### Fluid balance - the consequences of getting it wrong

### ....they may surprise you!



#### Dr John Vogel

# **Clinical Case**

59 yr old male Previously healthy Undergoing routine surgery Suddenly develops massive myocardial infarction Taken to ITU with cardiogenic shock low BP, low cardiac output, mottled skin low O2 sats and pulmonary oedema On "maximal" doses of inotropes Fluid or not?

# "Normal" microcirculatory flow?



# Cardiogenic shock



# Fluids or not?

% Responders

| Calvin (Surgery 81)       |                | 71% |
|---------------------------|----------------|-----|
| Schneider (Am Heart J 88) |                | 72% |
| Reuse (Chest 90)          |                | 63% |
| Magder (J Crit Care       |                | 52% |
| Diebel (Arch Surg         |                | 59% |
| Diebel (J Trauma          |                | 40% |
| Wagner (Ches              | NON RESPONDERS | 56% |
| Tavernier (Anesthes 52%   | 48%            | 60% |
| Magder (J Crit Ca         |                | 45% |
| Tousignant (A Ana         |                | 40% |
| Michard (AJRCCM           |                | 40% |
| Feissel (Chest 01)        |                | 53% |
|                           |                |     |
|                           | Mean           | 52% |

Michard & Teboul. Chest 121:2000-8, 2002



### **CONSEQUENCES OF TOO MUCH FLUID**



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Mortality after Fluid Bolus in African Children with Severe Infection

#### Mortality at 48 hrs



Deresuscitation of Patients With latrogenic Fluid Overload Is Associated With Reduced Mortality in Critical Illness



#### Too fluid much ..... endangers the Glycocalyx

# The glyco.....what?

#### SINGLE VASCULAR BARRIER

Ernest Starling: 1866-1927





### MICROVASCULAR FLUID EXCHANGE AND THE REVISED STARLING PRINCIPLE

But

In experiments, even when the COP inside and outside of the vessel were **equal**, there was still effective COP **drawing fluid in !** 

Cardiovascular Research (2010) 87, 198-210



Rehm et al Anesthesiology 2004;100:1211

# **ELECTRON MICROSCOPY - GLYCOCALYX**



# **GLYCOCALYX - COMPONENTS**



Pries et al Eur J Physiol; 440:653-666, 2000

# HEALTHY ENDOTHELIAL GLYCOCALYX



# DESTRUCTION OF THE GLYCOCALYX



Nieuwdorp et al Curr Opin Lipidol 2005; 16:507

# SEPSIS-DESTRUCTION OF GLYCOCALYX



Nieuwdorp et al Curr Opin Lipidol 2005; 16:507

# **GLYCOCALYX IN SEPSIS**



Increased shedding of glycocalyx in plasma with increasing severity of illness...a prognostic factor

Kohler et al Infection 39:117-118; 2011

# VOLUME EFFECTS OF COLLOIDS ARE "CONTEXT SENSITIVE"



Jacob et al Lancet 2007 16;369:1984-6

# **GLYCOCALYX ALTERATION**

#### **Atrial Natriuretic Peptide (ANP)**

#### a cardiac hormone released by acute volume loading

Isbister (1997) Trans Sci; 18:409-423

Tucker (1996) Am J Physiol; 271:R591



BJA

Liberal or restrictive fluid administration in fast-track colonic surgery: a randomized, double-blind study<sup>†</sup>

K. Holte<sup>1\*</sup>, N. B. Foss<sup>2</sup>, J. Andersen<sup>1</sup>, L. Valentiner<sup>1</sup>, C. Lund<sup>2</sup>, P. Bie<sup>3</sup> and H. Kehlet<sup>4</sup>

High fluidLow fluid



British Journal of Anaesthesia 99 (4): 500-8 (2007)



Am J Physiol Heart Circ Physiol 289: H1993-H1999, 2005

# **GLYCOCALYX - SUMMARY**

Large structure with important functions

- **\*** Vascular barrier function
- \* Thrombocyte and leucocyte adhesion ("teflon")
- Inflammation
- \* Vessel diameter

Jacob et al Anesthesiology 2006, 104:1223-1231

Jacob et al Cardiovasc Res 2007, 73:1235-1242



### D.I.C. ("DEATH IS COMING")



### TOO FLUID MUCH ...... "BACK PRESSURE"



Journal of the American College of Cardiology © 2009 by the American College of Cardiology Foundation Published by Elsevier Inc.

