Which fluid to non-critical surgical patient?

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History of fluid therapy

- Early on, very little fluids intraoperatively, as fluids were thought to increase the risk of postoperative complications
- Fluid administration during surgery became a standard of care
  - Liberal fluid therapy based on the concept that inadequate administration of fluids would result in poor outcomes
- Fluid overload in postoperative patients also caused rather severe complications
- With this in mind, it is imperative that we define the treatment goals for management of perioperative fluid therapy

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Fluid management in enhanced recovery

- Consider fluids as medications
  - Dose accurately calculated
- Intraoperative management of fluids during surgery should be guided by *goal-directed therapy (GDT)* rather than predetermined calculations
- Titrate to the desired effect

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Routes of fluid administration

- The best method to improve hydration is by increasing per os (PO) fluid intake!
- Not for the anaesthetized patient, BUT an important consideration during perioperative patient care
- Forget nil per os (NPO) guidelines
  - Focus on preoperative and early postoperative PO hydration

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Which PO fluid?

- Patients should be encouraged to continue PO hydration up until 2 h before surgery
- Clear liquids ending 2 h prior to surgery does not increase gastric volumes, and may even reduce the acidity of stomach fluids
- The recommended preoperative use of clear carbohydrate beverages prior to surgery has not been associated with any increase in the risk of aspiration or other pulmonary complications

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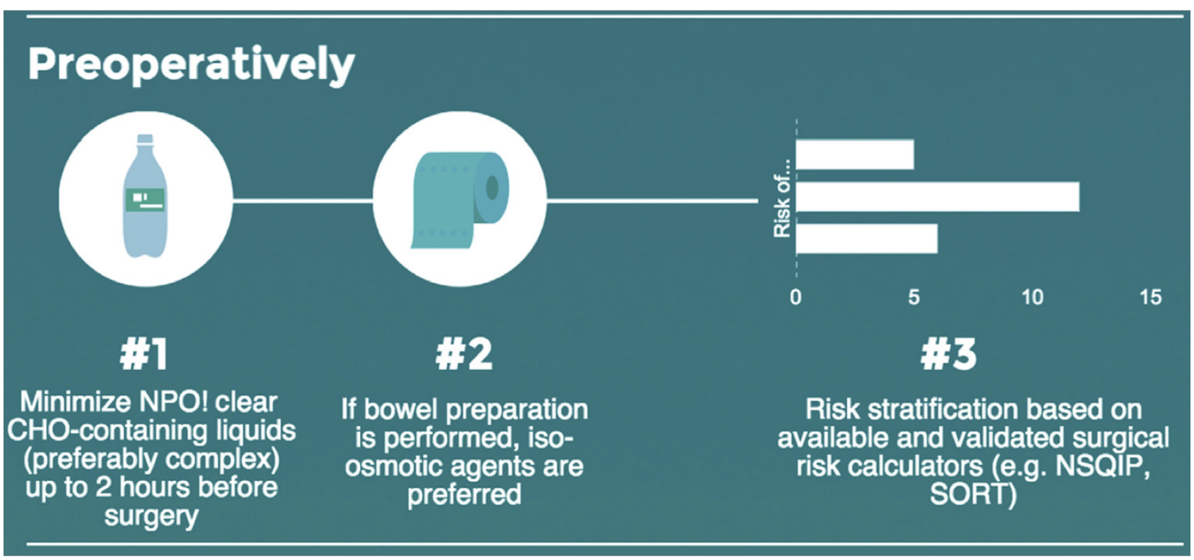

