Oxygen Delivery -"Precious bodily fluids"

Dr J Vogel FRCA

Summary of todays lecture

- Cardiac output and O2 delivery
- History of fluid replacement
- Consequences of fluid imbalance
- Physiology of fluid dynamics
- Resuscitation strategies
- Practical matters of fluid infusion

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Oxygen delivery ~

Cardiac output x Hb x % Sat O2

02 Delivery = C.O. \times Hb \times 02 Saturation





02



Cardiac output is the most important of the "Big 3"

The US Red Cross got it wrong!



"One of the most important discoveries, ... is the realization that anemia is well tolerated.... provided **blood** <u>volume</u> is maintained."

Daniel Ullyot, MD 1992



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Why does a tea kettle have a key role in fluid resuscitation ?



Ringer's solution



- Sidney Ringer clinician and pharmacologist (1882)
- Studied the effect of electrolytes on cardiac and involuntary muscle.
- Accidentally mixed a cardiac bath with **(London)** tap water

"The salts of sodium, potassium, calcium and chloride in definite concentrations and in precise proportion is necessary for protoplasmic activity"

Journal of Physiology 1882:3:380-393



Hartmanns solution

- Alexis Frank Hartmann (1898-1964)
- Paediatrician
- 1932 added sodium lactate to Ringer's solution "Normal" saline rehydration of children with diabetic ketoacidosis increased acidosis and worsened the prognosis
- "Need proportionally <u>more sodium</u> than chloride in parenteral solutions to avoid the development of an acidosis"

Observation :

"Decreased renal excretion of sodium in the postoperative period after major surgery is a well recorded event"

Why?

Moyer C.A Surg., 1950

"After Major Surgical Trauma, Body Normally <u>Conserves</u> Salt"

Postulated:

Normal endocrine response to trauma leads to conservation of sodium and water.

* "Therefore restrict fluids "

Moore, F.D, et al Ann Surg. 1955

"Fluid Restriction"



Fluid Volume (mL/kg)

Shire's Experiment on Hemorrhagic Shock

Dogs bled into Shock:

Group I given bled volume as blood
Group 2 given bled volume <u>plus</u> Ringers

Group I - 20 % Survived Group 2 - 70 % Survived

Shires, G.T., et al Arch. Surg. 88: 688, 1964.



Acute Change in Extracellular Fluids Associated with Major Surgical Procedures

Landmark paper

 $\sqrt{\text{Using}^{35}\text{S-tagged NaSO_4, measured "functional" ECF}}$

 $\sqrt{1}$ The greater the trauma, the greater the <u>"third space"</u>

 $\sqrt{\text{Therefore postoperative oliguria$ **not**due to normal neurohormonal factors causing fluid retention (Moore's theory)

Tom Shires MD et al Annals of Surgery November 1961

"Fill that Third Space"



Fluid Volume (mL/kg)

ARDS = "Danang Lung"



Ashbaugh, Bigelow, Petty Lancet 1967

Acute Change in Extracellular Fluids Associated with Major Surgical Procedures

But <u>Quantitively</u> <u>flawed</u> study

 $\sqrt{\text{Greatly over-estimated}}$ fluid loss (up to 28% of ECF) - due to measurement problems

 $\sqrt{\text{Advised} \sim 5-8}$ litres in addition to measured losses

 $\sqrt{10}$ Probable cause of "Danang Lung" (overdose of "Texas Blood")

Tom Shires MD et al Annals of Surgery November 1961

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Does sub-clinical hypovolaemia matter?

Effects of compensated "hypovolaemia" on gut

6 healthy volunteers bled 2×600 ml

600 ml ->

No significant change in BP, HR, stroke volume <u>Decrease</u> in gut intramucosal pH 1200 ml -> No significant change in BP, HR <u>Decrease</u> in stroke volume, Gut intramucosal pH worsened

Re-transfusion -> variables recovered, but **'flu-like'' symptoms** ICM (1997) 23: 276–281 The use of a <u>PostOperative Morbidity Survey</u> after elective surgery

P.O.M.Score

"Gastrointestinal dysfunction..the most common type of postoperative complication"

"...the gastrointestinal tract is extremely sensitive to hypovolemia."

