NOT all BALANCED solutions are equal ?

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Disclosure

Dr Laurence Weinberg discloses the following relevant affiliation or other financial relationship (1) with the manufacturers of any commercial product(s) and/or provider(s) of commercial services discussed in this educational presentation, and (2) with any commercial supporters of the activity. Conflict resolution occurred prior to the CME activity. The Department of Anaesthesia at Austin Hospital has disclosed the following information:

Research Funding

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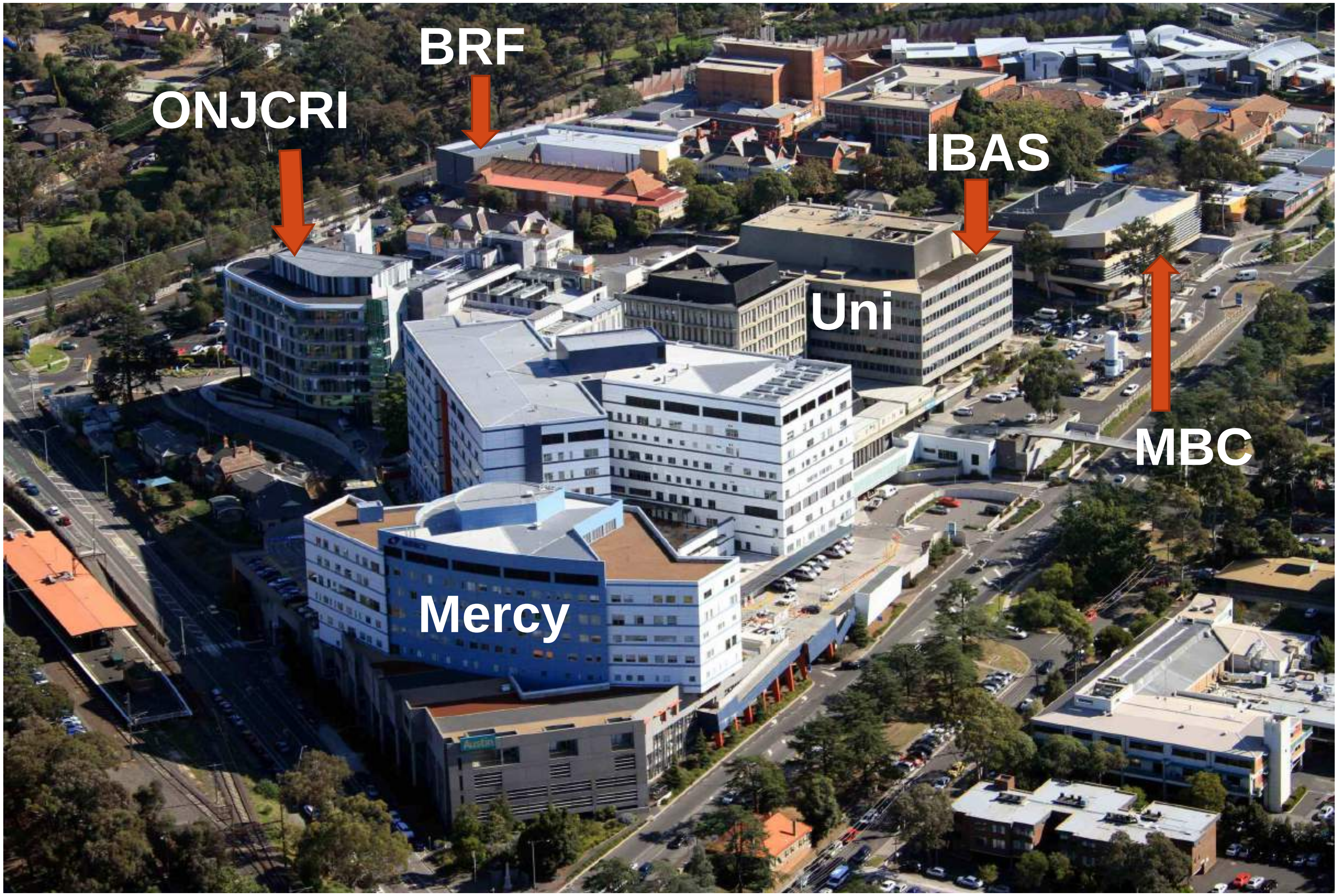
Scientific Consultant

Baxter Healthcare; Edwards Lifesciences


BRF
ONJCRI
IBAS
Uni
MBC
Mercy

Goals.......

Understand
AHDM concepts

Explore
Evidence for crystalloids & colloids

Understand
Physiochemical properties of fluids

Strategies?
Use in your daily clinical practice

“the mass of the profession is unable to decide; and thus, instead of any uniform mode of treatment, every town and village has its different system or systems”

-Editorial comment, Lancet 1832

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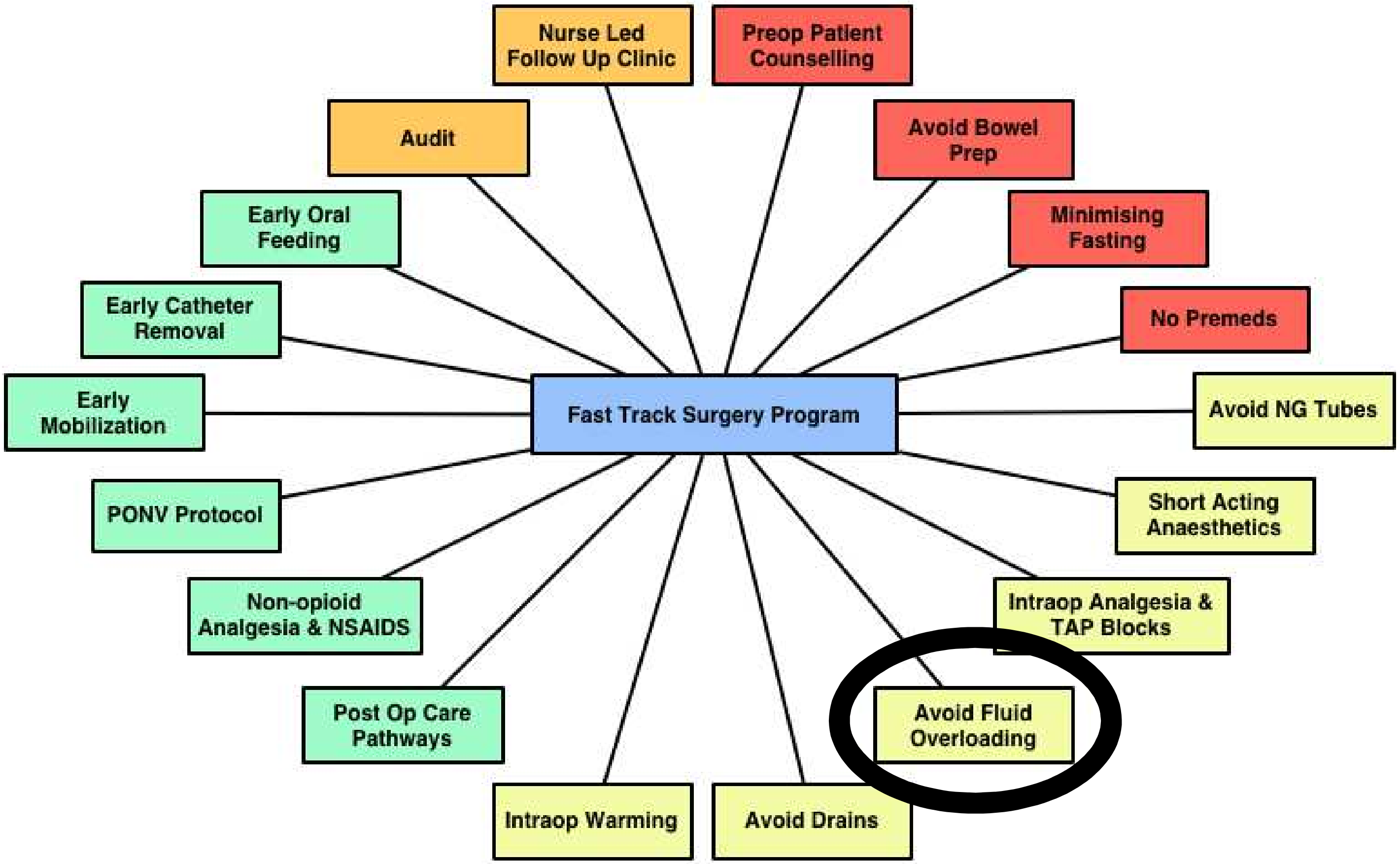

Fast Track Surgery Program
Nurse Led Follow Up Clinic
Preop Patient Counselling
Audit
Avoid Bowel Prep
Early Oral Feeding
Minimising Fasting
Early Catheter Removal
No Premeds
Early Mobilization
Avoid NG Tubes
PONV Protocol
Short Acting Anaesthetics
Non-opioid Analgesia & NSAIDS
Intraop Analgesia & TAP Blocks
Post Op Care Pathways
Avoid Fluid Overloading
Intraop Warming
Avoid Drains

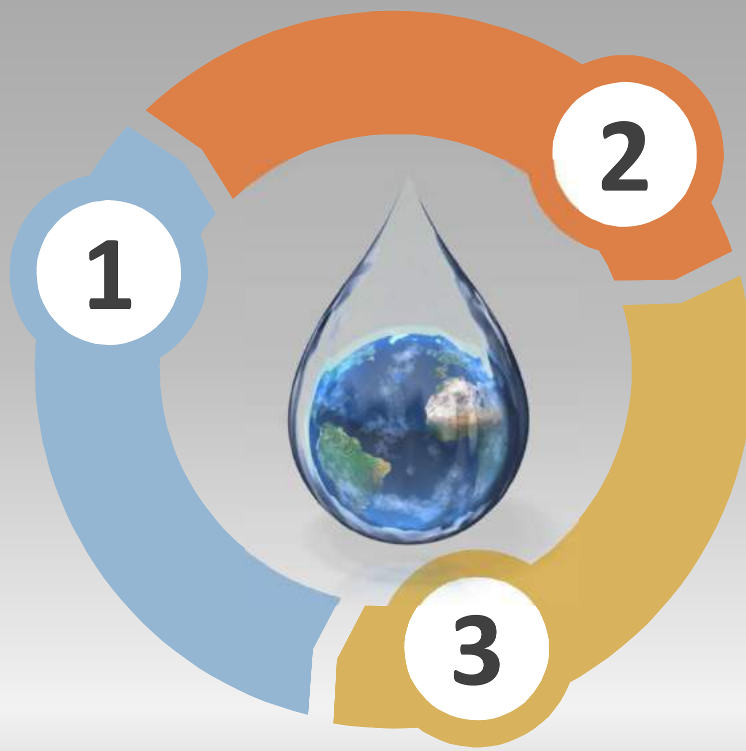
MAJOR COLON

World J Surg (2013) 37:259–284
DOI 10.1007/s00268-012-1772-0

World Journal of Surgery

Guidelines for Perioperative Care in Elective Colonic Surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

U. O. Gustafsson · M. J. Scott · W. Schwenk · N. Demartines · D. Roulin · N. Francis · C. E. McNaught · J. MacFie · A. S. Liberman · M. Soop · A. Hill · R. H. Kennedy · D. N. Lobo · K. Fearon · O. Ljungqvist



WHIPPLES

World J Surg (2013) 37:240–258
DOI 10.1007/s00268-012-1771-1

World Journal of Surgery

Guidelines for Perioperative Care for Pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society Recommendations

Contents lists available at ScienceDirect

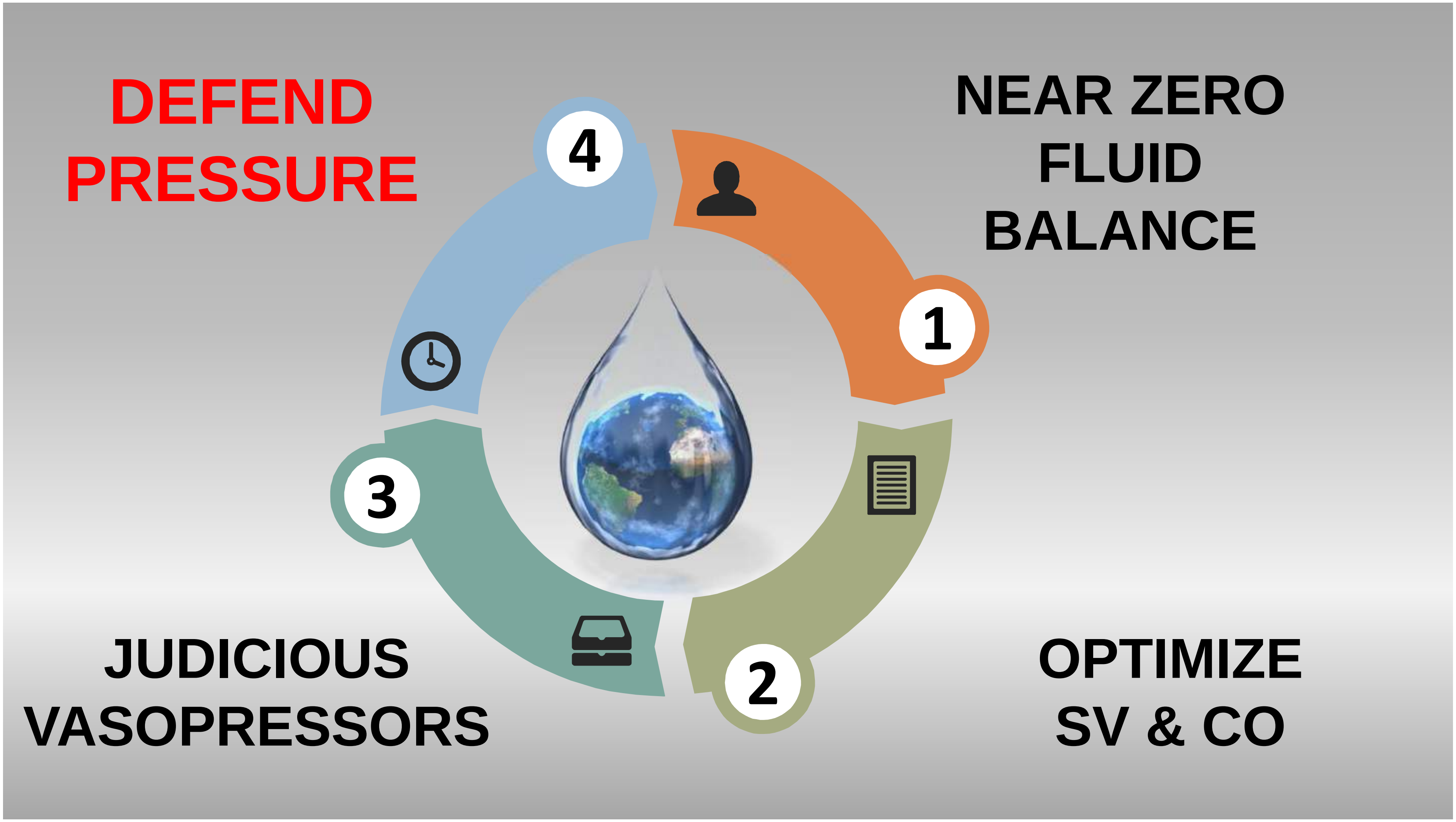
Clinical Nutrition

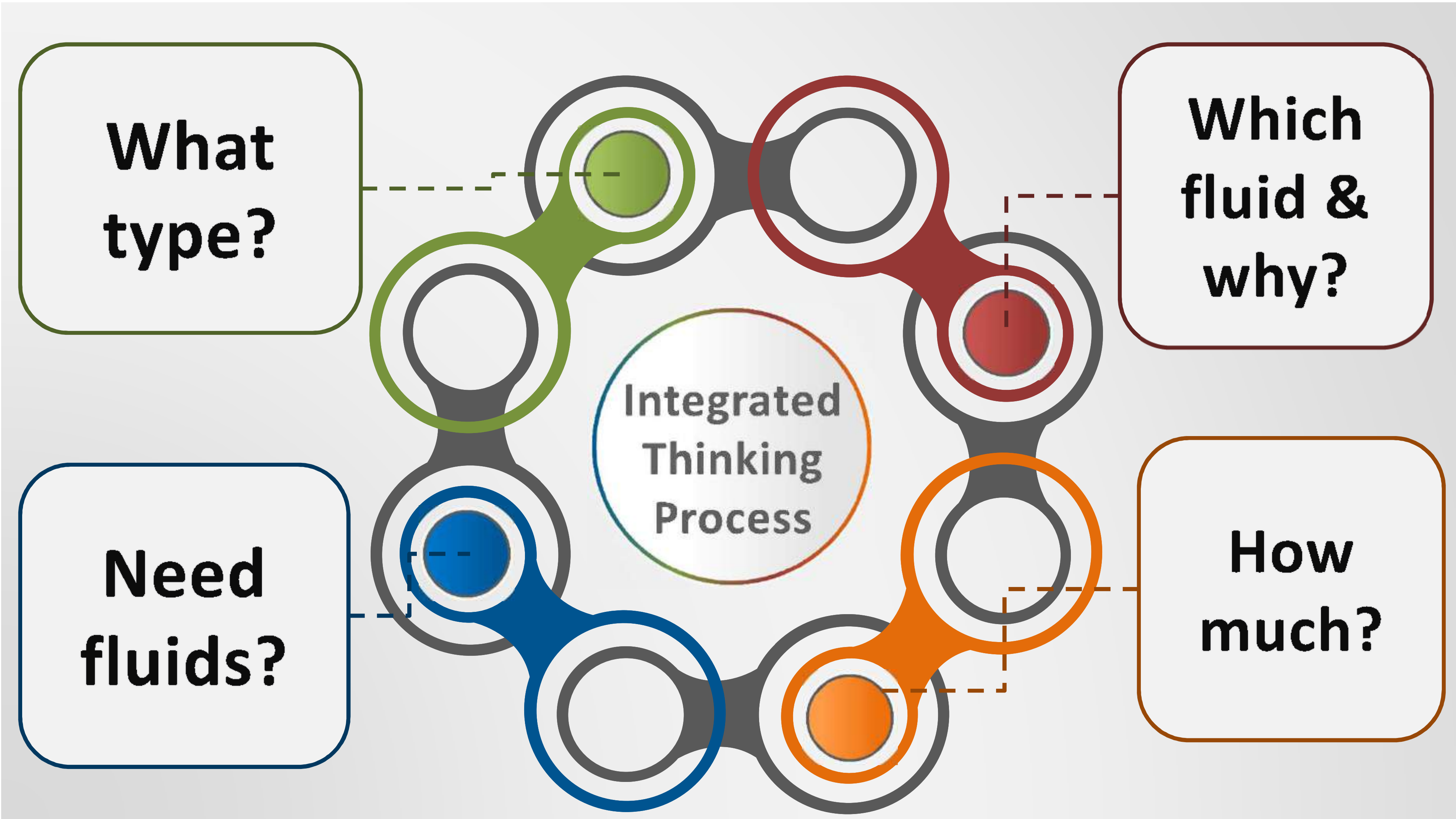
journal homepage: http://www.elsevier.com/locate/clnu