Makaryus et al. BJA 120:376e383, 2018

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	Main components	Na^+ (mmol $litre^{-1}$)	Cl^- (mmol $litre^{-1}$)	K^+ (mmol $litre^{-1}$)	Osmolarity (mOsm $litre^{-1}$)	pH
Crystalloids						
Normal saline (0.9% NaCl)	Na^+, Cl^-	154	154	0	308	4.5–7.0
Ringer's lactate	Na^+, Cl^-, K^+, lactate	130	109	4	273	6.0–7.5
Ringer's acetate	Na^+, Cl^-, K^+, acetate	130	112	5	276	6.0–8.0
Plasma-Lyte 148	Na^+, Cl^-, K^+, acetate	140	98	5	294	6.5–8.0
Dextrose 5%	Dextrose	0	0	0	278	3.5–5.5
Colloids						
HES 6%						
670/0.75	Na^+, Cl^-, poly(O-2-HE) starch (hetastarch)	154	154	0	308	3.5–7.0
200/0.50	Na^+, Cl^-, poly(O-2-HE) starch (pentastarch)	154	154	0	326	5.0
130/0.40	Na^+, Cl^-, poly(O-2-HE) starch (Voluven)	154	154	0	308	4.0–5.5
Gelatine	Na^+, Cl^-, gelatine	154	120	0	274	7.1–7.7
Albumin 5%	Na^+, Cl^-, albumin	130–160	130–160	<2	309	6.4–7.4
HyperHAES	Na^+, Cl^-, poly(O-2-HE) starch	1232	1232	0	2464	3.5–6.0
Balanced HES 6%					287	5.7–6.5
670/0.75	Na^+, Cl^-, poly(O-2-HE) starch, lactate (Hextend)	143	124	3	308	5.9
130/0.42	Na^+, Cl^-, poly(O-2-HE) starch, acetate (Tetraspan)	140	118	4	297	5.6–6.4
130/0.42	Na^+, Cl^-, poly(O-2-HE) starch, acetate (Volulyte)	137	110	4	287	5.7–6.5

Boer et al. BJA 120:384e396, 2018

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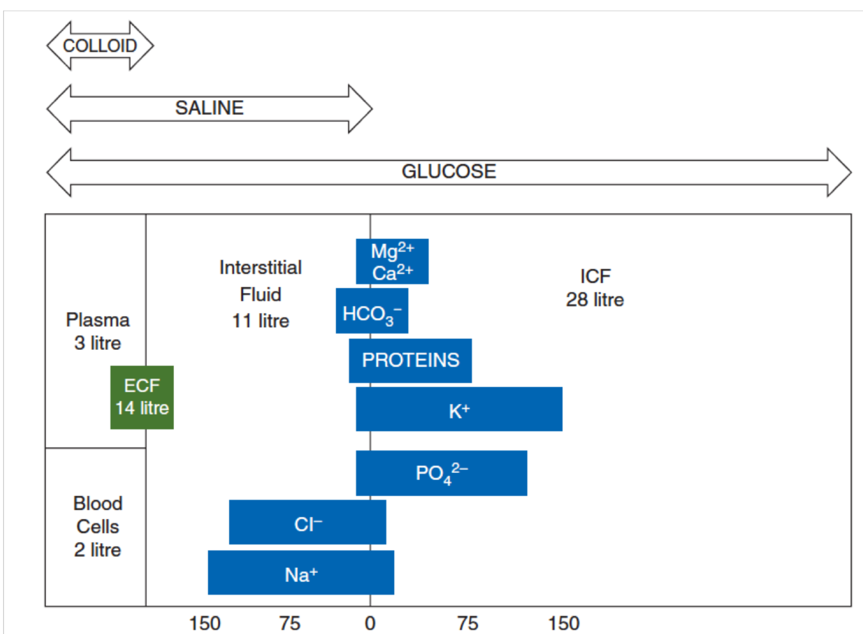

Doherty and Buggy BJA 109:69, 2012

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Side (Adverse?)-effects

- Infusion solutions for fluid therapy may have side-effects and are contraindicated in specific populations
- Registered as pharmaceutical products by local authorities
- Large volumes of crystalloid and colloid solutions can lead to hypervolaemia
- Also an imbalance in electrolytes
  - Hyponatraemia, hyperchloraemia, hyperkalaemia, and hypocalcaemia
- Of particular impact in severe renal, cardiac, or hepatic disease