"mechanical trauma not the only cause of GI dysfunction...32% of patients with prolonged L.O.S. ...were after extra-abdominal procedures (e.g., hip arthroplasty)"

Anesth Analg 1999;89:514-9

Sub-clinical "hypovolaemia" and postoperative recovery

- 60 patient study of Fast Tracking knee replacement surgery
- 45 % of patients audited showed signs of orthostatic dizziness
- Seems to be irrespective of analgesic technique.
- Orthostatic fainting led to prolonged length of stay
- Cost in increased LOS ££££

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All Fluids are Not Created Equal



In sepsis, the fluid does not stay in place!



NEJM 363;7: 12/8/2010

Does dopamine administration in shock influence outcome? Results of the Sepsis Occurrence in Acutely Ill Patients (SOAP) Study*

"... <u>higher mean fluid balance</u>...were independent risk factors for intensive care unit <u>mortality</u> in patients with shock."

Cause or effect?

Crit Care Med 2006 Vol. 34, No. 3

Fluid resuscitation in septic shock: A <u>positive fluid balance</u> and elevated CVP are associated with an increased mortality



Crit Care Med 2011 Vol. 39, No. 2

Clinical Case

21 yr old pregnant woman with flu-like illness Very breathless Admitted to ITU Failed attempt at NIV Patient was intubated and PICCO placed Very poor oxygenation with 100% 02 giving 02 sats of 80%

> PICCO reading reading: CO 2.9 I/min SVV <u>17</u>% (N= <10%) EVLW <u>35</u> mL/kg (N = <7mL/kg)

What do you do?

Comparison of Common Fluids

Fluid	Description	Volume effect of I liter infused	Duration
Dextrose 5%	Sugar water	70 ml	< 20 min
Hartmann's	Salt water	250 ml	20 min
Gelofusin™	Gelatin (bovine collagen)	700 ml	2 hrs
Voluven™	Starch water (corn/potato)	>	4-6 hrs

Diamonds are Forever...but Fluids aren't

Duration of Hartmann's



Adapted from Svensén C, et al Anesthesiology 1997;87:204 –12

Effect of 1 Litre IV Saline, Gelofusine and Voluven on Blood volume and ECF



SalineGelofusineVoluven

Crit Care Med 2010 Vol. 38, 464-470

Use of pharmacokinetics of Ringers to our advantage using co-hydration

- Preoperative infusion of I-2 litres of Ringers had no effect on hypotension in woman undergoing a C-section under spinal anaesthesia
- Rapid infusion at the <u>time</u> of placement of spinal showed dramatically improvement.
- Effect lasted the time required to deliver the foetus (~30 min)

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Resuscitation strategies

- First priority is supporting cardiac output with <u>fluids</u> - not anaemia
- Don't use Haematocrit to gauge bleeding
- Choose the right fluid for the right job
- ✤ <u>Speed</u> is of the essence

Zero tolerance for hypovolaemia...anaemia is less a problem



Clinical Case

78 yr old female Post op in ITU following vascular surgery BP 115/85 stable HR 90 stable Hct drops from 39 -> 21 %

What does this mean?



Effect of 1 Litre IV Saline, Gelofusine and Voluven on Haematocrit



Crit Care Med 2010 Vol. 38, 464-470

Choose the right fluid



Hypovolaemia-there is not a moment to lose!

Rapid resuscitation is the most important factor to avoid <u>irreversible</u> shock



Moomey et al CCM 1999; 27:154

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A central line for fluid therapy ?



Flow ~ radius⁴ x pressure gradient / length x viscosity A 20 cm Central Line is <u>NOT</u> the best option to give fluid rapidly !



Ann Emerg Med 1993; 22: 1551

Short and Fat is best! 200 Flow rate mL/min 00 0 16 G 16 G 16 G l4 cm 5 cm 30 cm

How about Trendelenburg ?

Effect of Trendelenburg

Change

Parameter	Supine	Head down	%	Ρ
BP (mean)	64	71	+11	<.001
PCWP	4.6	7.2	+57	<.001
Cardiac index	2. I	1.9	-9	NS

Why doesn't Trendelenburg work?

Increases cardiac filling pressures relative to atmosphere

Increases intrathoracic pressure
 Transmural pressure (i.e., distending

pressure of heart) does <u>not</u> change

Or raise ze legs!

- ✓ Rapidly "transfuses" ~ 500 ml
- ✓ Does <u>not</u> raise
 intra-thoracic pressure

Intensive Care Med (2008) 34:659-663





Cardiac output is THE most important factor
Beware of subtle degrees of 'hypovolaemia'
Use the right fluid for the right job
Speed is of the essence

Further reading:

http://web.me.com/johnvogel2

Questions ?