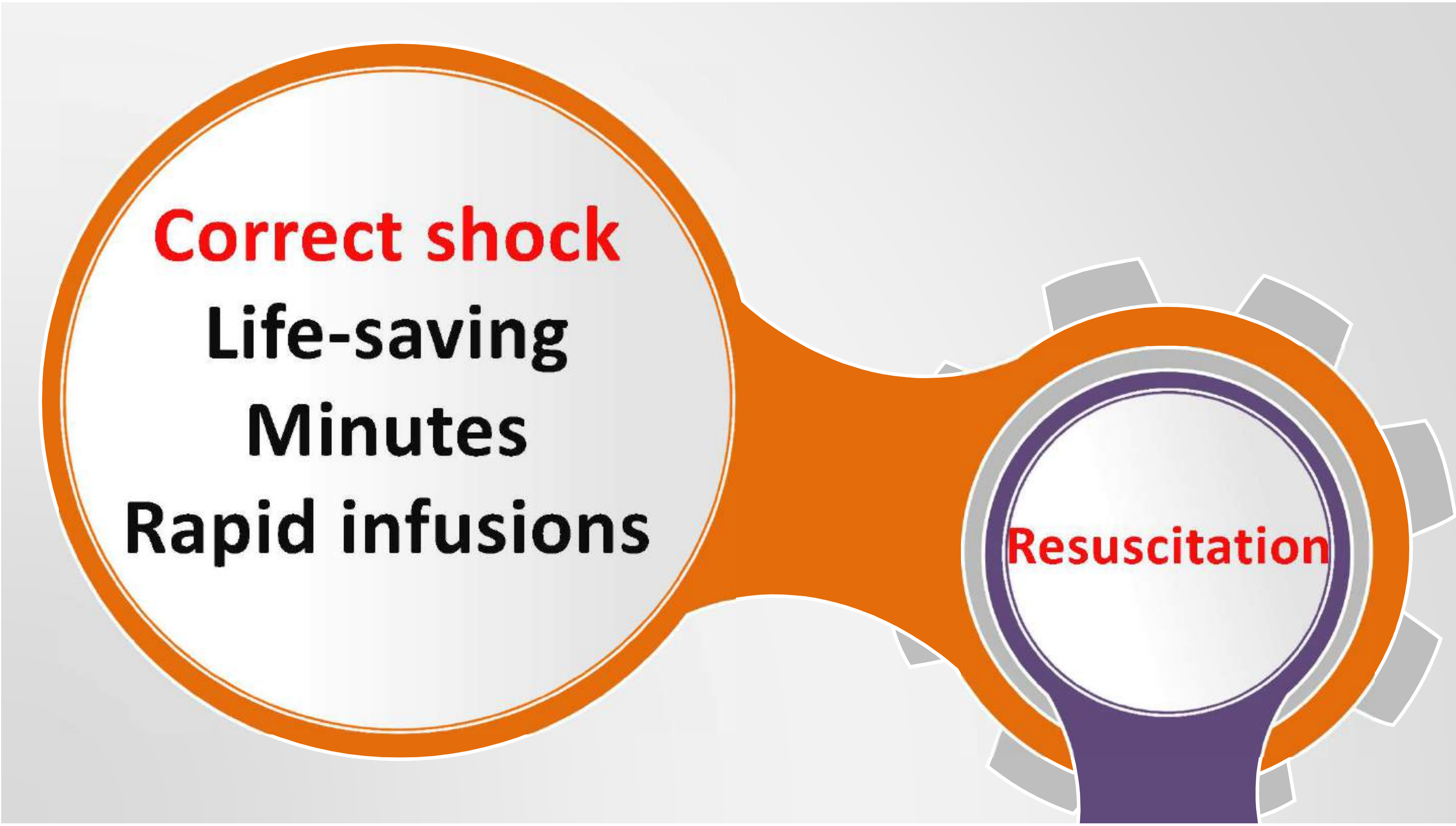
ELSEVIER

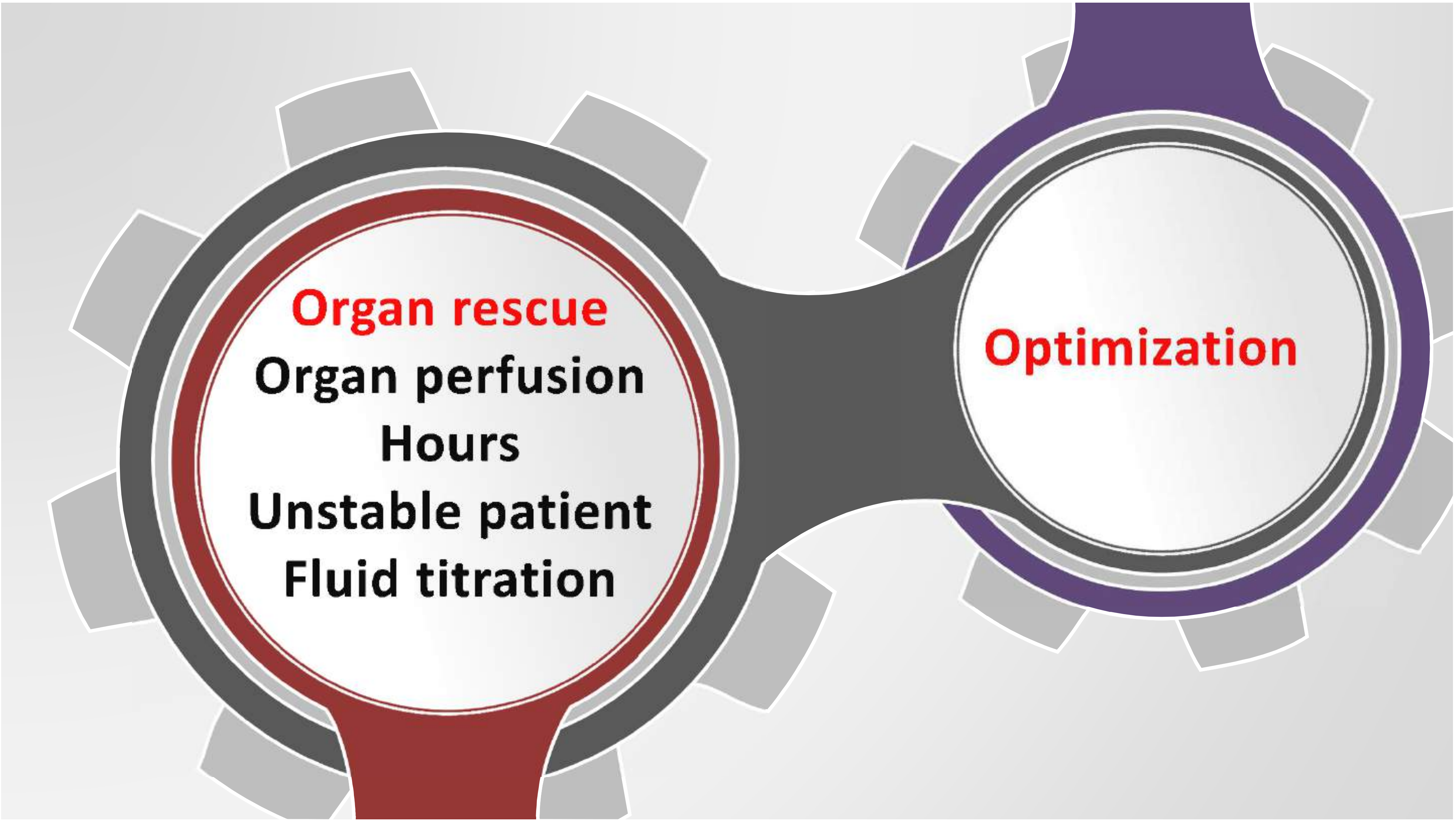
Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS®) society recommendations

CYSTECTOMY

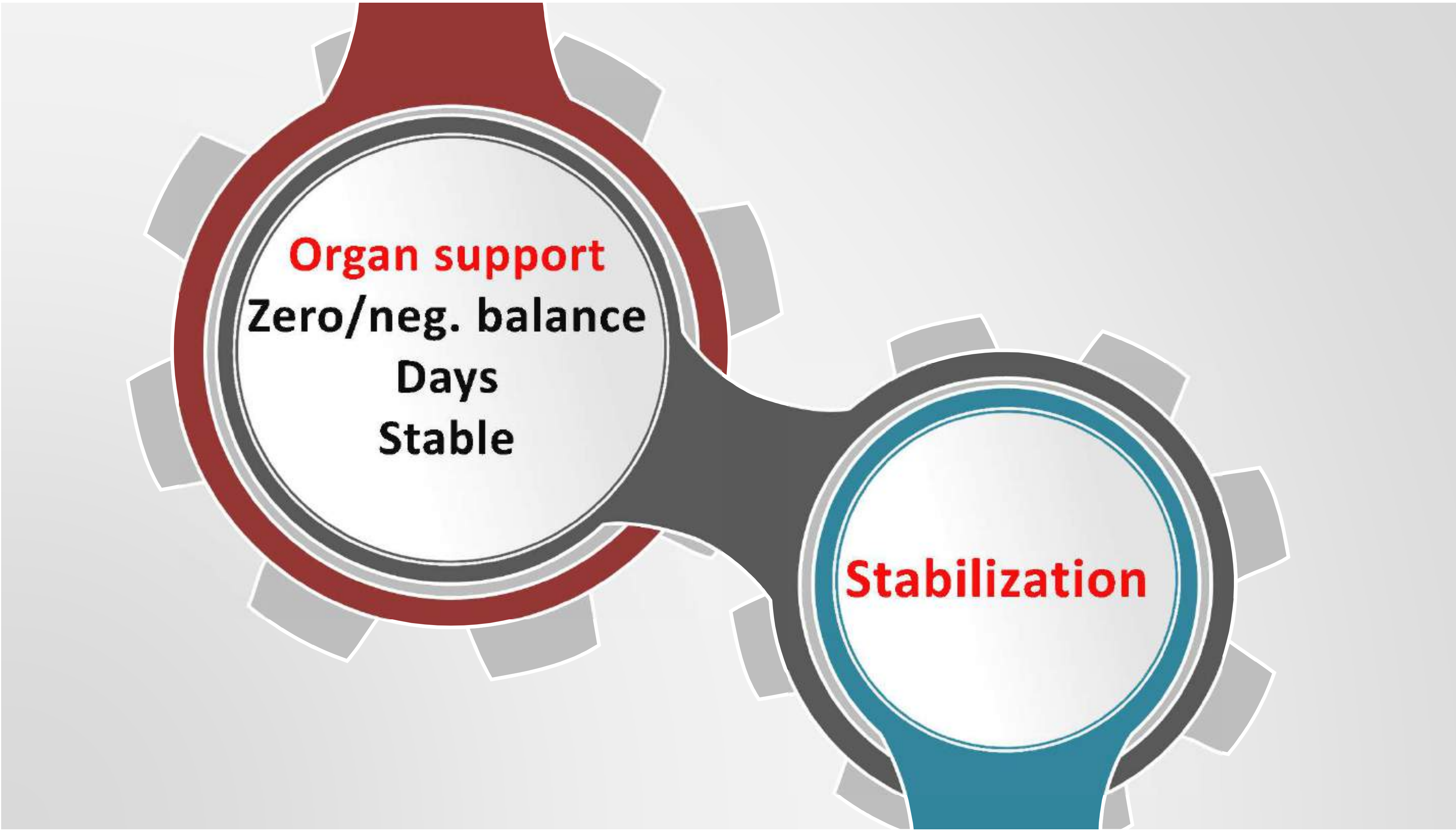

DEFEND PRESSURE
4
NEAR ZERO FLUID BALANCE
1
3
2
JUDICIOUS VASOPRESSORS
OPTIMIZE SV & CO

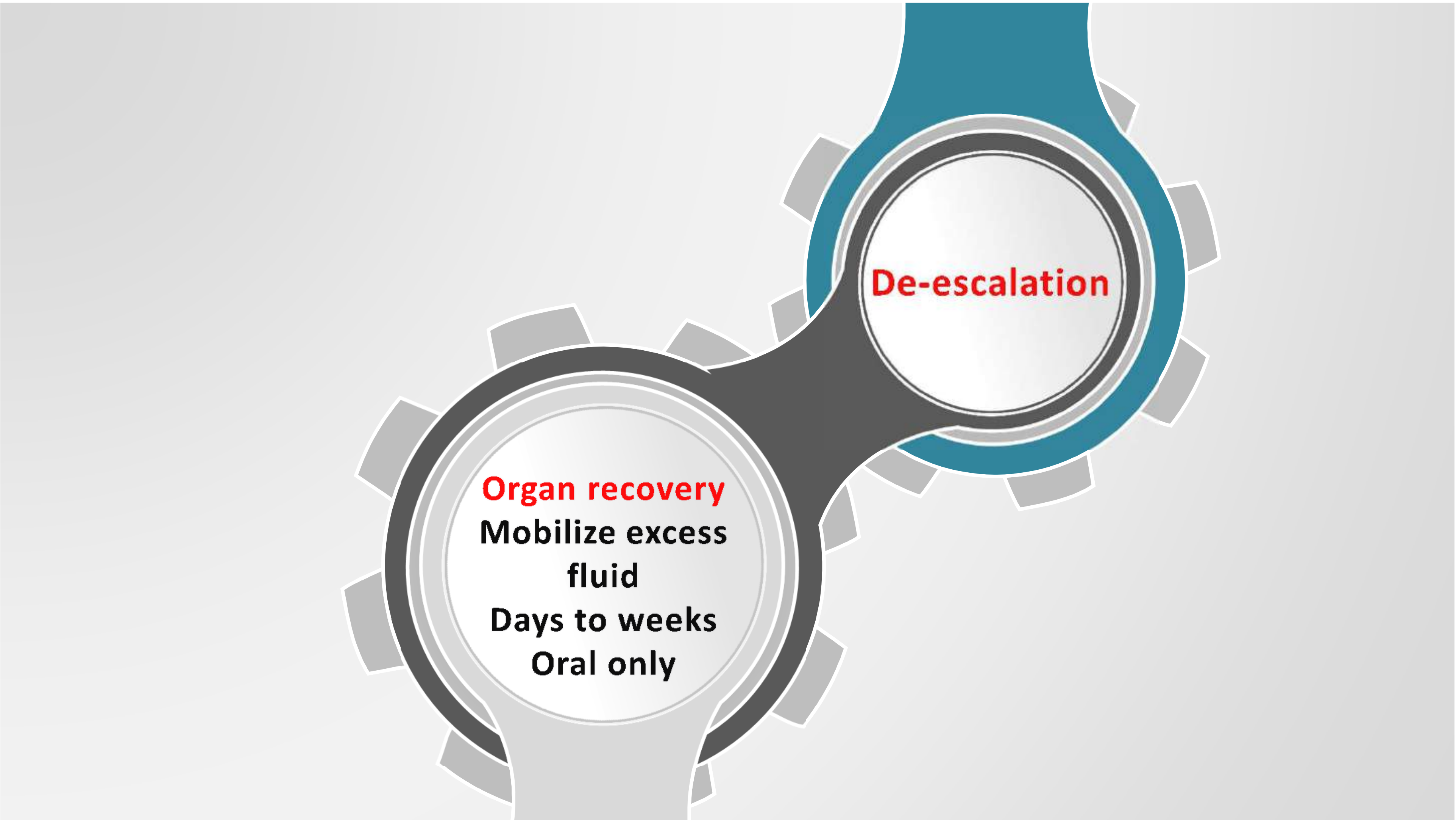

What type?
Which fluid & why?
Integrated Thinking Process
Need fluids?
How much?

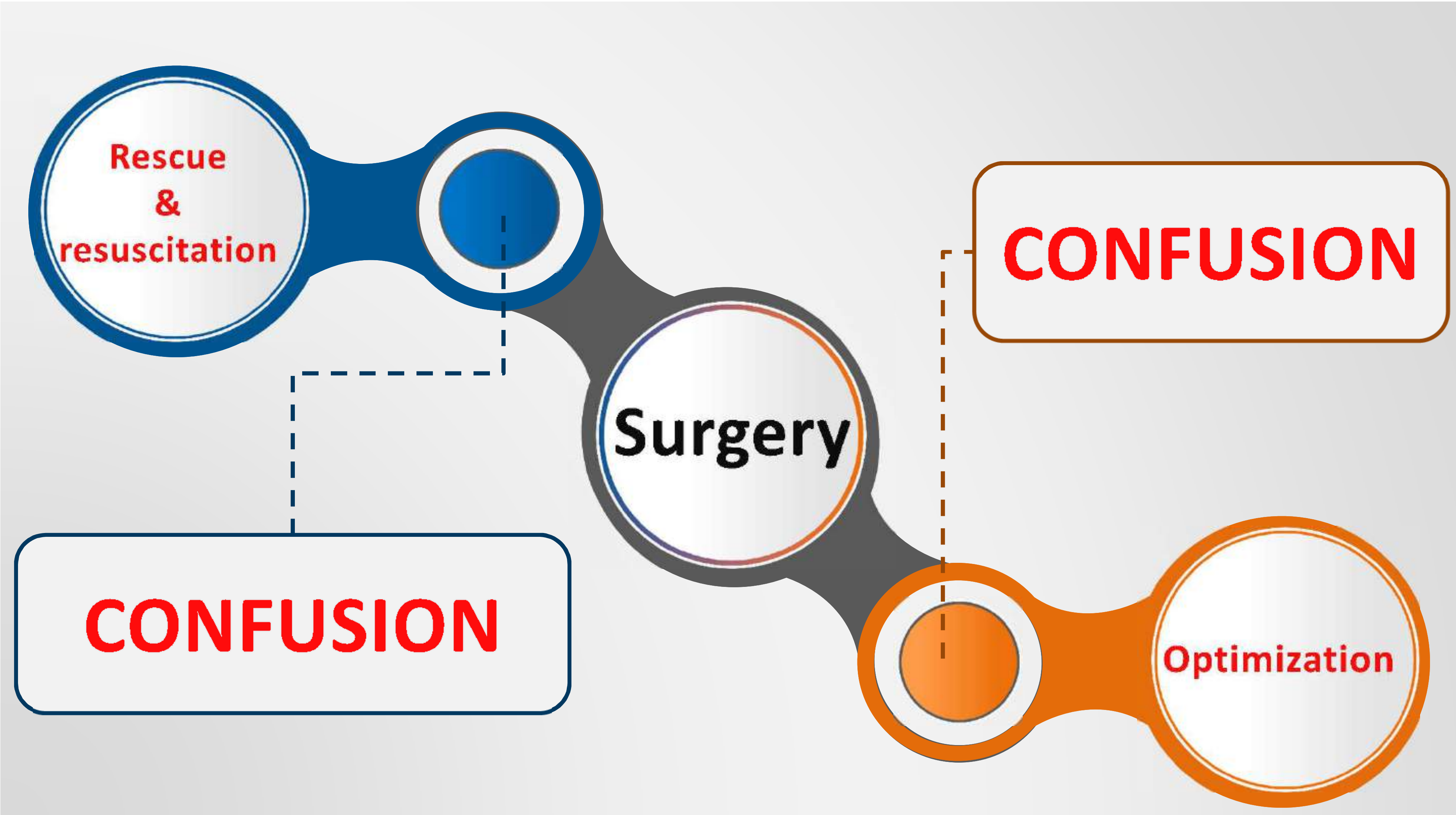

Correct shock
Life-saving
Minutes
Rapid infusions
Resuscitation



Organ rescue
Organ perfusion
Hours
Unstable patient
Fluid titration
Optimization


Organ support
Zero/neg. balance
Days
Stable
Stabilization


De-escalation
Organ recovery
Mobilize excess
fluid
Days to weeks
Oral only


Rescue
&
resuscitation
Surgery
Optimization
CONFUSION
CONFUSION

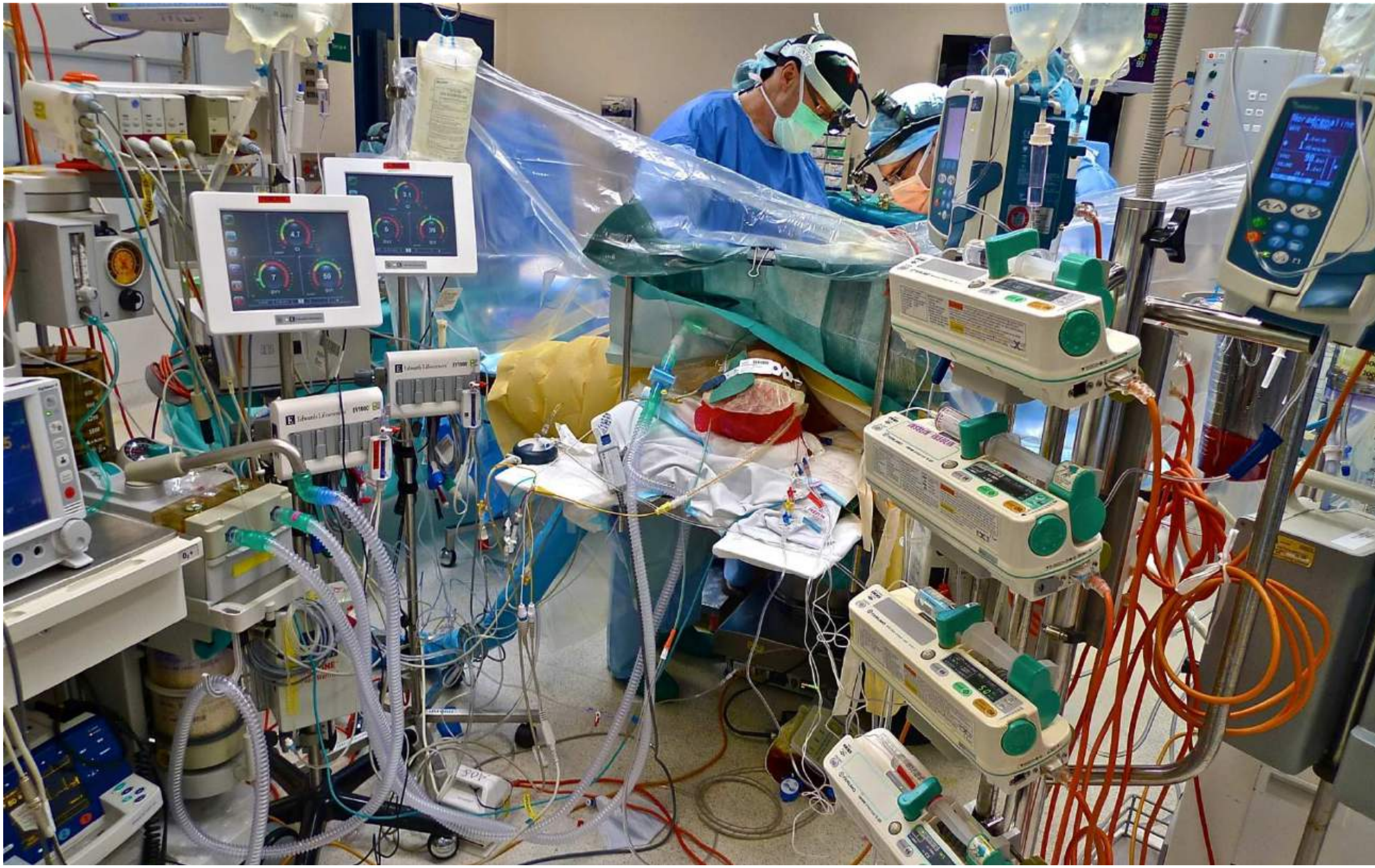
Monday morning.........

56 year male

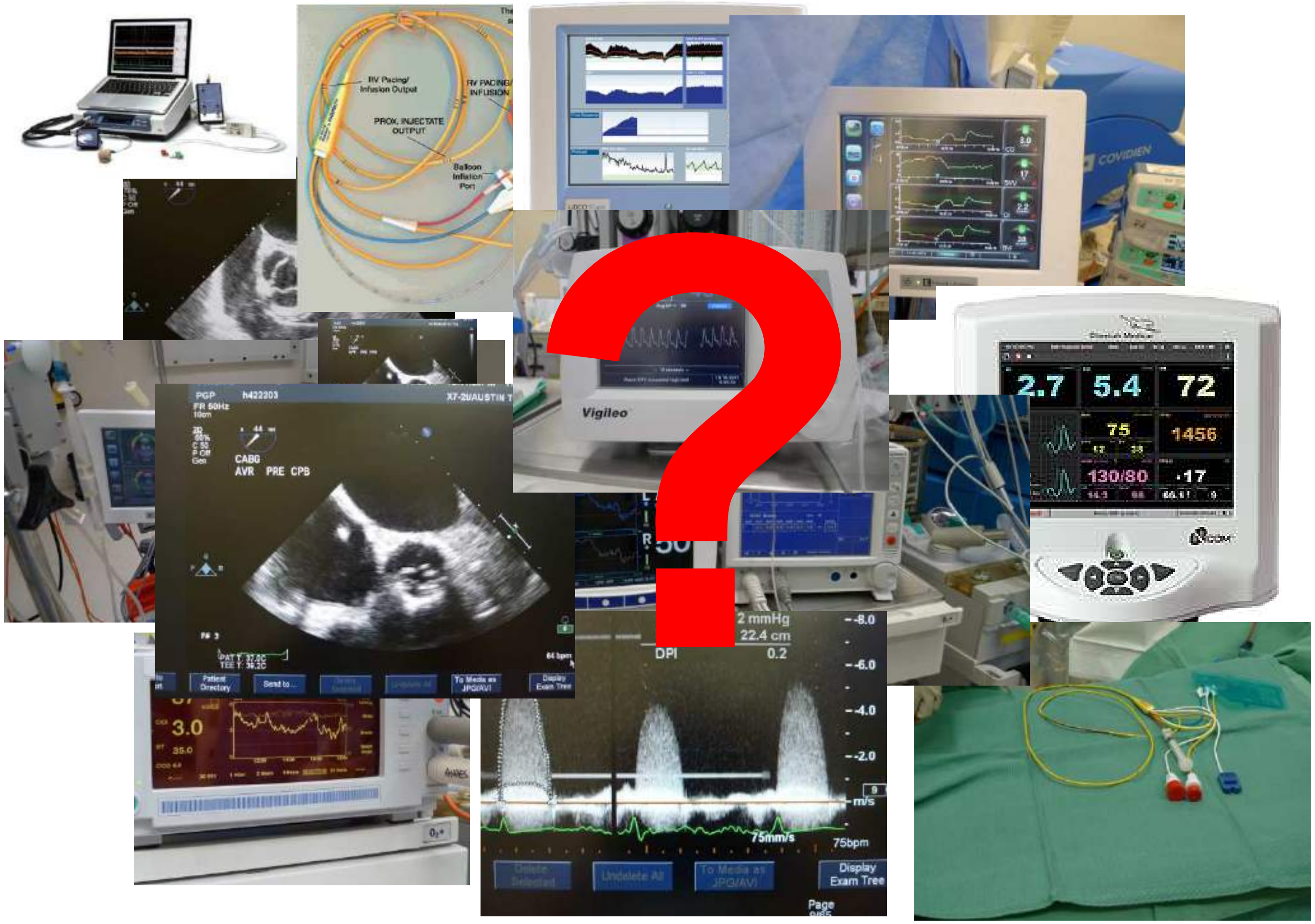
Massive abdominal mass

Elective surgery

Cardiorespiratory tests: normal



Understanding AHDM?