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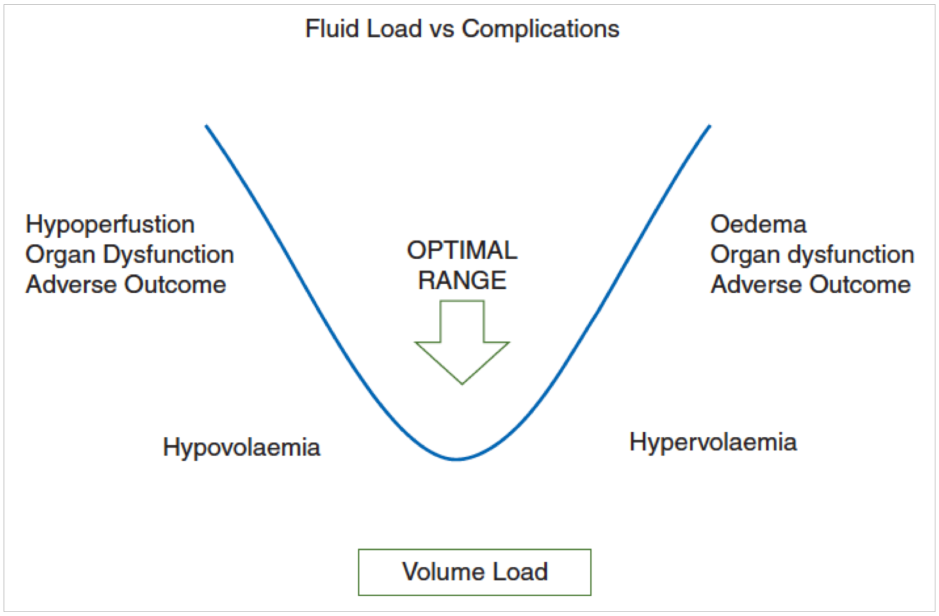

Modified from Hahn et al. Clinical Fluid Therapy in the Perioperative Setting, vol. 11. Cambridge: Cambridge University Press, 2011; 91–9

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The NEW ENGLAND JOURNAL *of* MEDICINE

ORIGINAL ARTICLE

Balanced Crystalloids versus Saline in Noncritically Ill Adults

Wesley H. Self, M.D., M.P.H., Matthew W. Semler, M.D., Jonathan P. Wanderer, M.D., Li Wang, M.S., Daniel W. Byrne, M.S., Sean P. Collins, M.D., Corey M. Slovis, M.D., Christopher J. Lindsell, Ph.D., Jesse M. Ehrenfeld, M.D., M.P.H., Edward D. Siew, M.D., Andrew D. Shaw, M.B., Gordon R. Bernard, M.D., and Todd W. Rice, M.D., for the SALT-ED Investigators*

Self et al NEJM 378:819, 2018

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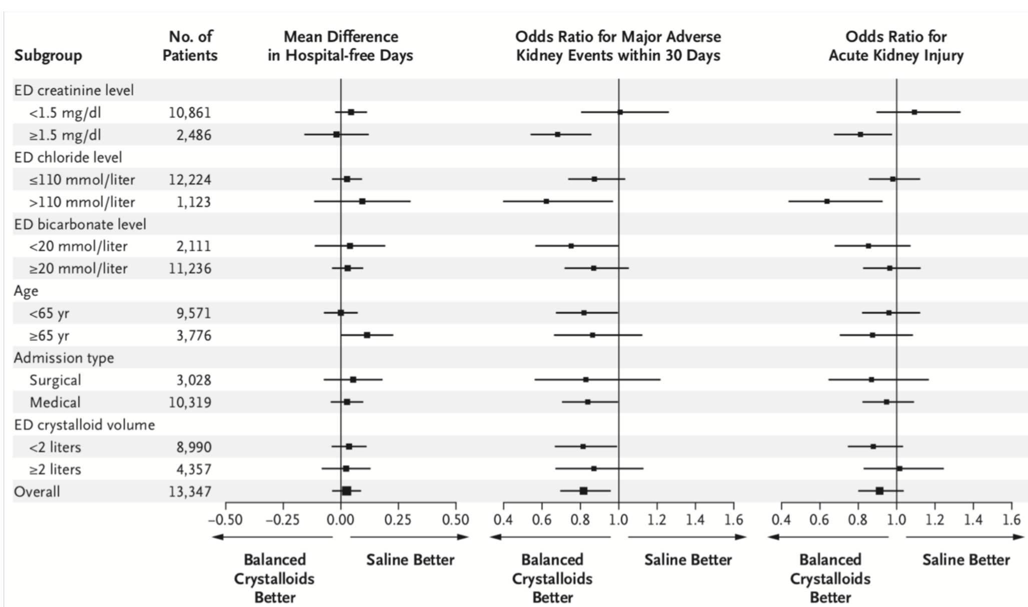