> Importance of Venous Congestion for Worsening of Renal Function in Advanced Decompensated Heart Failure



Vol. 53, No. 7, 2009

ISSN 0735-1097/09/\$36.00

doi:10.1016/j.jacc.2008.05.068

"Venous congestion rather than CI is the most important hemodynamic factor driving worsening renal function in advanced heart failure."

# "Cardiac liver"

- Chronic passive congestion
- \* Necrosis
- \* Haemorrhage
- Mottled appearance

("Nutmeg Liver")





malabsorption of nutrients, and increased translocation of bacteria"

# CONSEQUENCES OF TOO LITTLE FLUID



Effects of compensated "hypovolaemia" on gut 6 healthy volunteers bled 2 x 600 ml 600 ml →

BP, HR, cardiac output Gut intramucosal pH

1200 ml →

BP, HR

Cardiac output Gut intramucosal pH



Re-transfusion → variables recovered, but "flu-like" symptoms

ICM (1997) 23: 276-281

<sup>®</sup> PLoS one

#### Exercise-Induced Splanchnic Hypoperfusion Results in Gut Dysfunction in Healthy Men

Kim van Wijck<sup>1,2,3</sup>, Kaatje Lenaerts<sup>1,2,3</sup>\*, Luc J. C. van Loon<sup>1,2,4</sup>, Wilbert H. M. Peters<sup>5</sup>, Wim A. Buurman<sup>2,3</sup>, Cornelis H. C. Dejong<sup>1,2,3</sup>



# "Fluid Restriction"

Complications % 80 20

0

100

# Pre -1965 Francis Moore, M.D. et al

A Little Fluid Volume (mL/kg)

A Lot

Anaesthesia 2016, 71 (Suppl. 1), 40-45

doi:10.1111/anae.13309

#### Review Article

Peri-operative fluid management to enhance recovery R. Gupta<sup>1</sup> and T. J. Gan<sup>2</sup>

# Confirmed in 2018

# "Oliguria ... from a variety of non-renal stimuli, including pain, nausea, and type of surgery "

**III NARRATIVE REVIEW ARTICLE** 

Update on Perioperative Acute Kidney Injury

Alexander Zarbock, MD,\* Jay L. Koyner, MD,† Eric A. J. Hoste, MD,‡ and John A. Kellum, MD§

www.anesthesia-analgesia.org 2018

"... suggest that within an enhanced recovery protocol, oliguria should be anticipated and permitted..."



"Fill that Third Space" 100 Post -1965 Somplications % 80 G. Thomas Shires, M.D. et al 20 0 A Little A Lot Fluid Volume (mL/kg)

#### The NEW ENGLAND JOURNAL of MEDICINE

#### ORIGINAL ARTICLE

#### Restrictive versus Liberal Fluid Therapy for Major Abdominal Surgery

P.S. Myles, R. Bellomo, T. Corcoran, A. Forbes, P. Peyton, D. Story, C. Christophi,
K. Leslie, S. McGuinness, R. Parke, J. Serpell, M.T.V. Chan, T. Painter, S. McCluskey,
G. Minto, and S. Wallace, for the Australian and New Zealand College of Anaesthetists Clinical Trials Network and the Australian and New Zealand Intensive Care Society Clinical Trials Group\*

# Confirmed in 2018

# "the restrictive fluid regimen was associated with a higher rate of acute kidney injury."



# Confused.@



#### Preload (pressure)

# But....

Individualized Early Goal-Directed Therapy in Systemic Inflammation: Is Full Utilization of Preload Reserve the Optimal Strategy?



Maximizing SV causes more severe glycocalyx degradation and pancreatic inflammatory edema compared to maintaining "normal" values of SVI.

Crit Care Med 2014; 42:e741-e751



"The end-point of fluid resuscitation remains the Holy Grail of ITU medicine"





www.jvsmedicscorner.com (Mallory / Everest2013)

# Thanks for listening