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Diagnostic and Haemodynamic Monitoring tools

NOT

Therapeutic Interventions

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Treatments save lives

NOT

Monitors

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How do we use the information from the device?

?

64 years F: **Acute Abdomen**
- Type 2 DM, PVD
- BMI: 43

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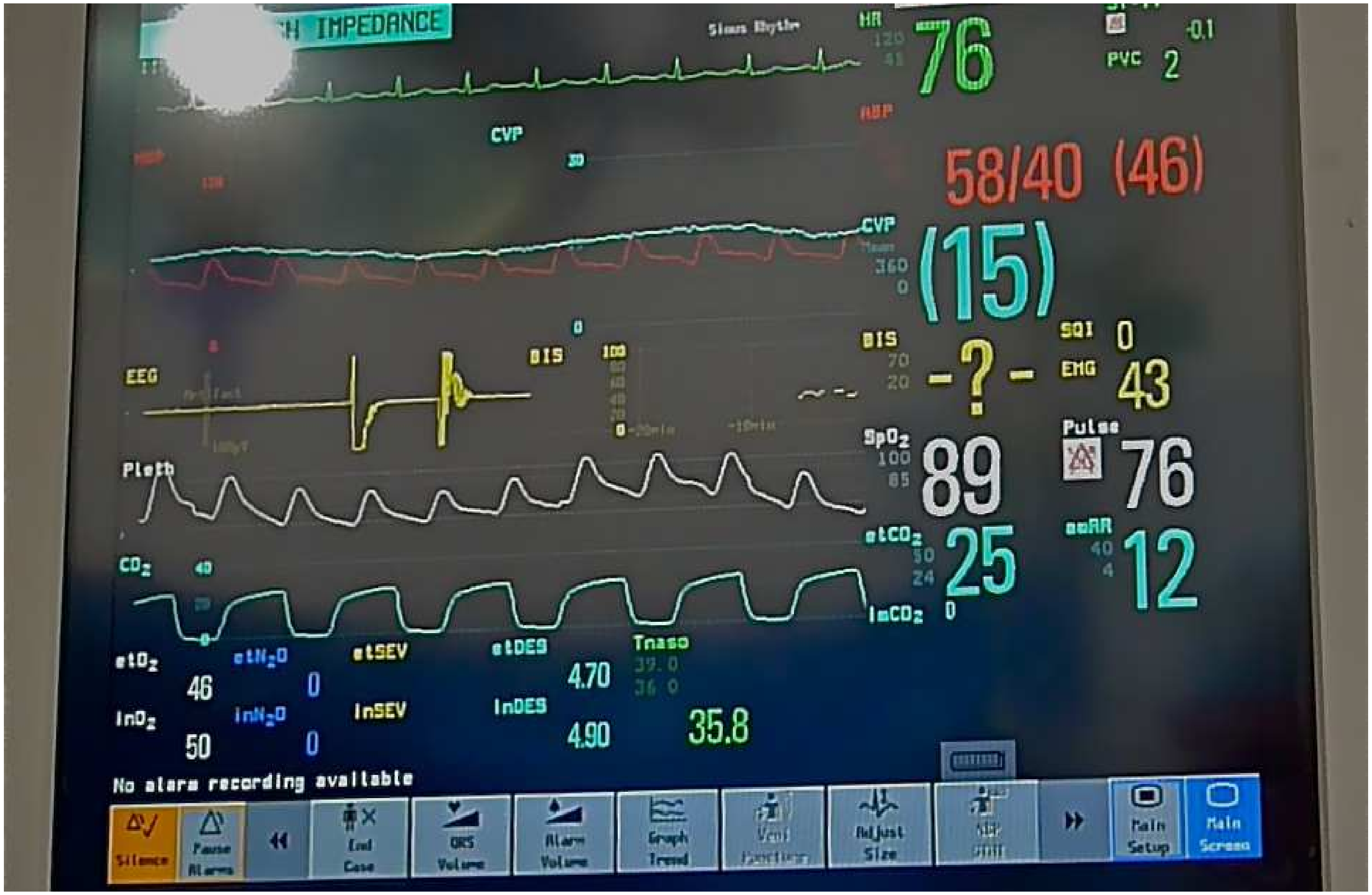

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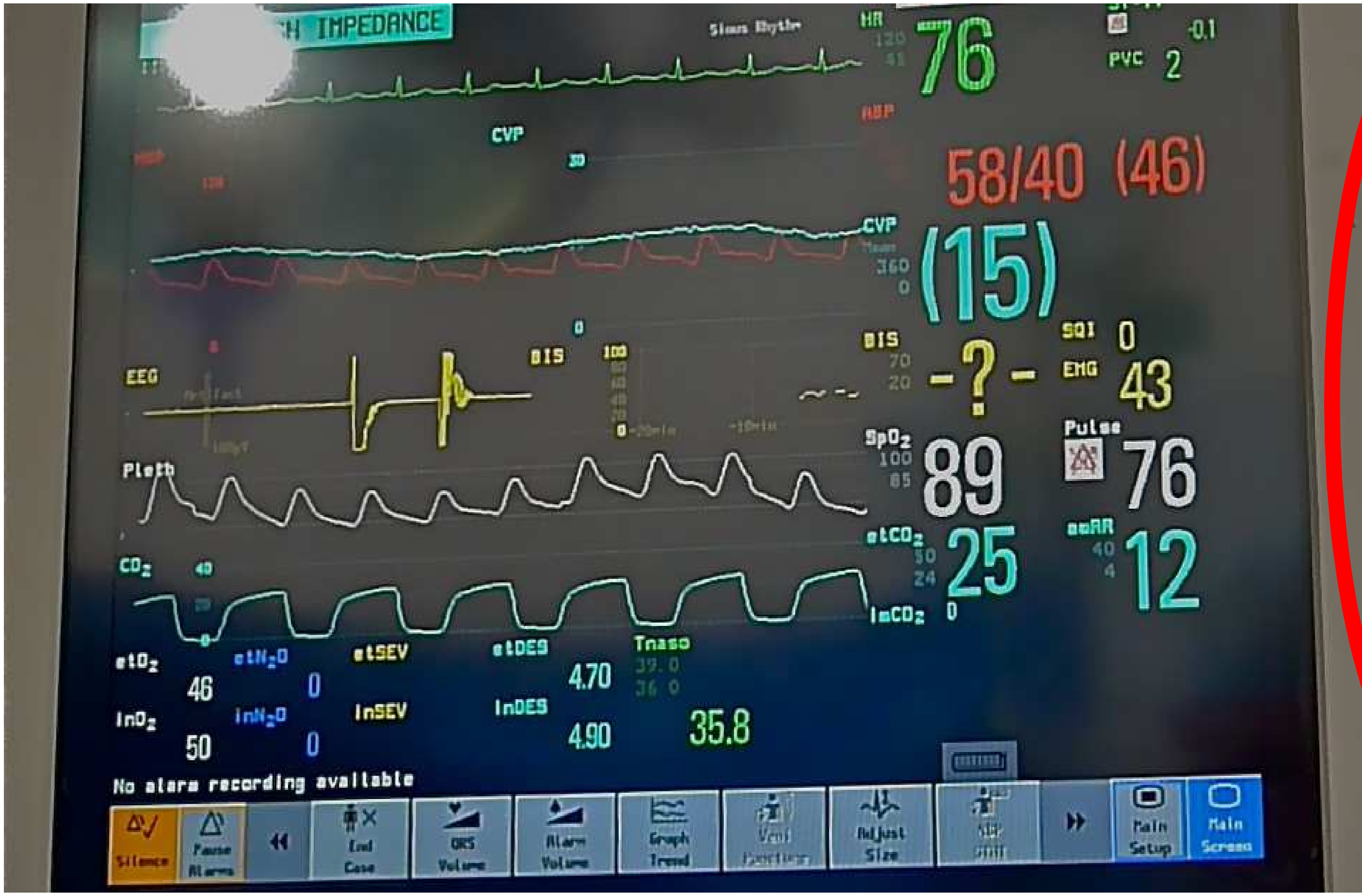
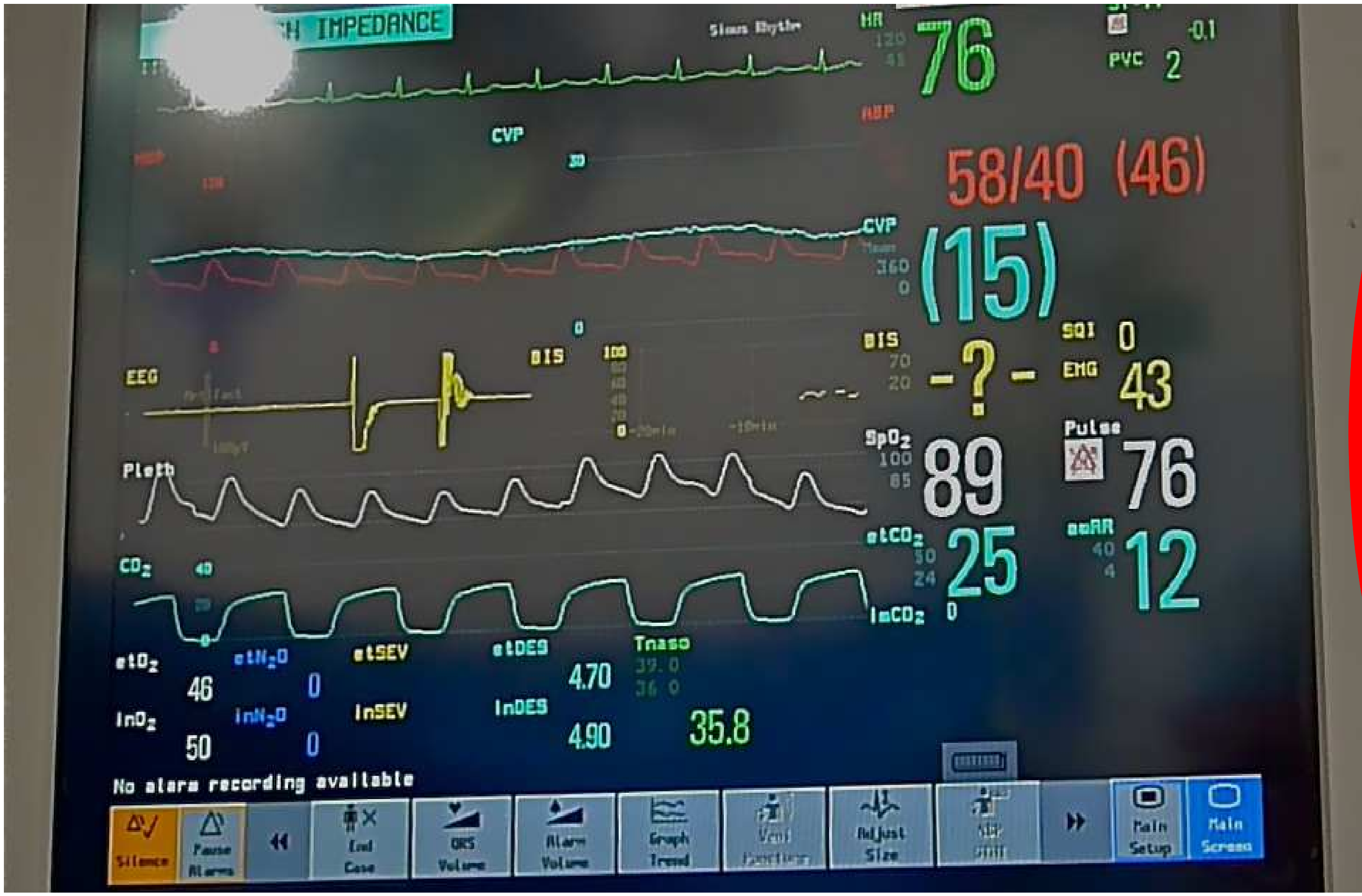

IMPEDANCE
Sinus Rhythm
HR
76
PVC 2
-0.1
CVP
ABP
58/40 (46)
CVP
(15)
EEG
BIS
-?-
SQI 0
EMG 43
Pleth
SpO2
89
Pulse
76
CO2
etCO2
25
awRR
12
imCO2 0
etO2
46
etN2O
0
etSEV
etDES
4.70
Tnaso
inO2
50
inN2O
0
inSEV
inDES
4.90
35.8
No alarm recording available
Silence
Pause Alarms
End Case
QRS Volume
Alarm Volume
Graph Trend
Adjust Size
Main Setup
Main Screen

5.7
L/min/m²
CI
11.2
L/min
CO
8
%
SVV
64
mL/b/m²
SVI


IMPEDANCE
Sinus Rhythm
HR
76
PVC 2
-0.1
CVP
ABP
58/40 (46)
CVP
(15)
EEG
BIS
BIS
-?-
SQI 0
EMG 43
Pleth
SpO2
89
Pulse
76
CO2
etCO2
25
awRR
12
imCO2
0
etO2
46
inO2
50
etN2O
0
inN2O
0
etSEV
inSEV
etDES
4.70
inDES
4.90
Tnaso
35.8
No alarm recording available
Silence
Pause Alarms
End Case
QRS Volume
Alarm Volume
Graph Trend
Adjust Size
Main Setup
Main Screen


36
%
SVV
0.7
L/min/m²
CI
5249
dyne-s-m²/cm⁵
SVRI

Proven outcomes….

Using a <u>treatment protocol</u> with <u>haemodynamic monitoring</u> (consistently) leads to improved clinical outcomes

BUT WHAT PROTOCOL?

	Goal	Surgery	Timing	Benefit
	DO_2I>600	General	D + A	Complications, mortality
	DO_2I>600	General	D + A	Complications, mortality
	SVmax with fluid	Cardiac	D	Complications, HLOS
Sinclair (1997)	SVmax with fluid	Hip	D	HLOS
Ueno (1998)	DO_2I>600	Liver	D + A	Complications
Wilson (1999)	DO_2I>600	General	D + A	Complications, HLOS
Lobo (2000)	DO_2I>600	General	D	Complications, mortality
Pölönen (2000)	SVO_2>70% fluid, dobutamine	Cardiac	A	Morbidity, HLOS
Gan (2002)	SVmax with fluid	General	D	Complications, HLOS
Venn (2002)	SVmax with fluid	Hip	D	Postoperative recovery
Conway (2002)	SVmax with fluid	Abdominal	D	Complications
McKendry (2004)	SVmax with fluid	Cardiac	A	HLOS
Pearse (2005)	DO_2I>600	General	A	Complications, HLOS
Wakeling (2005)	SVmax with fluid	Abdominal	D	Complications, HLOS
Noblett (2006)	SVmax with fluid	Abdominal	D	Complications, HLOS
Donati (2007)	$ScvO_2$>73%	General	D + A	Complications, HLOS
Chytra (2007)	SVmax with fluid	Trauma	A	Complications, HLOS
Benes (2010)	SVV<10%	Abdominal	D	Complications
Cecconi (2011)	SVmax, DO_2I>600 ml/min m_2	Hip	D	Complications

Two Goal Directed Protocol Philosophies

SV Optimization (Fluid First) ⟷ **Haemodynamic Stability (Observe First)**

Variations:
- *Different "trigger" parameters: SVV, CO/CI, DO2, SvO2 / ScvO2, CVP (declining)*
- *Different philosophies on degree of treatment*

Typical SV-optimization Protocol……

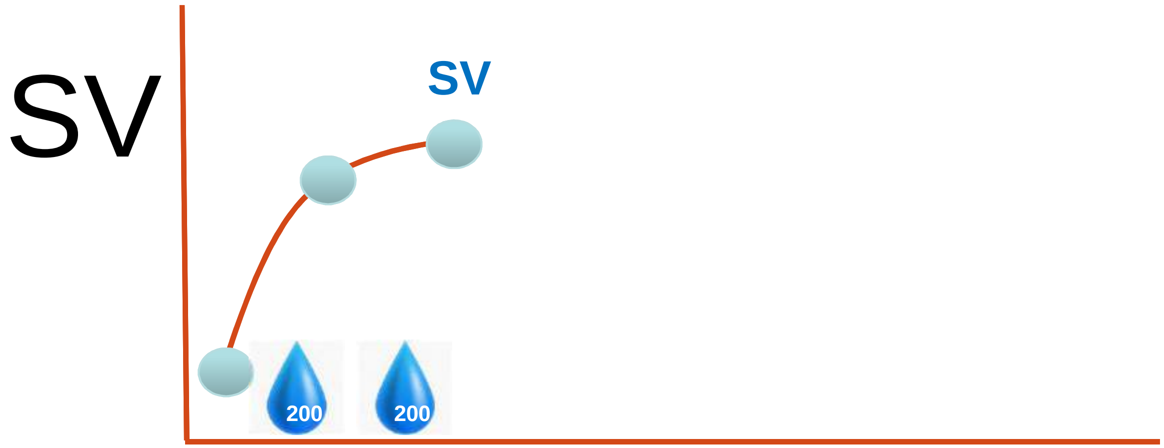
SV-optimization

SV-optimization

SV-optimization

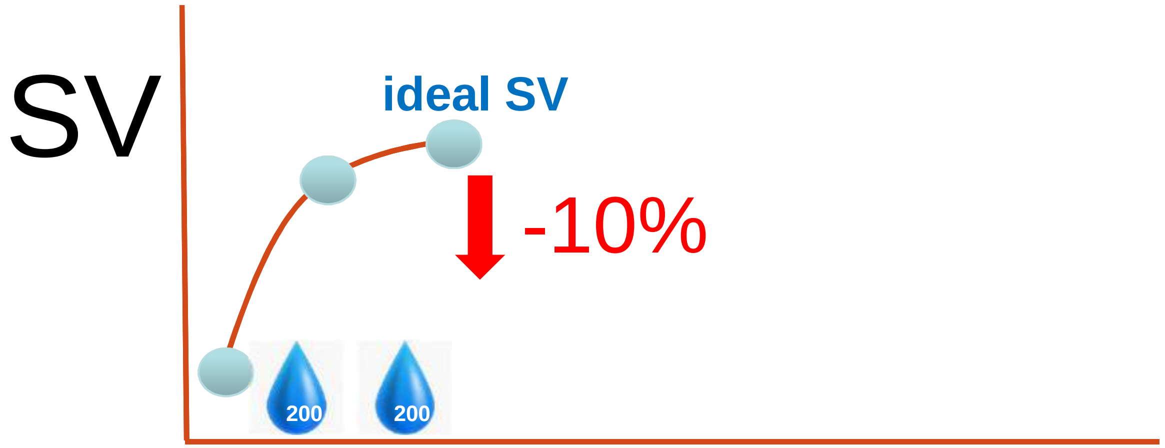
SV-optimization

SV-optimization



SV-optimization

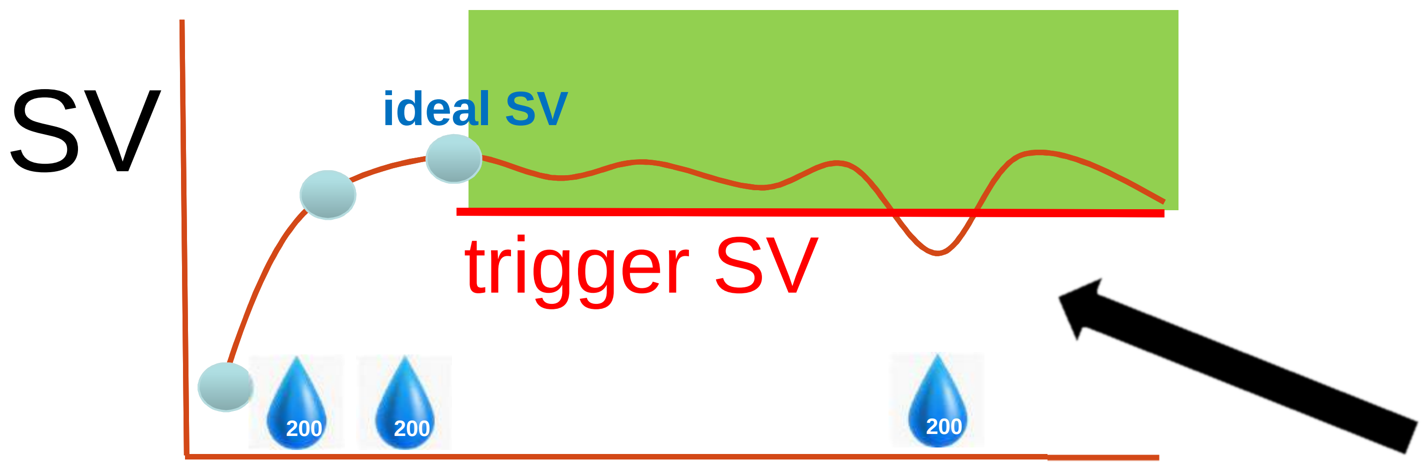
SV-optimization



SV-optimization

SV-optimization

SV-optimization



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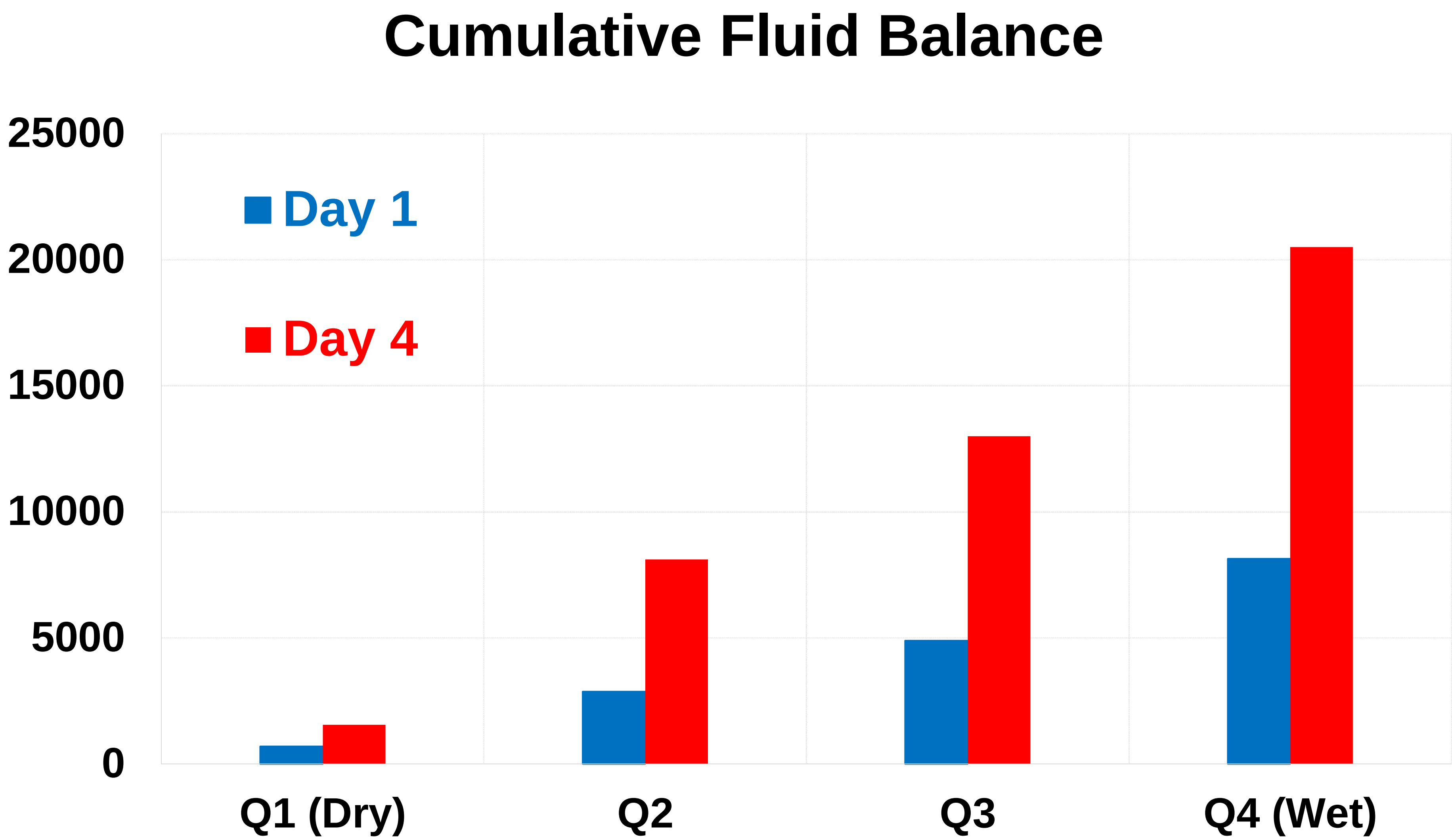
Problem….

