹

> *J Vet Emerg Crit Care (San Antonio)*. 2023 May-Jun;33(3):298–304. doi: 10.1111/vec.13294.
Epub 2023 Apr 23.

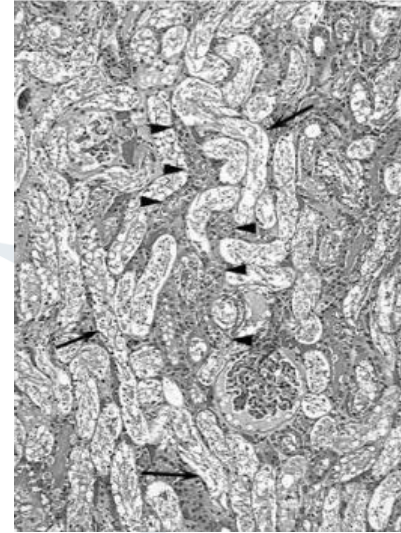
Tartaric acid induces toxicity in Madin–Darby canine kidney cells, but not human kidney–2 cells in vitro, and is prevented by organic anion transporter inhibition and human OAT–4 transfection

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Pre-emptive IVF for Grapes, Sultanas?

- Variable amount tartaric acid in grapes, sultanas etc
- Early effective decontamination helps prevents toxicity
- 6-20% of ingested cases develop acute kidney injury
- Delayed presentation cases more likely to develop AKI
- Azotemic patients definitely need IVF
- Hemodialysis, CRRT needed in severe cases





QUESTIONS?