Self et al NEJM 378:819, 2018

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HESs and renal function

- Controversial after an increasing number of studies in critically ill patients
- Administration was associated with an increased incidence of AKI or even mortality
- Several RCTs in abdominal, orthopaedic, or vascular surgery
  - **HES did not increase the risk for AKI** compared to crystalloids or gelatin (Raiman et al. EJA 33:42; Gillies et al. BJA 112:25; Kancir et al. Anesthesiology 121:948; Anesth Analg 120:608; Yates et al BJA 112:281; Godet et al. 25:986; Mahmood et al. 94:427)

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British Journal of Anaesthesia **112** (1): 25–34 (2014)
Advance Access publication 17 September 2013 · doi:10.1093/bja/aet303

BJA

REVIEW ARTICLES

Incidence of postoperative death and acute kidney injury associated with i.v. 6% hydroxyethyl starch use: systematic review and meta-analysis

M. A. Gillies[1]*, M. Habicher[2], S. Jhanji[3], M. Sander[2], M. Mythen[4], M. Hamilton[5] and R. M. Pearse[6]

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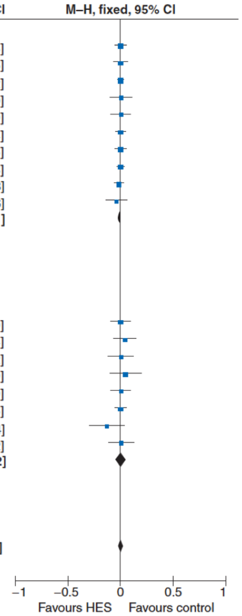
Study or subgroup	HES Events	HES Total	Control Events	Control Total	Weight	Risk difference M–H, fixed, 95% CI
Cardiac surgery						
Alavi and colleagues[20]	0	32	0	60	6.1%	0.00 [–0.05, 0.05]
Diehl and colleagues[22]	0	33	0	27	4.4%	0.00 [–0.06, 0.06]
Hecht-Dolnik and colleagues[9]	0	78	0	78	11.5%	0.00 [–0.02, 0.02]
Kuitunen and colleagues[28]	0	30	0	15	2.9%	0.00 [–0.10, 0.10]
Munsch and colleagues[32]	0	20	0	20	2.9%	0.00 [–0.09, 0.09]
Ooi and colleagues[33]	0	45	0	45	6.6%	0.00 [–0.04, 0.04]
Sirvinskas and colleagues[34]	0	40	0	40	5.9%	0.00 [–0.05, 0.05]
Van der Linden and colleagues[35]	0	55	0	55	8.1%	0.00 [–0.03, 0.03]
Van der Linden and colleagues[36]	0	64	1	68	9.7%	–0.01 [–0.06, 0.03]
Verheij and colleagues[37]	0	17	2	50	3.7%	–0.04 [–0.14, 0.06]
Subtotal (95% CI)		**414**		**458**	**62.0%**	**–0.00 [–0.02, 0.01]**
Total events	0		3			
Heterogeneity: χ^2=1.12, df=9 (P=1.00); I^2=0%						
Test for overall effect: Z=0.58 (P=0.56)						
Non-cardiac/mixed surgery						
Dehne and colleagues[21]	0	45	0	15	3.3%	0.00 [–0.09, 0.09]
Feldheiser and colleagues[23]	1	26	0	24	3.7%	0.04 [–0.06, 0.14]
Godet and colleagues[24]	2	32	2	33	4.8%	0.00 [–0.11, 0.12]
Gondos and colleagues[25]	15	50	38	150	11.1%	0.05 [–0.10, 0.19]
Guo and colleagues[26]	0	20	0	22	3.1%	0.00 [–0.09, 0.09]
Hung and colleagues[27]	0	41	0	39	5.9%	0.00 [–0.05, 0.05]
Mahmood and colleagues[30]	1	42	3	20	4.0%	–0.13 [–0.29, 0.04]
Marik and colleagues[31]	0	15	0	15	2.2%	0.00 [–0.12, 0.12]
Subtotal (95% CI)		**271**		**318**	**38.0%**	**0.00 [–0.12, 0.12]**
Total events	19		43			
Heterogeneity: χ^2=3.27, df=7 (P=0.86); I^2=0%						
Test for overall effect: Z=0.16 (P=0.87)						
Total (95% CI)		**685**		**776**	**100.0%**	**–0.00 [–0.02, 0.02]**
Total events	19		46			
Heterogeneity: χ^2=4.33, df=17 (P=1.00); I^2=0%						
Test for overall effect: Z=0.12 (P=0.91)						
Test for subgroup differences: χ^2=0.11, df=1 (P=0.74); I^2=0%						