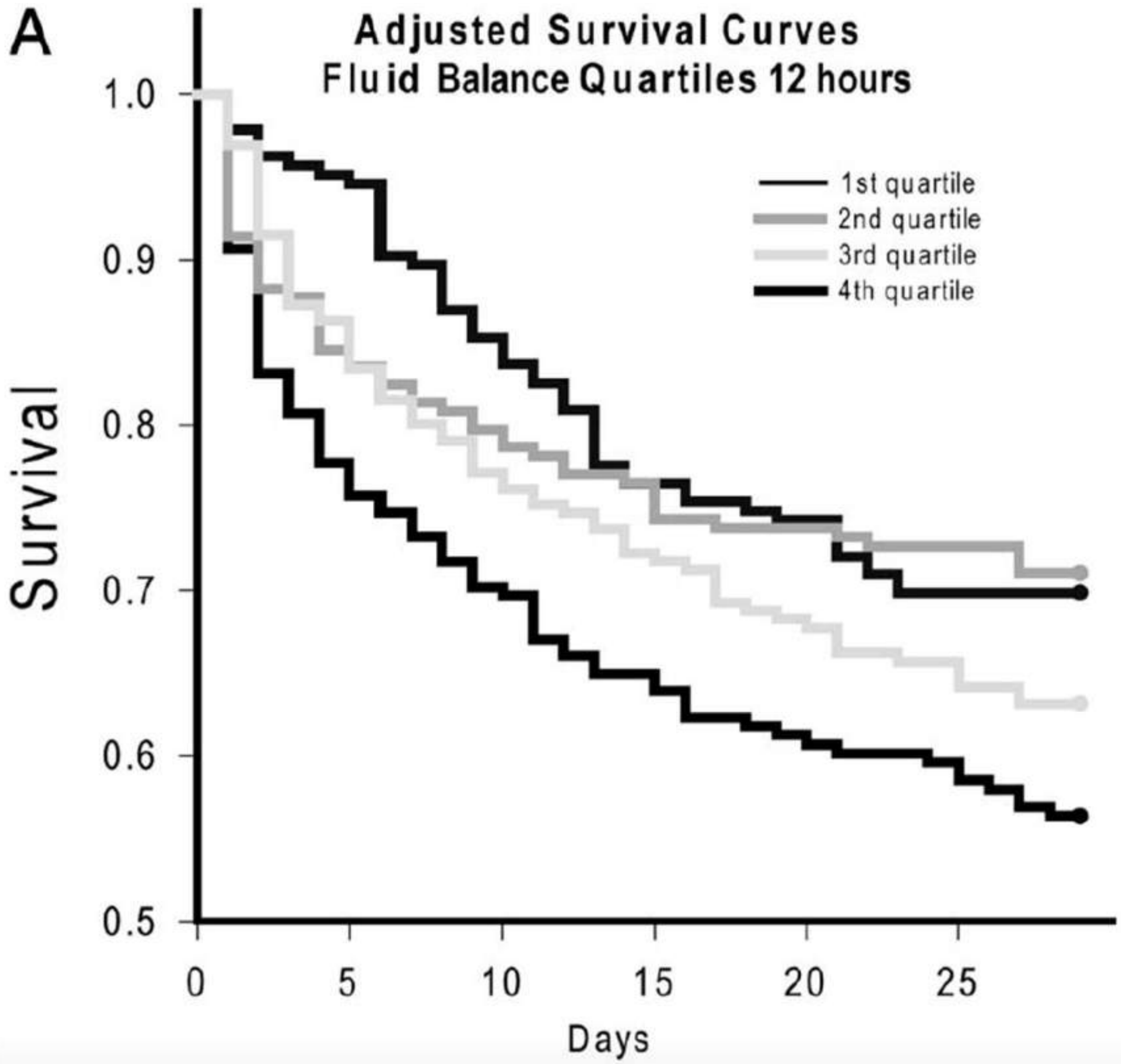
"Lets give some fluid and see what happens"

- **Risk:** large volumes of fluids
- Without understanding whether fluid is indicated
- **Or** whether the fluid is actually beneficial!

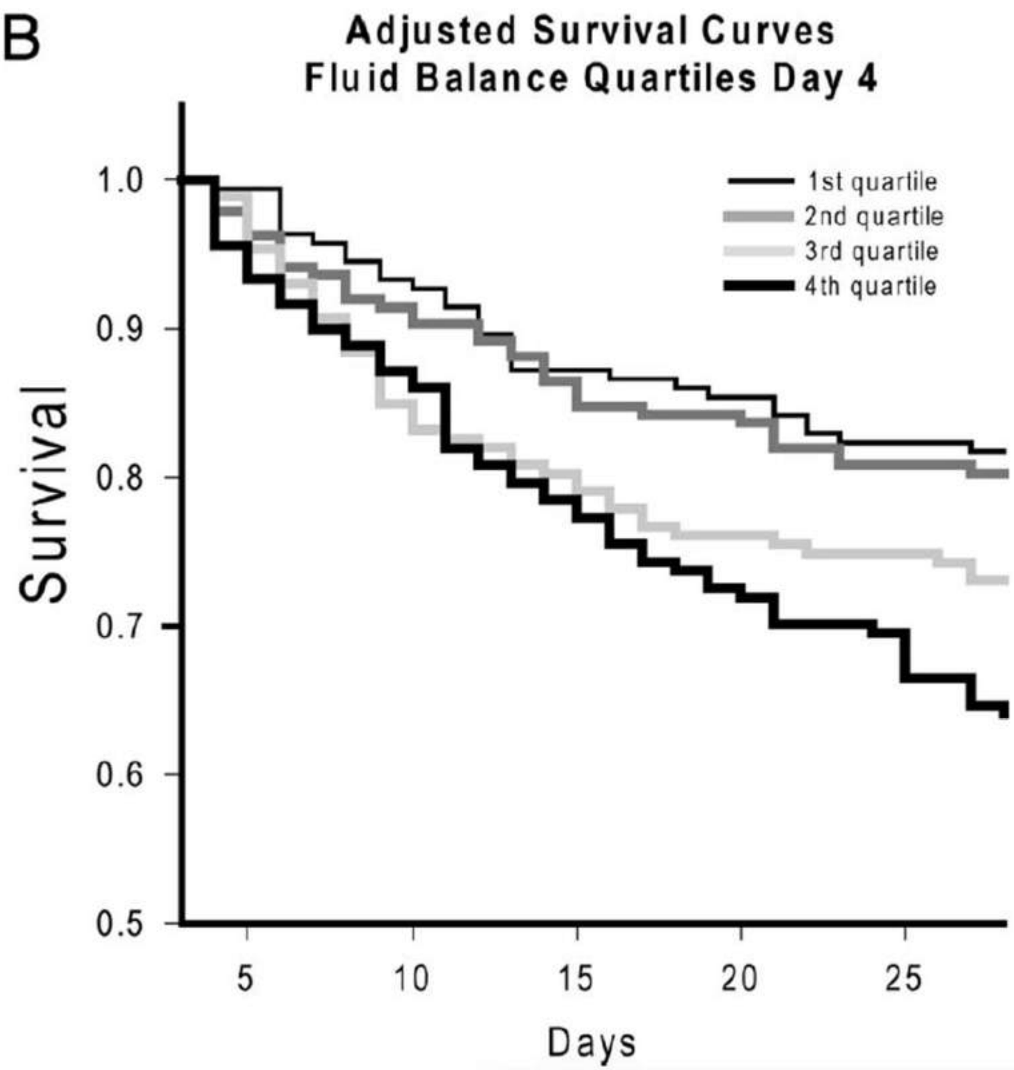
Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality*

Crit Care Med 2011 Vol. 39, No. 2


Cumulative Fluid Balance
25000
20000
15000
10000
5000
0
Day 1
Day 4
Q1 (Dry)
Q2
Q3
Q4 (Wet)


A
Adjusted Survival Curves
Fluid Balance Quartiles 12 hours
1st quartile
2nd quartile
3rd quartile
4th quartile
Survival
1.0
0.9
0.8
0.7
0.6
0.5
0
5
10
15
20
25
Days

B


Adjusted Survival Curves
Fluid Balance Quartiles Day 4
1st quartile
2nd quartile
3rd quartile
4th quartile
Survival
1.0
0.9
0.8
0.7
0.6
0.5
5
10
15
20
25
Days

Fluid overload, de-resuscitation, and outcomes in critically ill or injured patients: a systematic review with suggestions for clinical practice

Anaesthesiology Intensive Therapy
2014, vol. 46, no 5, 361–380

- 5,445 critically ill patients: 17 studies. Cumulative fluid balance by Day 7
- **Non-survivors (n= 2,609): positive: 6,982.6 mL (±5,629)**
- **Survivors: (n=2,449): positive: 2,449.1 mL (±2,965)**

Cumulative fluid balance = 4,533.5 mL (±3,626) more positive in non-survivors

Purpose of AHDM

- Assess circulatory performance
- Determine if CO is consistent with keeping tissue O_2 demand

AND IF NOT.....................

Purpose of ahdm

To determine **what components**

of the haemodynamic profile

need to be adjusted

to re-establish consumption-demand balance

To optimise outcomes

“Goal Directed Therapy" setting a haemodynamic goal and fitting the patient to the goal

“Haemodynamic Optimisation" i.e. looking at the patient and fitting the goal to the patient

Who is having a specific operation

Haemodynamic truth

Restoration of MAP may not restore microcirculation

i.e. Pressure is NOT flow

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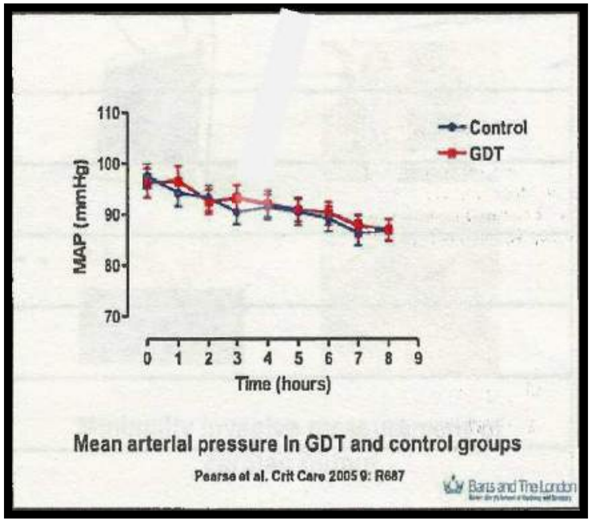
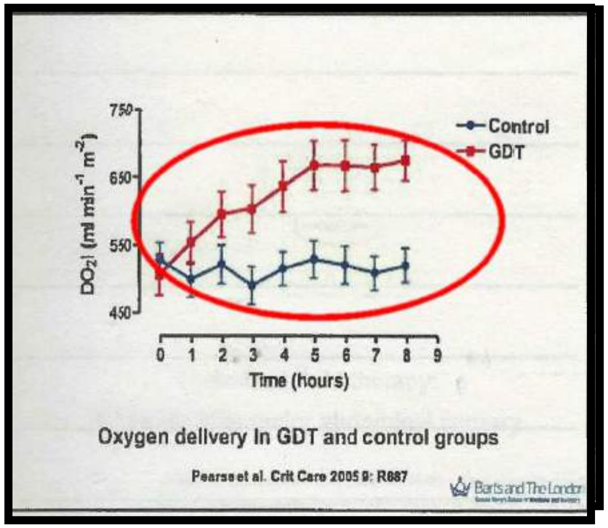
Pressure ≠ not flow





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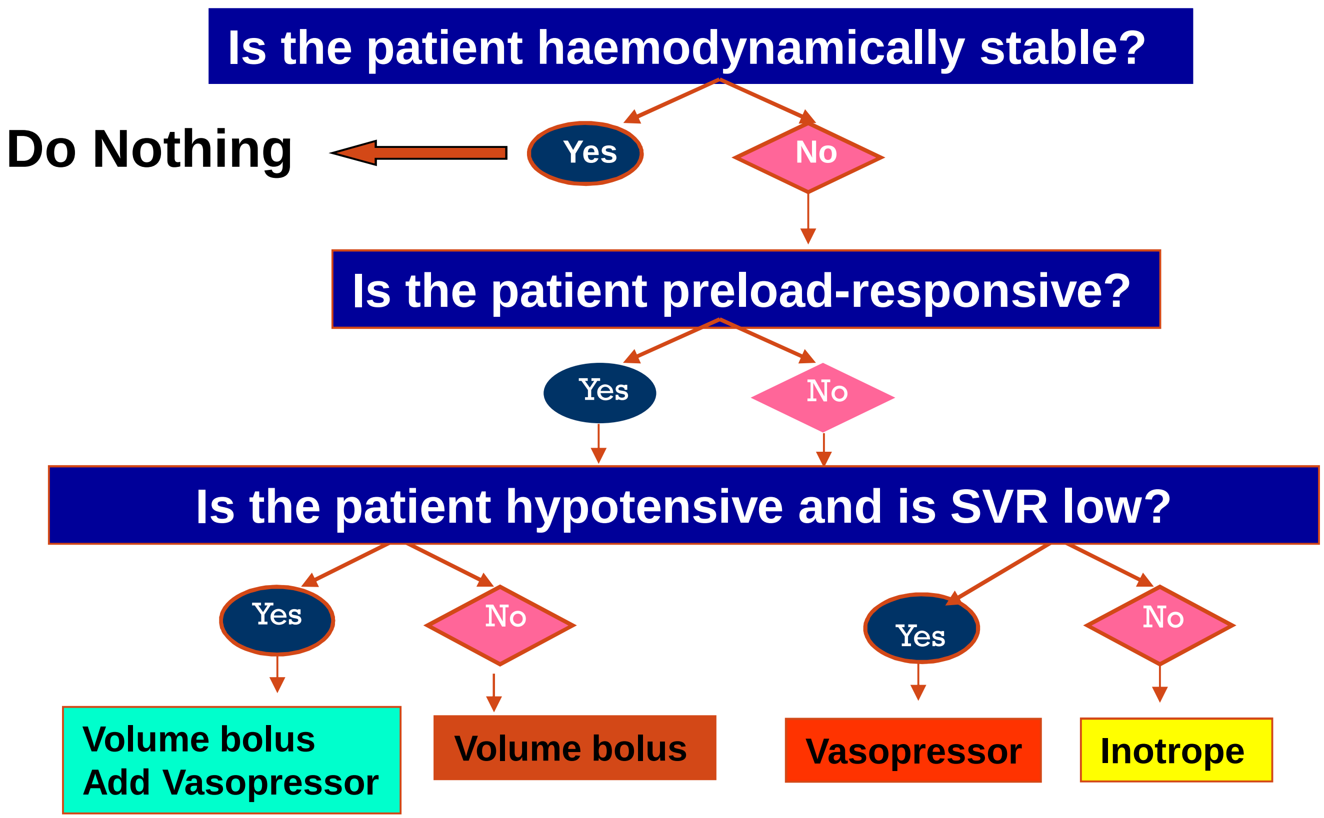
HAEMODYNAMIC STABILITY PROTOCOL

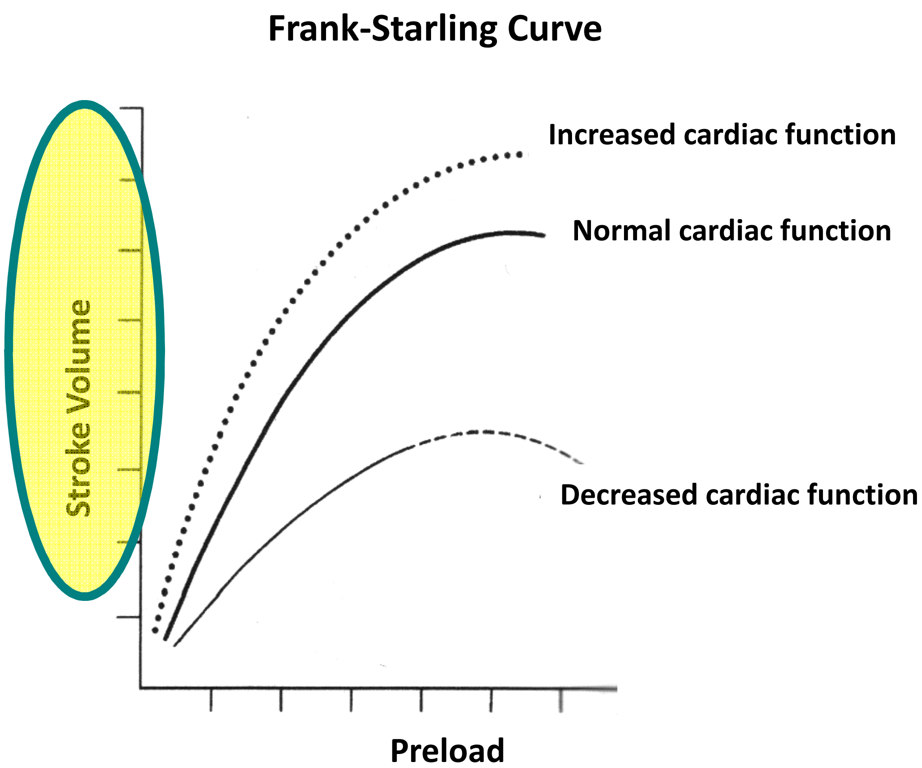


HOW TO MEASURE FLOW

- ✓ Stroke Volume
- ✓ Cardiac Index
- ✓ $ScVO_2\%$
- ✓ $SvO_2\%$
- ✓ Lactate
- ✓ Base deficit
- ✓ TOE

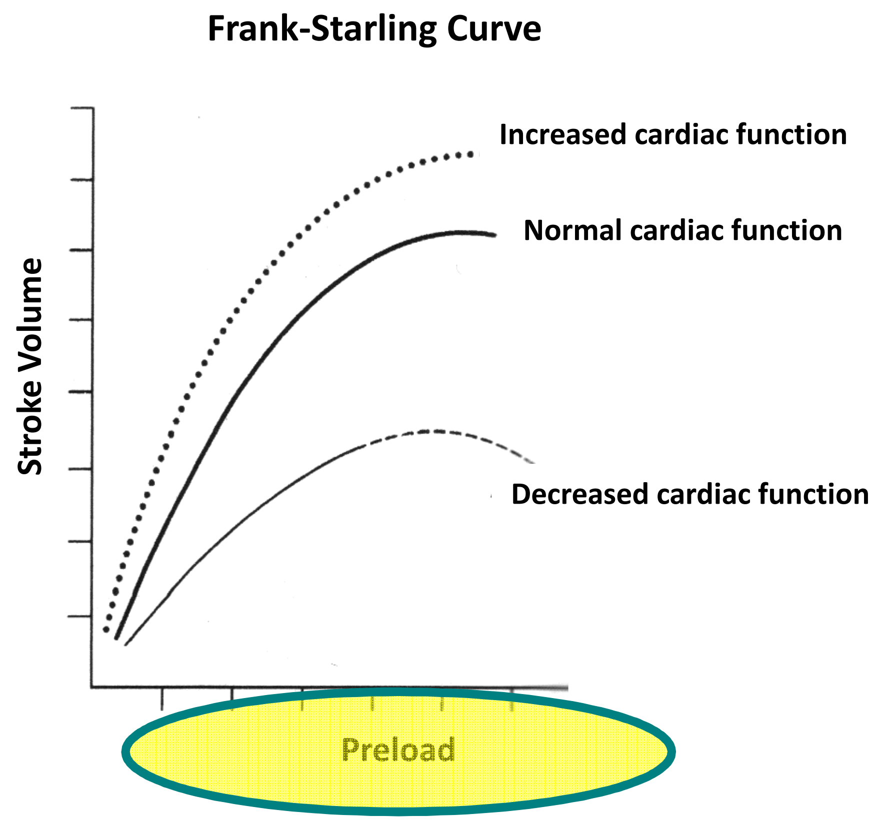
IS THE

PUMP WORKING?



- ✓ SVV
- ✓ SPV
- ✓ PPV
- ✓ TOE

IS THE TANK FULL?

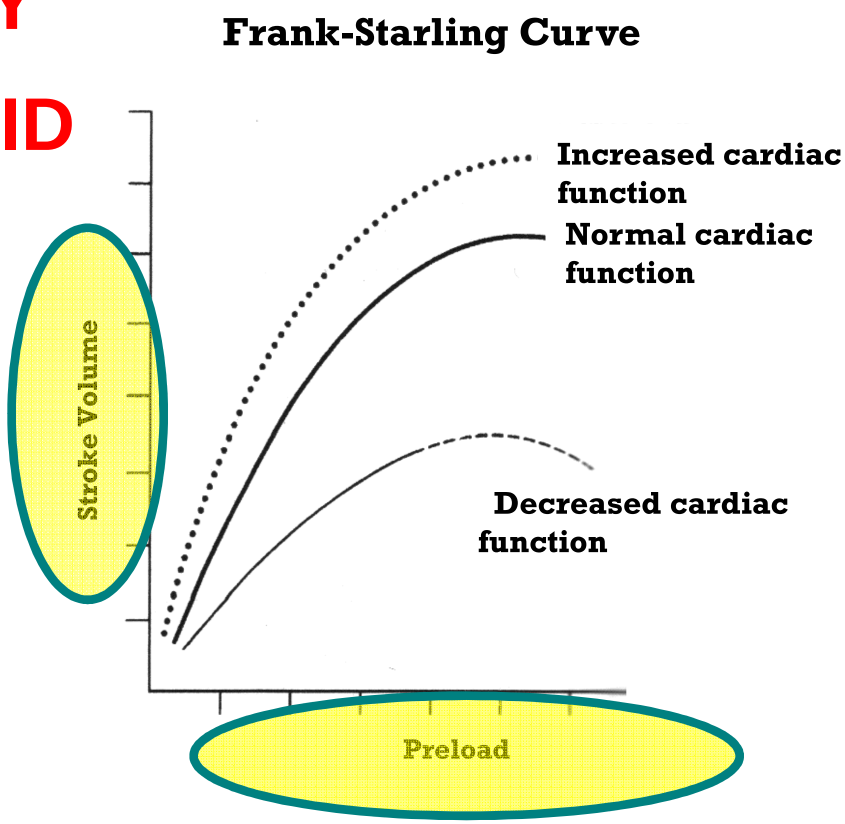


BOTH DIMENSIONS ARE NECESSARY TO OPTIMIZE FLUID STATUS

An indication of volume responsiveness

AND

A method of verifying that fluid is beneficial to the patient's status



Effect of a Perioperative, Cardiac Output–Guided Hemodynamic Therapy Algorithm on Outcomes Following Major Gastrointestinal Surgery
A Randomized Clinical Trial and Systematic Review

Rupert M. Pearse, MD; David A. Harrison, PhD; Neil MacDonald, FRCA; Michael A. Gillies, FRCA; Mark Blunt, FRCA; Gareth Ackland, PhD; Michael P. W. Grocott, MD; Aoife Ahern, BSc; Kathryn Griggs, MSc; Rachael Scott, PhD; Charles Hinds, FRCA; Kathryn Rowan, PhD; for the OPTIMISE Study Group

JAMA. 2014;311(21):2181-2190. doi:10.1001/jama.2014.5305
Published online May 19, 2014.

Figure 2. Cumulative Incidence of Mortality Up to 180 Days After Surgery Using a Cardiac Output–Guided Hemodynamic Therapy Algorithm Intervention vs Usual Care

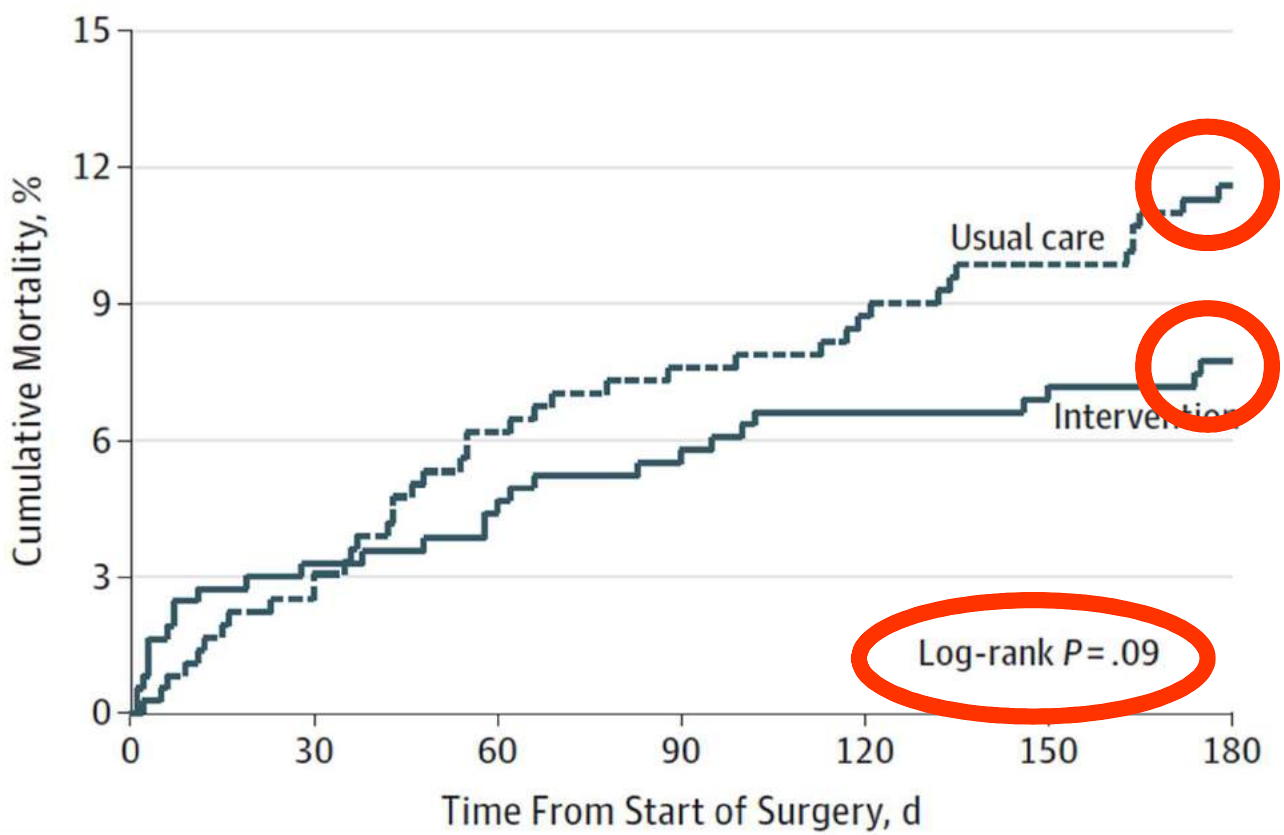


Figure 2. Cumulative Incidence of Mortality Up to 180 Days After Surgery Using a Cardiac Output–Guided Hemodynamic Therapy Algorithm Intervention vs Usual Care

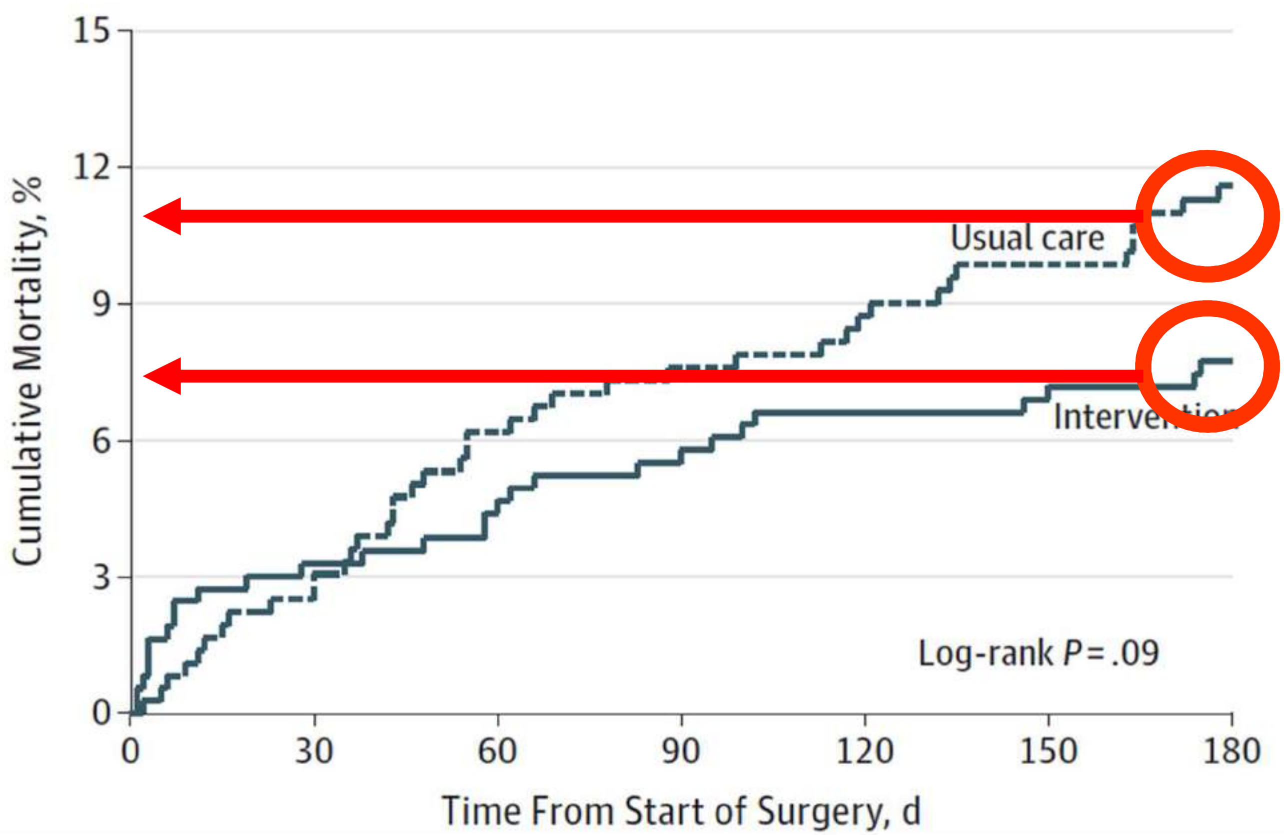


Figure 3. Meta-analysis of Number of Patients Developing Complications After Surgery

Source	Intervention No. of Events	Intervention Total No.	Control No. of Events	Control Total No.	Risk Ratio (95% CI)	Weight, %
Shoemaker et al,[20] 1988	8	28	30	60	0.57 (0.30-1.08)	1.7
Berlauk et al,[21] 1991	11	68	9	21	0.38 (0.18-0.79)	1.3
Mythen et al,[22] 1995	0	30	6	30	0.08 (0.00-1.31)	0.1
Sinclair et al,[23] 1997	1	20	1	20	1.00 (0.07-14.90)	0.1
Ueno et al,[24] 1998	4	16	5	18	0.90 (0.29-2.78)	0.5
Wilson et al,[25] 1999	38	92	28	46	0.68 (0.48-0.95)	[illegible]
Mayer et al,[33] 2010	6	30	15	30	0.40 (0.18-0.89)	1.1
Cecconi et al,[34] 2011	16	20	20	20	0.80 (0.64-1.02)	12.8
Challand et al,[35] 2012	10	89	13	90	0.78 (0.36-1.68)	1.2
Brandstrup et al,[36] 2012[a]	23	71	24	79	1.07 (0.66-1.71)	3.1
Salzwedel et al,[37] 2013[a]	21	79	36	81	0.60 (0.39-0.93)	3.6
Goepfert et al,[38] 2013[a]	34	50	42	50	0.81 (0.65-1.01)	13.7
OPTIMISE, 2014	134	368	158	365	0.84 (0.70-1.01)	21.8
Total	488	1548	614	1476	0.77 (0.71-0.83)	100.0

Heterogeneity: $\chi^2_{21} = 30.44$; $P = .08$; $I^2 = 31\%$

Test for overall effect: $z = 6.22$; $P < .001$

Favors Intervention | Favors Control

Risk Ratio (95% CI)

OPTIMISE, 2014	134	368	158	365	0.84 (0.70-1.01)
Total	488	1548	614	1476	0.77 (0.71-0.83)

Heterogeneity: $\chi^2_{21} = 30.44$; $P = .08$; $I^2 = 31\%$

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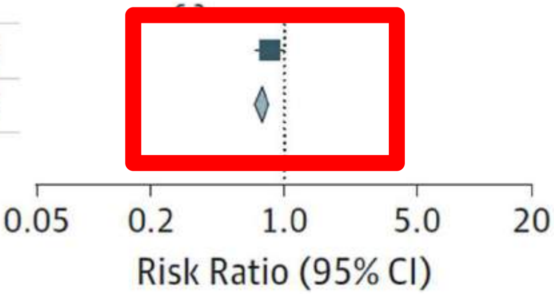
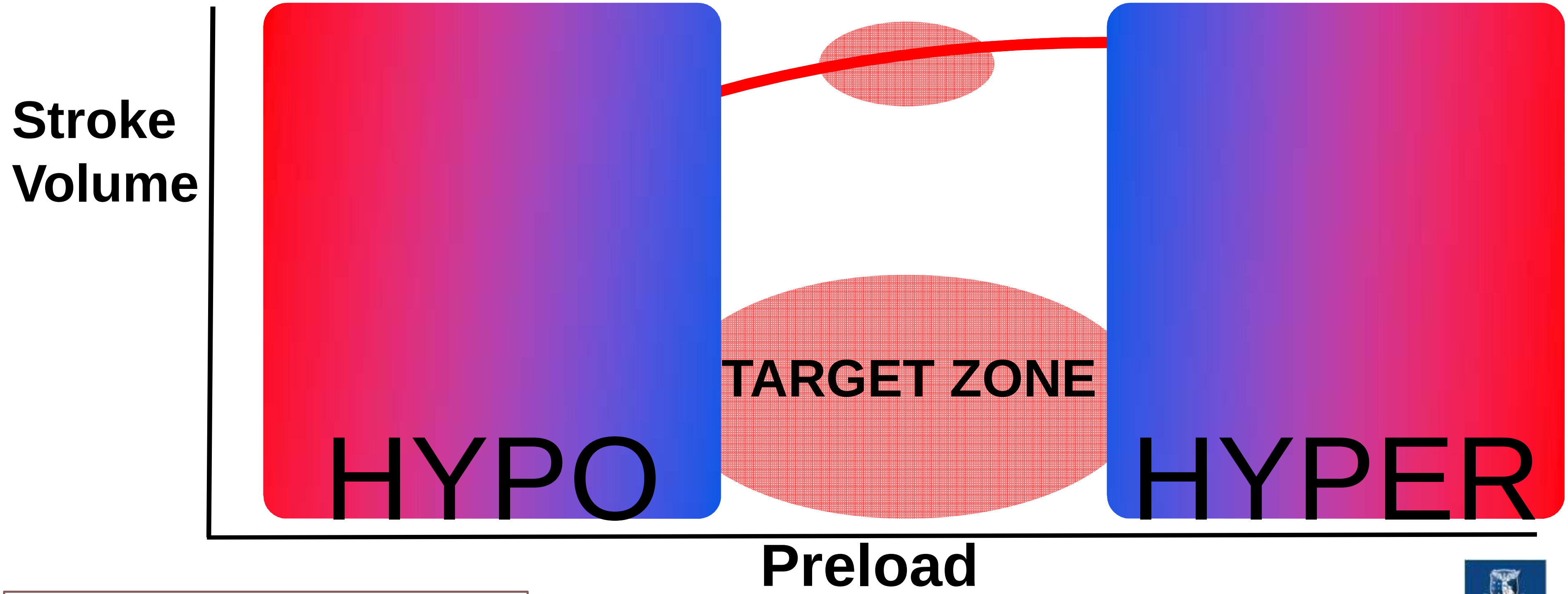


Frank-Starling relationship between preload and stroke volume



Wet, Dry or Something Else? BJA 97 (6): 755-7 (2006)

Which Crystalloid?

Crystalloids & Why?

CRYSTALLOIDS?

- Effective
- Inexpensive
- Long shelf life
- Readily available
- No allergic reactions
- Resuscitation and maintenance
- No religious objections

BALANCED SOLUTIONS?

British Consensus Guidelines on Intravenous Fluid Therapy for Adult Surgical Patients

GIFTASUP

Jeremy Powell-Tuck (chair)[1], Peter Gosling[2], Dileep N Lobo[1,3] Simon P Allison[1], Gordon L Carlson[3,4], Marcus Gore[3], Andrew J Lewington[5], Rupert M Pearse[6], Monty G Mythen[6]

On behalf of [1]BAPEN Medical - a core group of BAPEN, [2]the Association for Clinical Biochemistry, [3]the Association of Surgeons of Great Britain and Ireland, [4]the Society of Academic and Research Surgery, [5]the Renal Association and [6]the Intensive Care Society.

BAPEN Advancing Clinical Nutrition

The Association for Clinical Biochemistry

ASGBI Association of Surgeons of Great Britain and Ireland

SARS

The Renal Association

The Intensive Care Society

<u>Recommendation 1:</u>

"AVOID 0.9% saline"

"hyperchloraemic acidosis"

"Replace with balanced salt solutions"

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SALINE: UN-PHYSIOLOGICAL?

	Plasma	**Plasma-Lyte**	**Hartmann's**	**Sterofundin**	**Saline (0.9%)**
Na^{2+}	**136 – 145**	140	129	**145**	**154**
K^{+}	3.5 – 5.0	5.0	5.0	**4**	
Mg^{2+}	0.8 – 1.0	1.5		**1**	
Ca^{2+}	2.2 – 2.6		2.5	**2.5**	
Chl^{-}	**98 – 106**	98	109	**127**	**154**
Acetate		27			
Gluconate		23			
Malate				5	
Lactate			29		
osmolarity (mOsmol/l)	290 – 310	295	274	309	308

SALINE VS. BALANCED

	Plasma	Plasma-Lyte	Hartmann's	Sterofundin	Saline (0.9%)
Na2+	136 – 145	**140**	**129**	**145**	154
K+	3.5 – 5.0	**5.0**	**5.0**	**4**	
Mg2+	0.8 – 1.0	**1.5**		**1**	
Ca2+	2.2 – 2.6		**2.5**	**2.5**	
Chl-	98 – 106	**98**	**109**	**127**	154
Acetate		27			
Gluconate		23			
Malate				5	
Lactate			29		
osmolarity (mOsmol/l)	290 – 310	295	274	309	308

BALANCED VS. PHYSIOLOGICAL

	Plasma	Plasma-Lyte	Hartmann's	Sterofundin	Saline (0.9%)
Na^{2+}	**136 – 145**	140	**129**	145	154
K^{+}	**3.5 – 5.0**	5.0	5.0	4	
Mg^{2+}	**0.8 – 1.0**	1.5		1	
Ca^{2+}	**2.2 – 2.6**		2.5	2.5	
Chl^{-}	**98 – 106**	98	**109**	127	154
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Ca^{2+}	2.2 – 2.6		2.5	2.5	
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Mg^{2+}	0.8 – 1.0	1.5		1	
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Chl^{-}	98 – 106	98	109	127	154
Acetate		27			
Gluconate		23			
Malate				5	
Lactate			29		
eSID	**42**	**49**	**27**	**25.5**	**0**

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

Perel P, Roberts I, Ker K

THE COCHRANE COLLABORATION®

Citation: Perel P, Roberts I, Ker K. Colloids versus crystalloids for fluid resuscitation in critically ill patients. *Cochrane Database of Systematic Reviews* 2013, Issue 2. Art. No.: CD000567. DOI: 10.1002/14651858.CD000567.pub6.

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Authors' conclusions

There is no evidence from randomised controlled trials that resuscitation with colloids reduces the risk of death, compared to resuscitation with crystalloids, in patients with trauma, burns or following surgery. Furthermore, the use of hydroxyethyl starch might increase mortality. As colloids are not associated with an improvement in survival and are considerably more expensive than crystalloids, it is hard to see how their continued use in clinical practice can be justified.

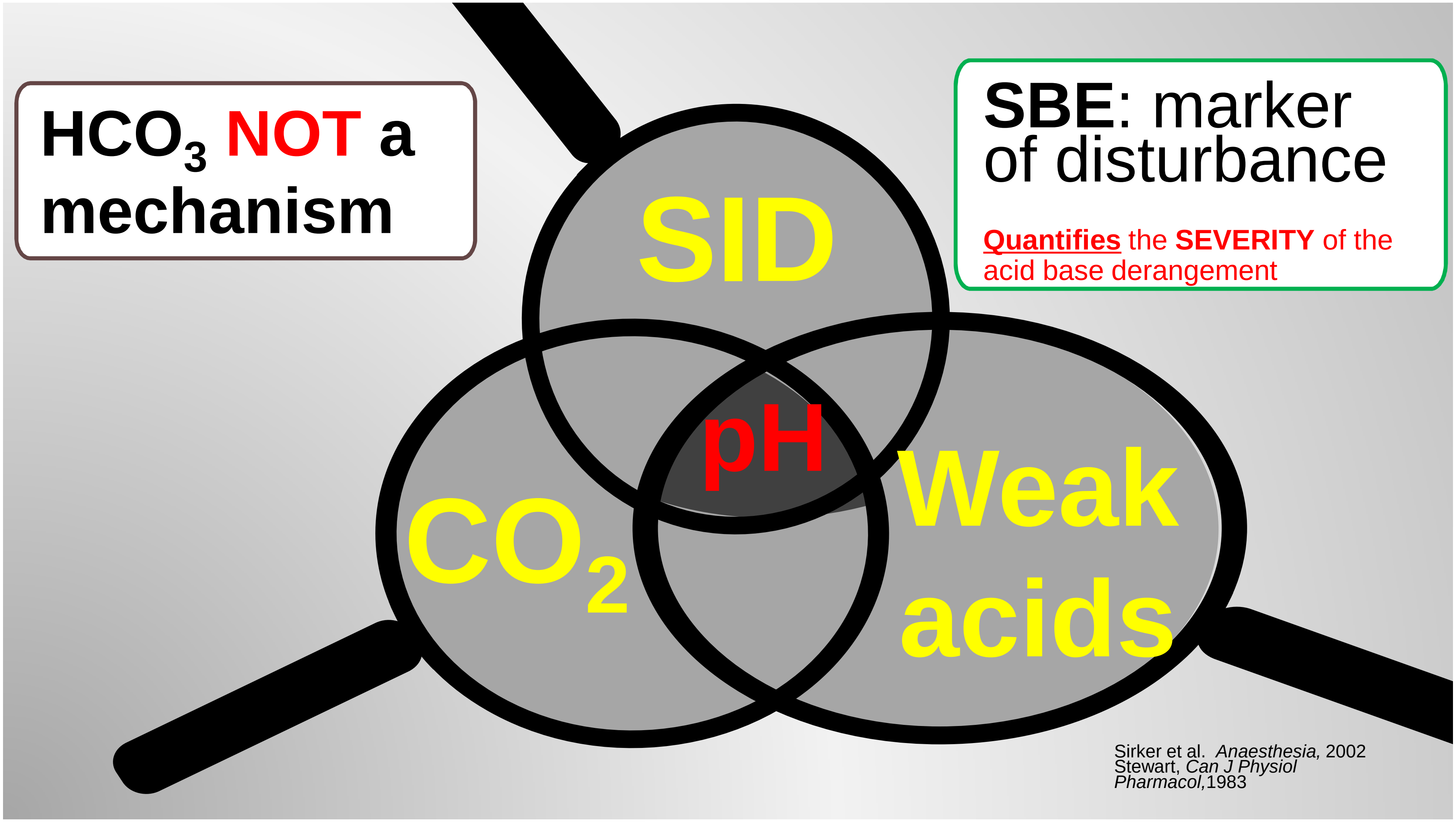
- **No evidence colloids better**
- **HES might increase mortality**
- **Expensive**
- **Hard to see how their continued use in clinical practice can be justified**

BALANCED COLLOID

20% Albumin+ Crystalloid carrier
Na^{+}: 122-130
Chl^{-}: 78
SID: 44

BALANCED COLLOID

	Voluven	VoluLyte	Albumex 4%	Gelofusine	**Balanced Colloid**
[Na^+]	154	137	140	154	**122-130**
[Cl^-]	154	110	128	120	**78**
SID	0	31	12	34	**44**


HCO3 NOT a mechanism
SBE: marker of disturbance
Quantifies the SEVERITY of the acid base derangement
SID
pH
CO2
Weak acids
Sirker et al. Anaesthesia, 2002
Stewart, Can J Physiol Pharmacol,1983

SID = CATIONS - ANIONS

Na^+
K^+
Mg^{2+}
Ca^{2+}

Chl^-
Lactate
Anion

METABOLIC ACIDOSIS

SID = CATIONS - ANIONS

Na^+
K^+
Mg^{2+}
Ca^{2+}

Chl^-
Lactate
Anion

METABOLIC ALKALOSIS

CRYSTALLOIDS

SID ONLY

No A_{TOT}

DILUTES

Plasma A_{TOT}

FORCES ECF SID TOWARD THE SID OF THE CRYSTALLOID

SALINE 0.9%

SALINE

154 mmol Na+
154 mmol Cl-
SID = 0

DILUTES
Plasma A_{TOT}

FORCES ECF SID TOWARD THE SID OF THE CRYSTALLOID

Metabolic Acidosis

HARTMANN'S & STEROFUNDIN

HARTMANN'S
SID = 27

STEROFUNDUN
SID = 25.5

→

DILUTES
Plasma A_{TOT}

FORCES ECF SID TOWARD THE SID OF THE CRYSTALLOID

→

Balanced

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PLASMA-LYTE

PLASMA-LYTE
SID = 49

→

DILUTES Plasma A_{TOT}

FORCES ECF SID TOWARD THE SID OF THE CRYSTALLOID

→

Physiological

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NA HCO_3 (8.4%)

Sodium Bicarb (8.4%)
(100mL)

100mmol Na^+
100mmol/L HCO_3

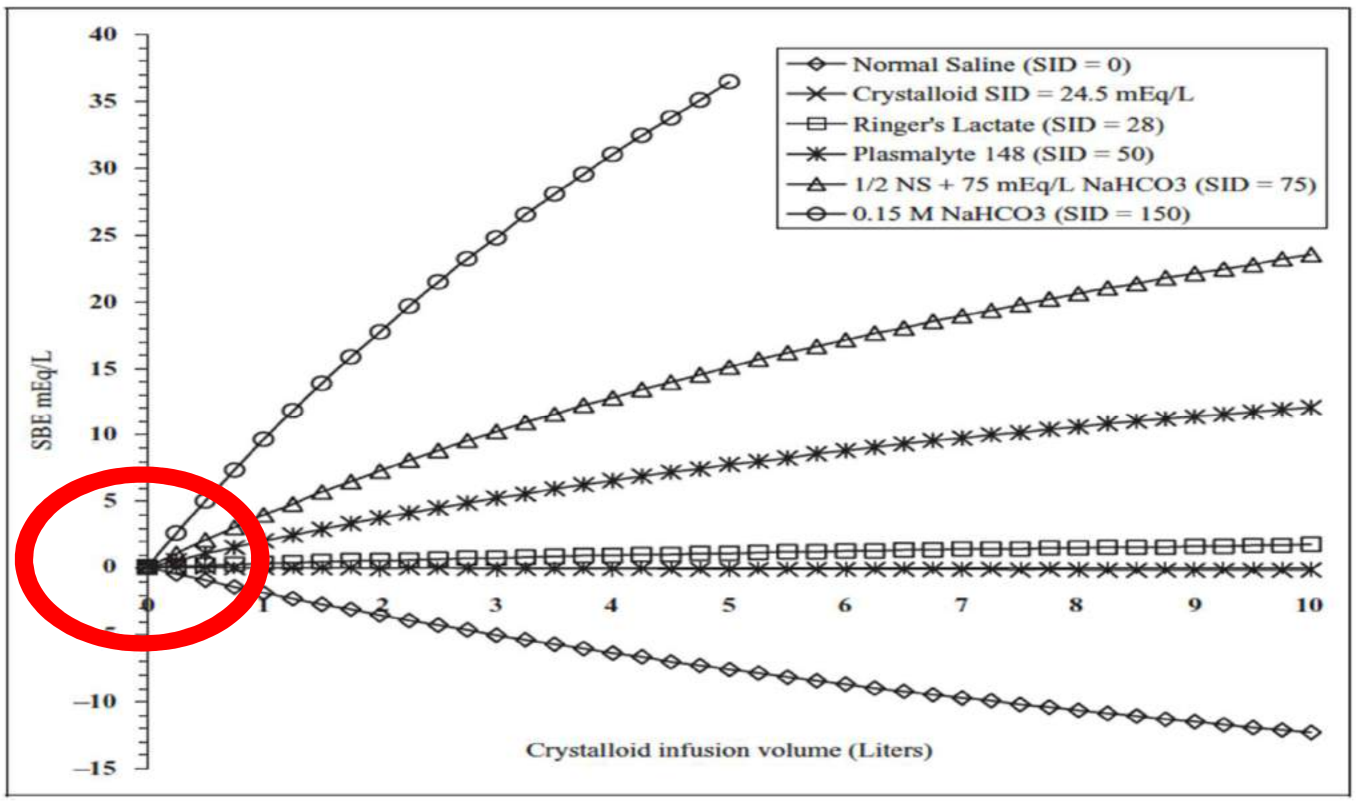
SID = 100mEq/L

DILUTES
Plasma A_{TOT}

FORCES ECF SID TOWARD THE SID OF THE CRYSTALLOID

Alkalanising

MODEL OF CRYSTALLOID INFUSION



Standard base excess (SBE) as a function of crystalloid infusion volume in liters.

Omron EM et al. ***J Intensive Care Med 2010 25: 271***

BALANCED VS. PHYSIOLOGICAL

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osmolarity (mOsmol/l)	290 – 310	295	274	309	308

IS CHLORIDE EVIL???

ANIMAL STUDIES

Chloride Regulates Afferent Arteriolar Contraction in Response to Depolarization
Pernille Bjørg Hansen, Boye L. Jensen and Ole Skøtt
Hypertension 1998;32;1066-1070

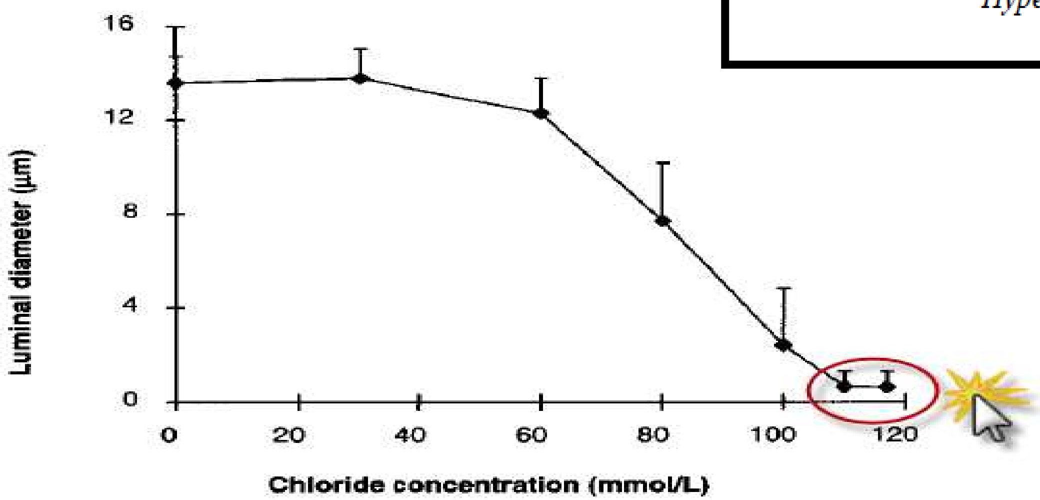

Figure 1. Influence of chloride concentration in the bath on K^+ action in afferent arterioles.

Hansen et al Hypertension 1998;32;1066-1070

HEALTHY VOLUNTEER STUDIES

A Randomized, Controlled, Double-Blind Crossover Study on the Effects of 2-L Infusions of 0.9% Saline and Plasma-Lyte 148 on Renal Blood Flow Velocity and Renal Cortical Tissue Perfusion in Healthy Volunteers

Abeed H. Chowdhury, BSc, MRCS, Eleanor F. Cox, PhD,† Susan T. Francis, PhD.†*
*and Dileep N. Lobo, DM, FRCS, FACS**

(*Ann Surg* 2012;00:1–7)

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RETROSPECTIVE STUDIES

Major Complications, Mortality, and Resource Utilization After Open Abdominal Surgery

0.9% Saline Compared to Plasma-Lyte

(*Ann Surg* 2012;255:821–829)

Anesth Analg 2013;117

PRELIMINARY COMMUNICATION

JAMA, October 17, 2012—Vol 308, No. 15 **1569**

Association Between a Chloride-Liberal vs Chloride-Restrictive Intravenous Fluid Administration Strategy and Kidney Injury in Critically Ill Adults

CME **Hyperchloremia After Noncardiac Surgery Is Independently Associated with Increased Morbidity and Mortality: A Propensity-Matched Cohort Study**

Stuart A. McCluskey, PhD, MD,* Keyvan Karkouti, MSc, MD,*† Duminda Wijeysundera, PhD, MD,* Leonid Minkovich, PhD, MD,* Gordon Tait, PhD,* and W. Scott Beattie, PhD, MD*

Systematic review

BJS 2015; **102**: 24–36

Meta-analysis of high- *versus* low-chloride content in perioperative and critical care fluid resuscitation

M. L. Krajewski[1], K. Raghunathan[1,2], S. M. Paluszkiewicz[3], C. R. Schermer[4] and A. D. Shaw[5]

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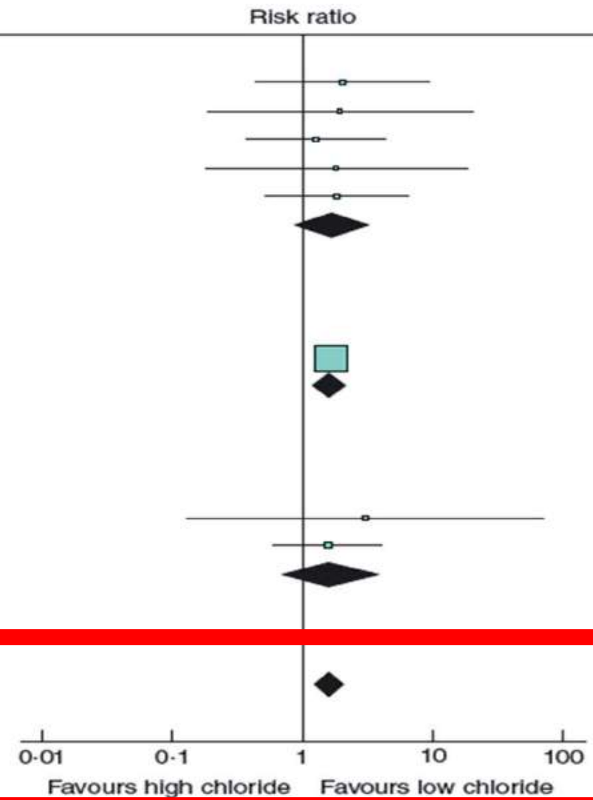
SYSTEMATIC REVIEWS EVIDENCE

Reference	AKI/renal failure: High-chloride	AKI/renal failure: Low-chloride	Weight (%)	Risk ratio
RCTs				
Hadimioglu *et al.*[12]	3 of 30	3 of 60	2·4	2·00 (0·43, 9·32)
O'Malley *et al.*[50]	2 of 26	1 of 25	1·2	1·92 (0·19, 19·90)
Waters *et al.*[14]	5 of 33	4 of 33	4·8	1·25 (0·37, 4·25)
Wu *et al.*[53]	2 of 21	1 of 19	1·3	1·81 (0·18, 18·39)
Young *et al.*[54]	6 of 24	3 of 22	3·7	1·83 (0·52, 6·46)
Subtotal	18 of 134	12 of 159	13·4	1·66 (0·83, 3·31)
Heterogeneity: $\chi^2 = 0·31$, 4 d.f., $P = 0·99$; $I^2 = 0\%$				
Test for overall effect: $Z = 1·44$, $P = 0·15$				
CCTs				
Yunos *et al.*[26,55]	105 of 760	65 of 773	77·0	1·64 (1·23, 2·20)
Subtotal	105 of 760	65 of 773	77·0	1·64 (1·23, 2·20)
Heterogeneity: not applicable				
Test for overall effect: $Z = 3·33$, $P < 0·001$				
Observational/retrospective studies				
Berger *et al.*[41]	1 of 20	0 of 20	0·6	3·00 (0·13, 69·52)
Shaw *et al.*[27]	23 of 2778	5 of 926	9·0	1·53 (0·58, 4·02)
Subtotal	24 of 2798	5 of 946	9·6	1·63 (0·65, 4·07)
Heterogeneity: $\chi^2 = 0·16$, 1 d.f., $P = 0·69$; $I^2 = 0\%$				
Test for overall effect: $Z = 1·04$, $P = 0·30$				
Total	147 of 3692	82 of 1878	100·0	1·64 (1·27, 2·13)
Heterogeneity: $\chi^2 = 0·47$, 7 d.f., $P = 1·00$; $I^2 = 0\%$				
Test for overall effect: $Z = 3·76$, $P < 0·001$				
Test for subgroup differences: $\chi^2 = 0·00$, 2 d.f., $P = 1·00$; $I^2 = 0\%$				



SYSTEMATIC REVIEWS EVIDENCE

Reference	AKI/renal failure High-chloride	AKI/renal failure Low-chloride	Weight (%)	Risk ratio
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Test for overall e				
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Subtotal				1·64 (1·23, 2·20)
Heterogeneity: n				
Test for overall e				
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Risk ratio

0·01 0·1 1 10 100
Favours high chloride Favours low chloride

Clear signals of AKI harm

PROSPECTIVE STUDIES

Volume 32 | e-Supplement 53 | June 2015
www.ejanaesthesiology.com

ESA 10 YEARS

EJA
European Journal of Anaesthesiology

FLUid intervention and renal outcome trial in patients undergoing major surgery: an observational single-centre study (the FLURO trial)

Weinberg L.[1], Armellini A.[1], Hewitt T.[1], Tan C.[1], Mcnicol L.[1], Bellomo R.[2]
[1]Austin Hospital, Dept of Anaesthesiology, Heidelberg, Australia, [2]Austin Hospital, Dept of Intensive Care, Heidelberg, Australia

Austin Health

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FACTORS ASSOCIATED WITH AKI

	AKI (n = 53) 9.8%	No AKI (n = 489) 90.2%	*Univariate*		*Multivariate*	
			Odds ratio (Confidence interval)	p value	Odds ratio (Confidence interval)	p value
Demographics						
Age ≥ 60	36 (68%)	273 (56%)	1.7 (0.9-3.1)	0.09	1.0 (0.4-2.4)	0.95
ASA ≥ III	39 (74%)	294 (60%)	1.7 (0.9-3.2)	0.11	1.5 (0.5-4.2)	0.46
Creatinine ≥ 110	**14 (26%)**	48 (10%)	**3.2 (1.6-6.3)**	**0.001***	1.7 (0.5-5.1)	0.36
Operative details						
[redacted]	[redacted]	[redacted]40 (49%)	**1.8 (1.0-3.3)**	[redacted]	[redacted]	[redacted]
Emergency surgery	**17 (32%)**	[redacted]14 (23%)	**1.5 (1.1-2.9)**	**0.01**	**3.3 (1.2-8.7)**	**0.017**
Intraop balance ≥ 2000 mL	**26 (49%)**	[redacted]98 (61%)	**1.6 (1.1-2.4)**	**0.01**	**3.8 (1.2-12)**	**0.02**
[redacted]						
Day 1 Cl^- liberal ≥ 1500 mL	**17 (32%)**	99 (20%)	**1.9 (1.0-3.4)**	**0.049***	1.6 (0.5-4.4)	0.39

Quantitative toxicity…. not **qualitative!**

Austin Health

Saline (0.9%) vs. Plasma-Lyte® 148 Fluid Intervention Trial in Major Surgery Patients (The SPLIT- Major Surgery study)

A single-centred randomised double-blind pilot trial investigating the safety and efficacy of using 0.9% saline or Plasmalyte® 148 as fluid therapy in adult patients undergoing major surgery

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PRIMARY OUTCOME

RIFLE Criteria	Plasmalyte n = 476	Saline n = 634	p-value	Grand Total n = 1110
Risk	37 (7.8%)	45 (7.0%)	0.7	82 (7.3%)
Injury	12 (2.5%)	12 (1.9%)	0.53	24 (2.2%)
Failure	3 (0.6%)	1 (0.2%)	0.3	4 (0.4%)
Loss	0 (0%)	0 (0%)	-	0 (%)
Total patients with AKI	52 (10.9%)	59 (9.3%)	0.41	111 (10%)

AKI: 6.0 days vs. 4.9 days

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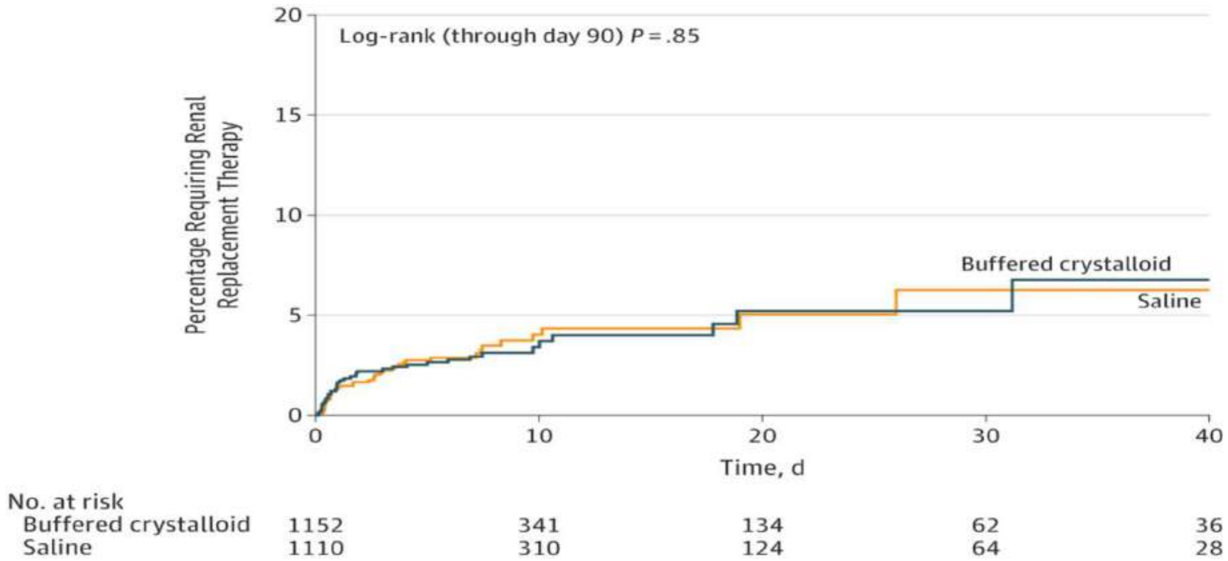
The JAMA Network

From: **Effect of a Buffered Crystalloid Solution vs Saline on Acute Kidney Injury Among Patients in the Intensive Care Unit: The SPLIT Randomized Clinical Trial**
JAMA. 2015;314(16):1701-1710. doi:10.1001/jama.2015.12334



Cumulative Incidence of Patients Requiring **Renal Replacement Therapy** Until Day 90 After Enrollment in the SPLIT TrialCensoring applied at hospital discharge or death. The x-axis is truncated at 40 days because the number of participants still in follow-up beyond 40 days is small.

BALANCED VS. PHYSIOLOGICAL

	Plasma	Plasma-Lyte	Hartmann's	Stereofundin	Saline (0.9%)
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K^{+}	3.5 – 5.0	5.0	5.0	4	
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Acetate		**27**			
Gluconate		**23**			
Malate				**5**	
Lactate			**29**		
osmolarity (mOsmol/l)	290 – 310	295	274	309	308

METABOLIZABLE ANIONS

- **Hyperchloraemic acidosis preventable** if:
- **Substitution Chloride for HCO_3**
- **Following anions used as metabolizable bases**

- Lactate -> **24 mmol/L bicarbonate**
- Gluconate -> **24 mmol/L bicarbonate**
- Acetate -> **24 mmol/L bicarbonate**
- Malate -> **48 mmol/L bicarbonate**
- Citrate -> **72 mmol/L bicarbonate**

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METABOLIZABLE ANIONS

Following anions used as metabolizable bases:

- Lactate -> **24 mmol/L bicarbonate**
- Gluconate -> **24 mmol/L bicarbonate**
- Acetate -> **24 mmol/L bicarbonate**
- Malate -> **48 mmol/L bicarbonate**
- **Citrate** -> **72 mmol/L bicarbonate** --> **Iatrogenic infusion induced alkalosis**

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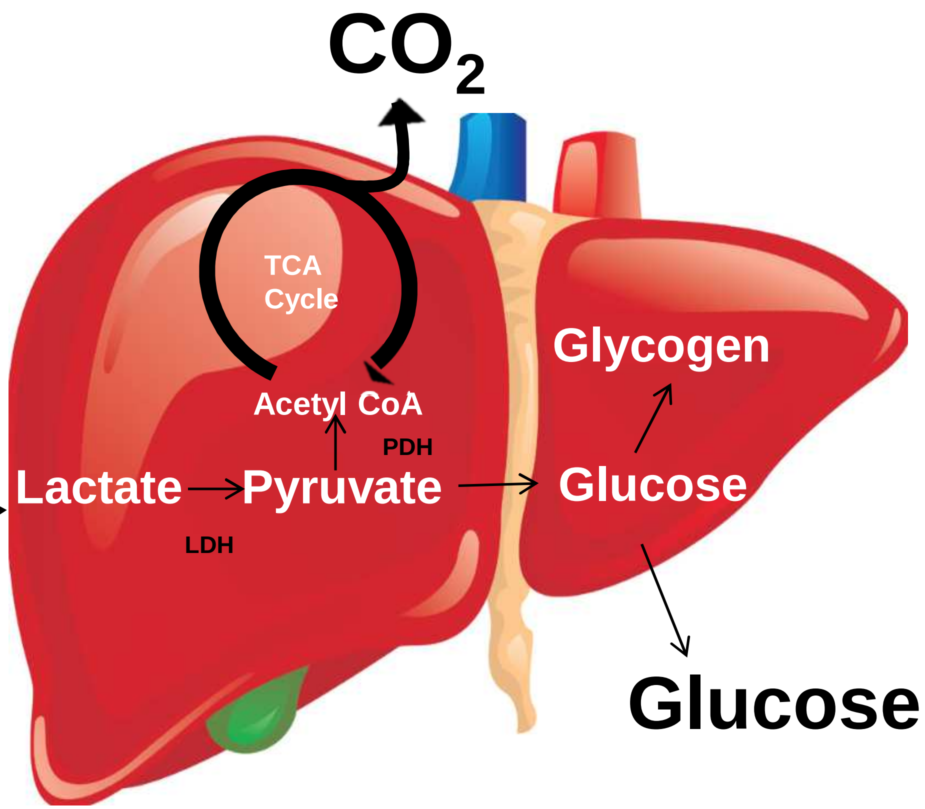
Lactate in hartmann's

Exogenous acids

- **Lactate**



Lactate: metabolised by liver (100mmol/hr = 4 L/hr)

HARTMANN'S: USES

✓**Useful**: ECF & intravasc vol replacement

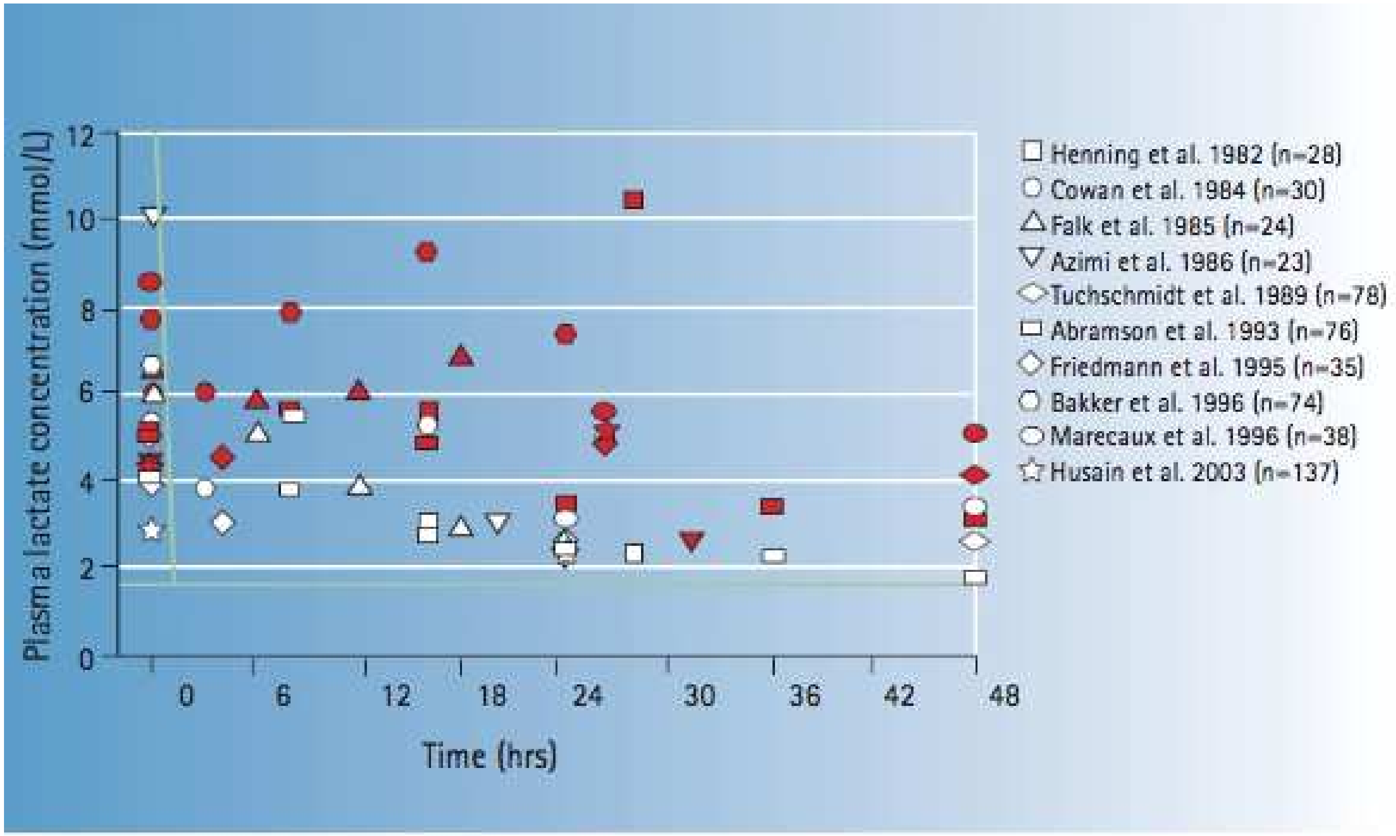
✓**Acidaemia** = inadequate hepatic metabolism

-> production of HCO_3: is impaired

-> lactate cannot act as a HCO_3 source

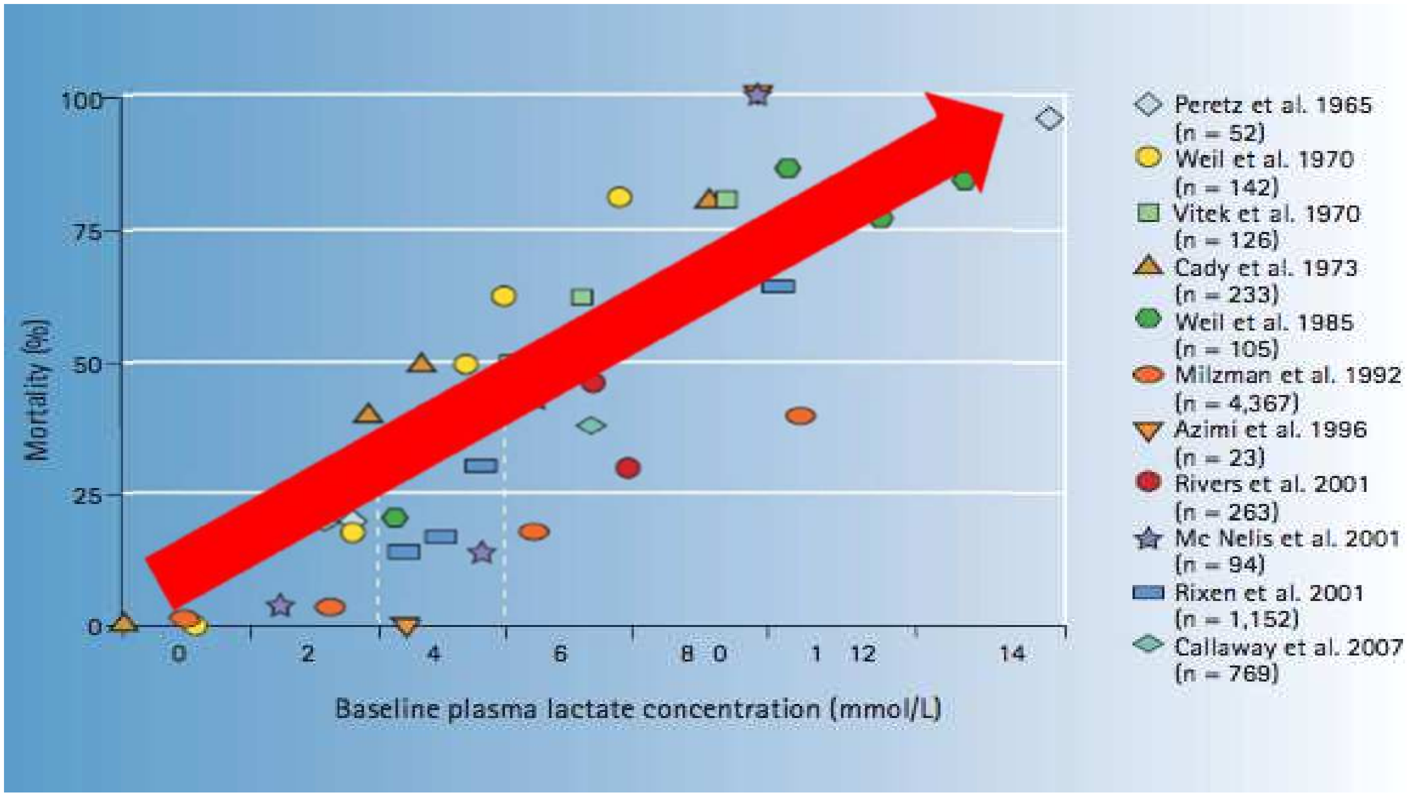
- **Serum lactate increases**
- **Serial index of severity of the acidosis compromised**

LACTATE CLEARANCE IN SHOCK



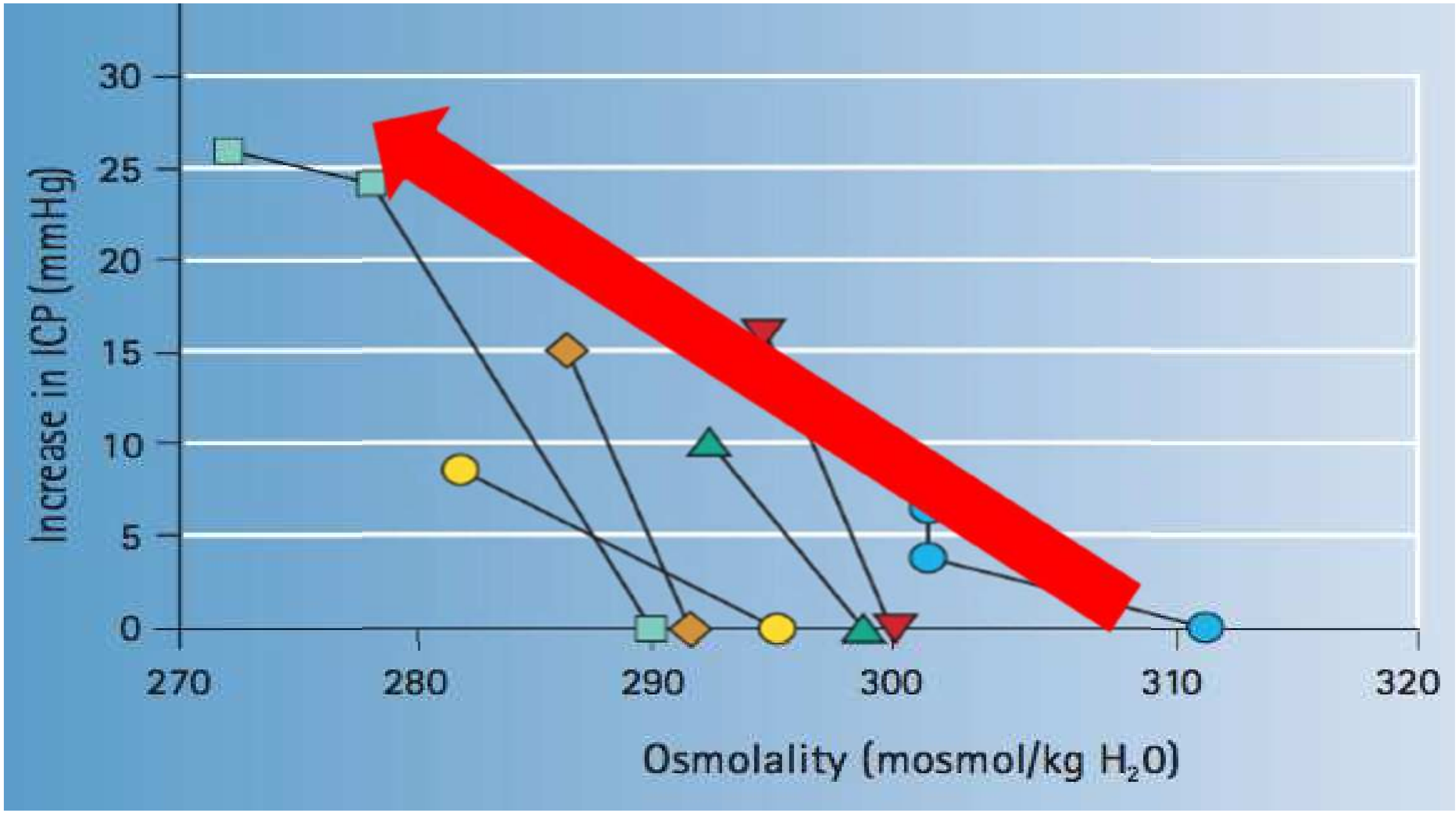
R. Zander: Fluid Management, 2nd Ed.

LACTATE & MORTALITY



R. Zander: Fluid Management, 2nd Ed.

HYPO-OSMOLALITY & ICP



R. Zander: Fluid Management, 2nd Ed.

Hartmann's…

- **Lactate:** as a marker of resuscitation
- **Liver disease/transplantation**
- **Diabetics**
- **Hypotonic:** cerebral oedema
- **Calcium:** in US, AUS/NZ: blood clotting

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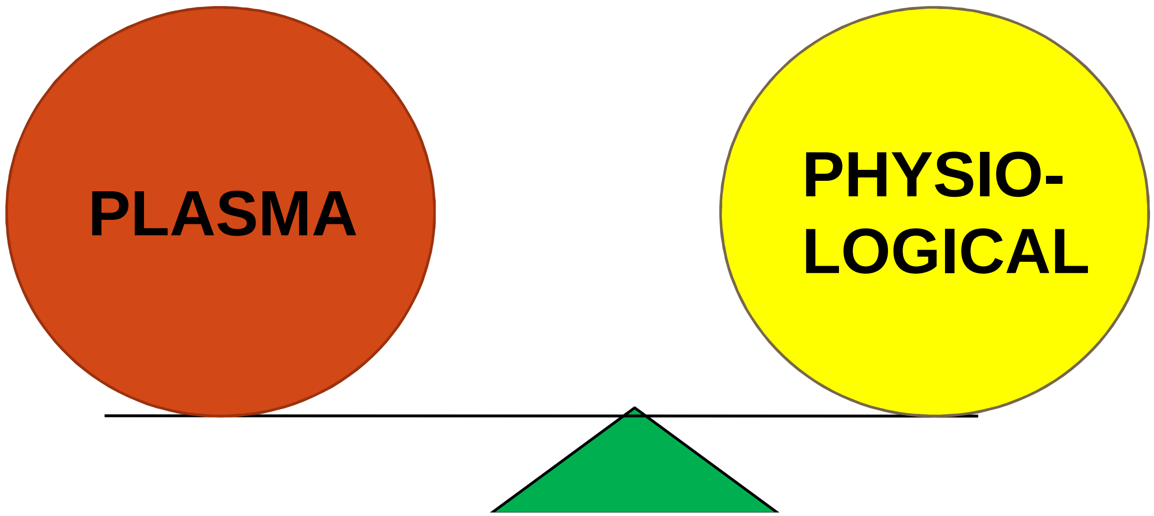
SEARCH FOR THE PERFECT SOLUTION

- Isotonic
- Favourable acid-base physio-chemistry
- No Lactate
- No Calcium



ACETATE

- **No hyperglycaemia**
- **Converted:** HCO_3 in liver **and** extra-hepatic tissue
- **More rapidly:** converted than lactate
- **More alkalinizing:** than lactate
- **Metabolism:** not age related
- **Metabolism:** preserved in shock

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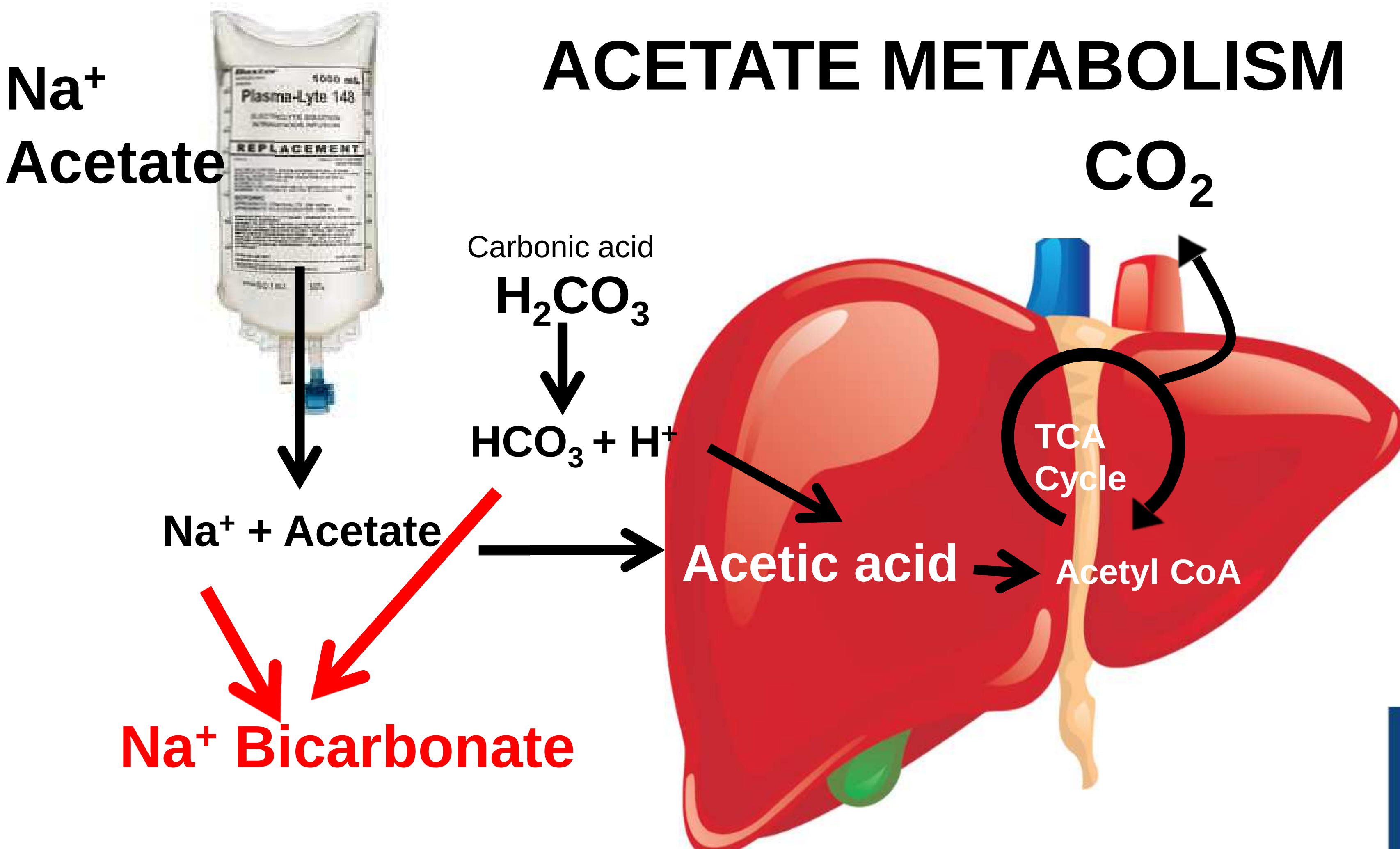
ACETATE METABOLISM



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ACETATE HARM

- CVS effects observed: **high dose & high rates**
- **85 mmol acetate over 20 min**
- **160 mmol acetate over 60 min**

- Observed: plasma acetate concentration of 6 mmol/L:

Plasma acetate, gluconate and interleukin-6 profiles during and after cardiopulmonary bypass: a comparison of Plasma-Lyte 148 with a bicarbonate-balanced solution

Critical Care 2011, **15**:R21 doi:10.1186/cc9966

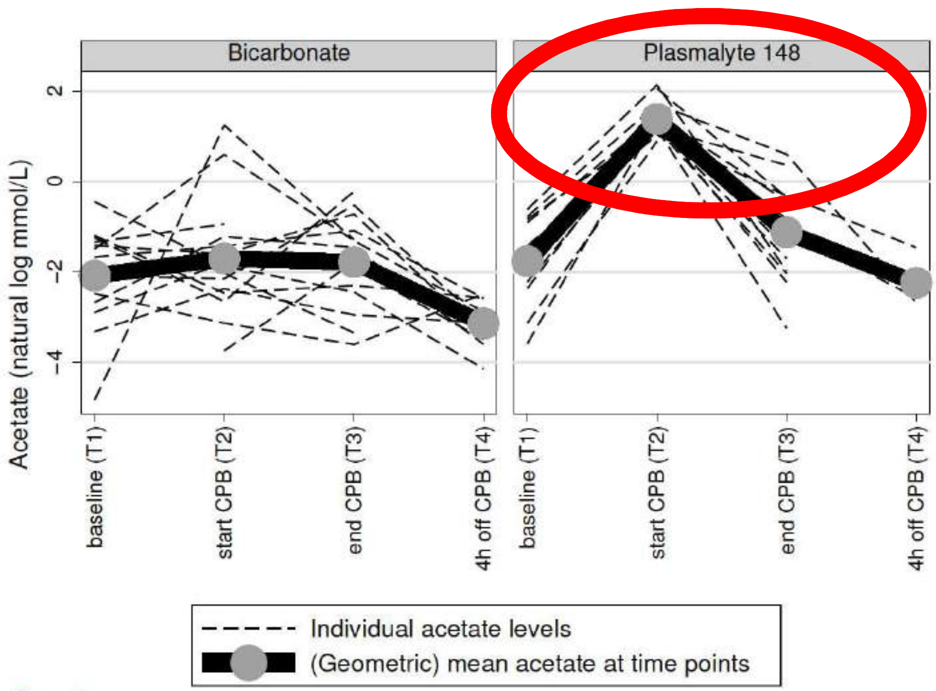

Figure 1

"Supra-physiological" levels

? Clinical significance

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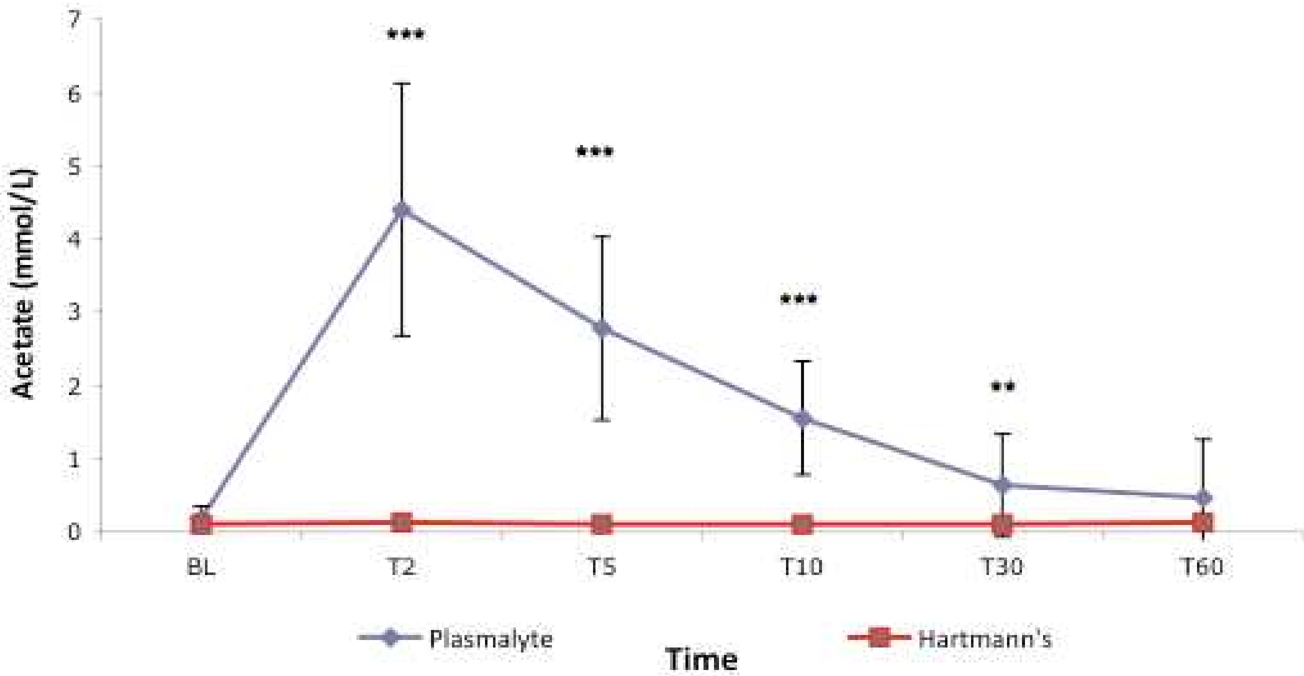
The acid-base impact of Hartmann's solution vs. Plasma-Lyte 148 for cardiopulmonary bypass pump prime: a double-blind randomised controlled trial

Weinberg L, Lisakser F, Bellomo R et al.



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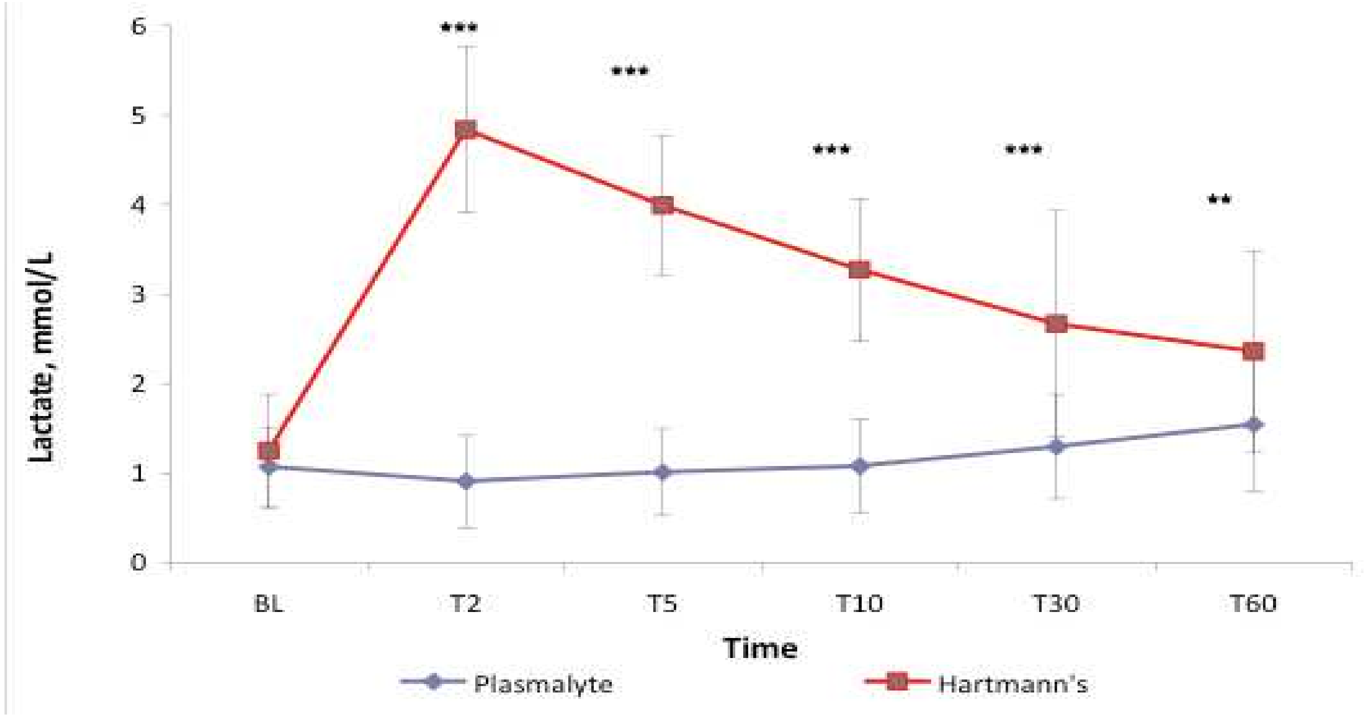
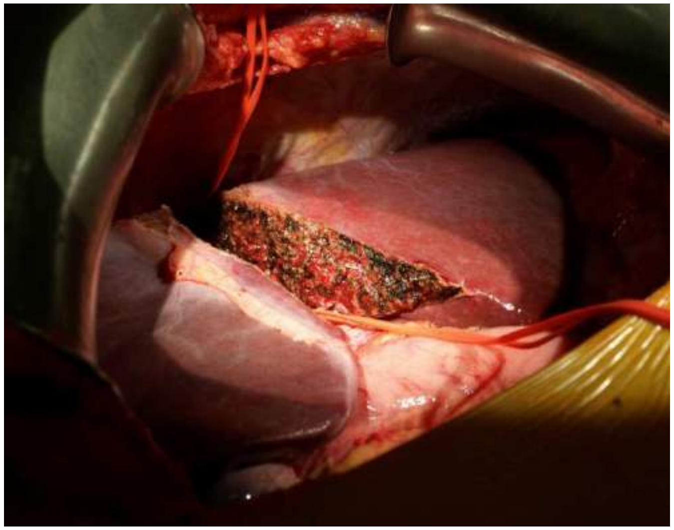
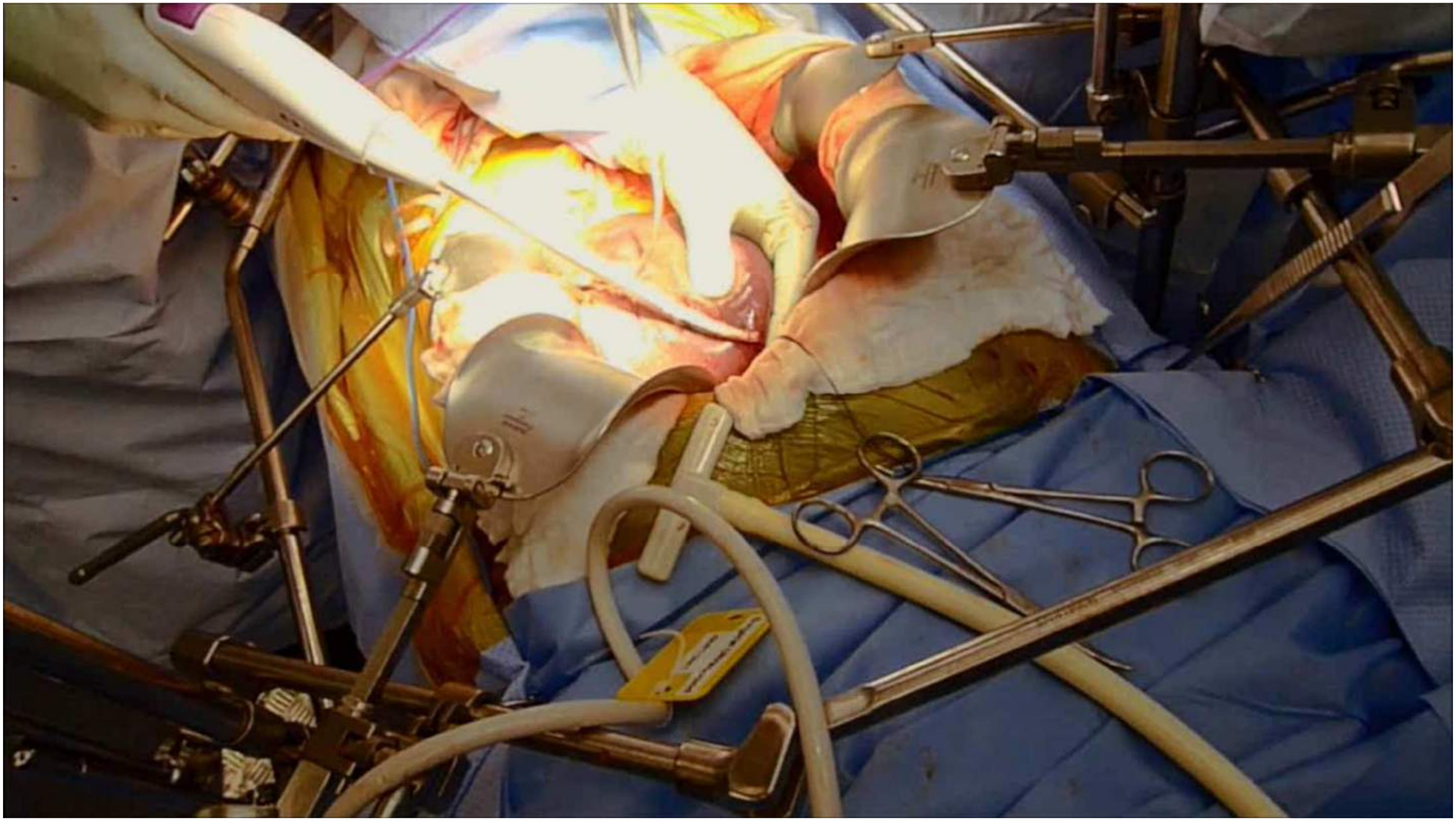


The effects of plasmalyte-148 *vs.* Hartmann's solution during major liver resection: a multicentre, double-blind, randomized controlled trial

L. WEINBERG [1, 2, 3], B. PEARCE [1], R. SULLIVAN [4], L. SIU [5], N. SCURRAH [1]
C. TAN [1], M. BACKSTROM [5], M. NIKFARJAM [2], L. McNICOL [1]
D. STORY [2], C. CHRISTOPHI [2], R. BELLOMO [6]

(Minerva Anestesiol 2015;81:1288-97)





FLUID INTERVENTION: AUSTIN

Normal acid base status:	**Hartmann's**
Pre-existing metabolic acidosis & Complex liver/cardiac:	**Plasma-Lyte**
Pre-existing metabolic alkalosis	**Normal saline**
Raised ICP:	**Plasma-Lyte or NS**
Renal Tx	**Plasma-Lyte**

The Effects of Normal Saline and an Acetate-Buffered Crystalloid Solution on Hyperkalemia in Deceased Donor Renal Transplantation: a Randomized Blinded Trial

L L Weinberg[3], Harris[1], P Mount[2], F Ierino[2], D Story[1,3], G Eastwood[4], L McNicol[3], R Bellomo[4],
[1]University of Melbourne, [2]Department of Nephrology, [3]Department of Anaesthesia, [4]Department of Intensive Care, Austin Hospital, Australia

	Normal Saline		Plasmalyte-148		
	Count	**Mean ± SD**	**Count**	**Mean ± SD**	**P value**
Intraoperative					
Highest Serum Potassium (mmol/L)		5.4 ± 1.1		4.9 ± 0.8	0.23
Hyperkalaemia ≥5.5 (mmol/L)	7/15		7/19		0.73
Number of patients treated for hyperkalaemia	4		1		0.27
Post Operation (48hrs)					
Highest Serum Potassium (mmol/L)		**6.1±0.8**		**5.4±0.9**	**0.009**
Hyperkalemia ≥5.5 (mmol/L)	**20/25 (80%)**		**12/24 (50%)**		**0.038**
Patients treated for hyperkalaemia	**16**		**5**		**0.003**

The Effect of Different Crystalloid Solutions on Acid-Base Balance and Early Kidney Function After Kidney Transplantation

(Anesth Analg 2008;107:264–9)

A Randomized, Double-Blind Comparison of Lactated Ringer's Solution and 0.9% NaCl During Renal Transplantation

(Anesth Analg 2005;100:1518–24)

An Acetate-Buffered Balanced Crystalloid Versus 0.9% Saline in Patients with End-Stage Renal Disease Undergoing Cadaveric Renal Transplantation: A Prospective Randomized Controlled Trial

Anesth Anal 2015;120:123-9

CONCLUDING THOUGHTS

Colloids

- ✓Expensive
- ✓There may clinical benefit
- ✓There may be harm with starches

Hyperchloraemia

- ✓There is no physiological benefit
- ✓There is no clinical benefit
- ✓There may be harm

Crystalloids

- ✓Unbalanced: no clinical benefit and possibly harm
- ✓Physiological: better than balanced
- ✓Awaiting results of prospective studies

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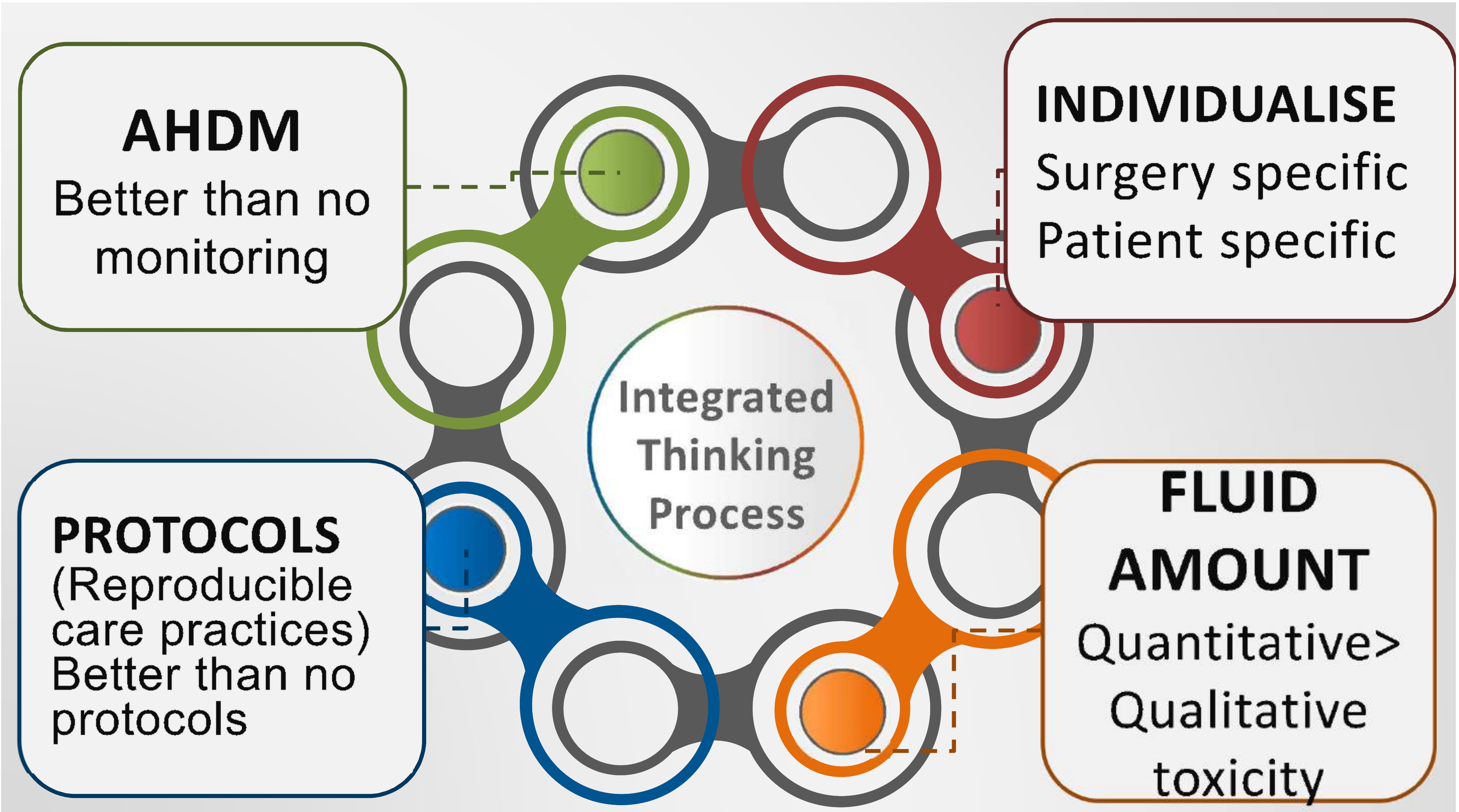
AHDM
Better than no monitoring
INDIVIDUALISE
Surgery specific
Patient specific
Integrated Thinking Process
PROTOCOLS
(Reproducible care practices)
Better than no protocols
FLUID AMOUNT
Quantitative>
Qualitative
toxicity

Thank you

Email: laurence.weinberg@austin.org.au

Austin Health

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Anaesth Intensive Care 2010; 38: 259-265

Original Papers

Perioperative fluid prescription, complications and outcomes in major elective open gastrointestinal surgery

TABLE 3
Summary of patients with complications and associated hospital length of stay

	All surgeries	Colorectal	Non-colorectal	*P*
Patients with at least one complication	57 (57%)	28 (43%)	29 (82%)	0.003
Patients with major complications	32 (32%)	14 (21%)	18 (51.4%)	0.004
Patients with minor complications	52 (52%)	27 (41.5%)	25 (71.4%)	0.009
Number of overall minor complications	104	46	58	0.003
Number of overall major complications	63	23	40	0.012
Major cardiac complications*	10	4	6	0.78
Respiratory complications§	30	11	19	0.000
Tissue healing complications¶	20	8	12	0.012
Total hospital days, mean (SD)	18 (30)	12	30	0.004

TABLE 2

Perioperative fluid therapy

	All operations	Colorectal surgery	Non-colorectal surgery	*P*
Intraoperative				
Duration of surgery, min (median, IQR)	240 (125-330)	160 (120-245)	[illegible]	<0.001
Total fluid volume, ml, (mean, SD)	4229 (1840)	3557	5315	<0.001
Crystalloid	3762 (1687)	3180	[illegible]	<0.001
Colloid	467 (601)	360	648	0.019
Blood transfusion (% of patients)	11	9	14	0.538
Postoperative				
Fluid therapy (ml) during first 24 hours post surgery, (mean, SD)				
Total	6305 (2799)	5685	7464	0.003
Crystalloid	5400 (2608)	4716	[illegible]	0.001
Colloid	630 (718)	481	883	0.006
Blood transfusion (% of patients)	17	18	14	0.482
Fluid therapy (ml) during second 24 hours post surgery, (mean, SD)				
Total	3719 (1027)	3786	3657	0.646
Crystalloid	3761 (867)	2756	2814	0.700
Colloid	305 (515)	588	138	<0.001
Blood transfusion (% of patients)	7	9	0	0.036
Enteral fluid volume	498 (595)	656	228	<0.001
Overall 48 hour fluid balance	6411 (2956)	6150	6857	0.250

Weinberg et al. BMC Anesthesiology 2014, 14:35
http://www.biomedcentral.com/1471-2253/14/35

BMC Anesthesiology

RESEARCH ARTICLE Open Access

The impact of fluid intervention on complications and length of hospital stay after pancreaticoduodenectomy (Whipple's procedure)

Laurence Weinberg[1*], Derrick Wong[2], Dharshi Karalapillai[3], Brett Pearce[2], Chong O Tan[4], Stanley Tay[5], Chris Christophi[6], Larry McNicol[1] and Mehrdad Nikfarjam[7]

Table 7 Factors associated with post-operative length of two weeks or less following pancreaticoduodenectomy

	Discharge before 2 weeks (n = 62)	Discharge after 2 weeks (n = 88)	*Univariate* Odds ratio (Confidence interval)	*Univariate* p value	*Multivariate* Odds ratio (Confidence interval)	*Multivariate* p value
Demographics						
Male	41 (66%)	48 (55%)	1.6 (0.8–3.2)	0.155		
Diabetes	16 (26%)	19 (22%)	1.3 (0.6–2.7)	0.548		
COPD	2 (3%)	10 (11%)	0.3 (0.1–1.2)	0.124		
Age ≥ 70	20 (32%)	38 (43%)	0.6 (0.3–1.2)	0.176		
BMI ≥ 25	29 (50%)	42 (62%)	0.6 (0.3–1.3)	0.184		
Albumin ≤ 30 g/l	12 (21%)	16 (28%)	0.7 (0.3–1.7)	0.414		
Creatinine ≥100 (μmol/l)	6 (10%)	17 (21%)	0.4 (0.2–1.2)	0.088	0.3 (0.1–1.2)	0.085
Operative details						
Time ≥ 8 hours	24 (39%)	25 (28%)	1.6 (0.8–3.1)	0.185		
Blood loss ≥ 600 ml	9 (15%)	20 (23%)	0.6 (0.2–1.4)	0.202		
Intraoperative fluid balance ≤ 3 litre	20 (32%)	13 (15%)	2.7 (1.2–6.1)	0.01*	1.7 (0.5–5.1)	0.382
High surgical volume	39 (63%)	13 (25%)	9.8 (4.5–21.4)	<0.001*	11.3 (3.8–33.8.)	<0.001*
[illegible]	49 (79%)	76 (86%)	0.6 (0.3–1.4)	[illegible]		
Post–operative details						
Complication	15 (24%)	71 (80%)	0.1 (0.0–0.2)	<0.001*	0.1 (0.1–0.4)	<0.001*
Day 1 fluid balance ≤ 1 litre	35 (57%)	27 (31%)	2.9 (1.5–5.8)	0.002*	2.9 (1.1–6.6)	0.037*
Day 2 fluid balance ≤ 0.2 litre	33 (53%)	37 (31%)	2.6 (1.3–5.0)	0.006*	0.8 (0.3–2.5)	[illegible]
Day 3 fluid balance ≤ 0.2 litre	36 (58%)	32 (36%)	2.4 (1.2–4.7)	0.009*	2.5 (1.0–6.6)	0.056

[illegible] n (range).
COPD – Chronic obstructive pulmonary disease. *BMI* – body mass index; Missing: BMI – 24, Albumin –35, Creatinine 10, Estimate blood loss - 3 *p ≤ 0.05; Chi-Square/ Fisher's exact test.

A Fast Track Recovery Program Significantly Reduces Hospital Length of Stay Following Uncomplicated Pancreaticoduodenectomy

Mehrdad Nikfarjam, Laurence Weinberg, Nicholas Low, Michael A Fink, Vijayaragavan Muralidharan, Nezor Houli, Graham Starkey, Robert Jones, Christopher Christophi

J Pancreas 2013

TABLE 4. Factors associated with discharge following pancreaticoduodenctomy by post-operative day 8

	8 Days or less LOS (n=14)	More than 8 days LOS (n=27)	Univariate		Multivariate	
			Odds ratio (Confidence interval)	Difference (p value)	Odds ratio (Confidence interval)	Difference (p value)
Post-operative details	2(14%)	6(22%)	0.6(0.1-3.4)	0.543		
Fast-track recovery	13(93%)	7(26%)	37(4.1-338.1)	<0.001*	37(4.1-338.1)	0.001
Blood transfusion post-operative						
Negative fluid balance day 1	1(7%)	2(7%)	1.0(0.1-11.6)	0.975		
Negative fluid balance day 2	8(57%)	7(26%)	3.8(1.0-14.9.)	0.049*	0.5(0.1-3.7)	0.510
Negative fluid balance day 3	9(64%)	11(41%)	2.6(0.7-10.0)	0.153		

Surgery-specific cardiac output-guided haemodynamic algorithm improves outcomes in patients undergoing pancreaticoduodenectomy in a high volume centre: **a retrospective comparative study**

Weinberg L, Banting J, Churiloc L et al.

	ERAS + GDT (n=47)	ERAS only (n=98)	p-value
Length of hospital stay (days)	10 (8.0:14.0)	13 (8.8:21.3)	0.006
Intra-operative crystalloid (mls)	2200 (2000:4000)	4000 (3000:5000)	<0.0001
Intra-operative colloid (mls)	00 (0:450)	500 (100:1000)	0.001
Total Intra-operative fluid (mls)	3000 (2050:4175)	4500 (3275:5325)	<0.0001
Noradrenaline	22 (47%)	15 (15%)	0.002
Dopamine	12 (25%)	0	<0.0001

Physiologic fluid optimisation algorithm improves outcomes in patients undergoing pancreaticoduodenectomy: **a prospective multicentre randomized controlled trial**

Weinberg L,, Ianno D, Churilov L, et al.

	ERAS + GDT (n=26)	ERAS only (n=26)	p value
Fluids			
Crystalloid (mL)	1750 (1000:2100)	4000 (2313:4206)	<0.0001
Colloid (mL)	200 (0:500)	200 (0:500)	0.499
Hospital stay (days)	9.5 (7.0:14.3)	12.5 (9.0:22.3)	0.002