Gillies et al BJA 112:25, 2014

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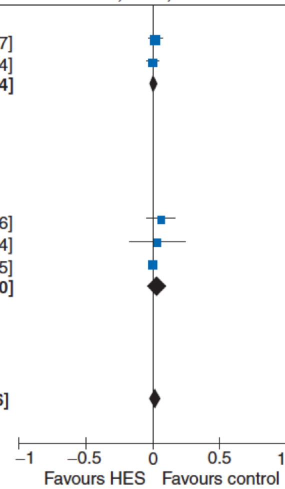
Study or subgroup	HES Events	HES Total	Control Events	Control Total	Weight	Risk difference M–H, fixed, 95% CI
Cardiac surgery						
Lee and colleagues[29]	1	53	0	53	26.5%	0.02 [–0.03, 0.07]
Ooi and colleagues[33]	0	45	0	45	22.5%	0.00 [–0.04, 0.04]
Subtotal (95% CI)		**98**		**98**	**49.0%**	**0.01 [–0.02, 0.04]**
Total events	1		0			
Heterogeneity: χ^2=0.33, df=1 (P=0.56); I^2=0%						
Test for overall effect: Z=0.58 (P=0.56)						
Non-cardiac/mixed surgery						
Diehl and colleagues[22]	2	33	0	27	14.8%	0.06 [–0.04, 0.16]
Godet and colleagues[24]	8	32	7	33	16.2%	0.04 [–0.17, 0.24]
Hung and colleagues[27]	0	41	0	39	20.0%	0.00 [–0.05, 0.05]
Subtotal (95% CI)		**106**		**99**	**51.0%**	**0.03 [–0.04, 0.10]**
Total events	10		7			
Heterogeneity: χ^2=1.87, df=2 (P=0.39); I^2=0%						
Test for overall effect: Z=0.78 (P=0.43)						
Total (95% CI)		**204**		**197**	**100.0%**	**0.02 [–0.02, 0.06]**
Total events	11		7			
Heterogeneity: χ^2=2.21, df=4 (P=0.70); I^2=0%						
Test for overall effect: Z=0.95 (P=0.34)						
Test for subgroup differences: χ^2=0.22, df=1 (P=0.64); I^2=0%						



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Gillies et al BJA 112:25, 2014

Effect of fluids on haemostasis

- No difference in 24h blood loss
  - Albumin vs. HES130/0.4, pediatric patients (Hanart el al. CCM 37:696)
  - HES130/0.4 vs Gelatine, CABG (Kasper et al. Anesthesiology 99:42)
  - Balanced crystalloid vs HES130/0.4, CABG (Kimenai et al. Perfusion 28:512)
  - Balanced crystalloid vs HES130/0.4, CABG (Lee et al. Circ J 75:2397)
  - Albumin 5% vs. Ringer, cystectomy (Rasmussen et al. Medicine 95:e2720)
  - Ringer vs. Dextran70, cystectomy (Rasmussen et al. BMC Anesth 15:178)
  - Albumin vs. HES130/0.4 vs. Ringer, cardiac (Skhirtladze et al. BJA 112:255)

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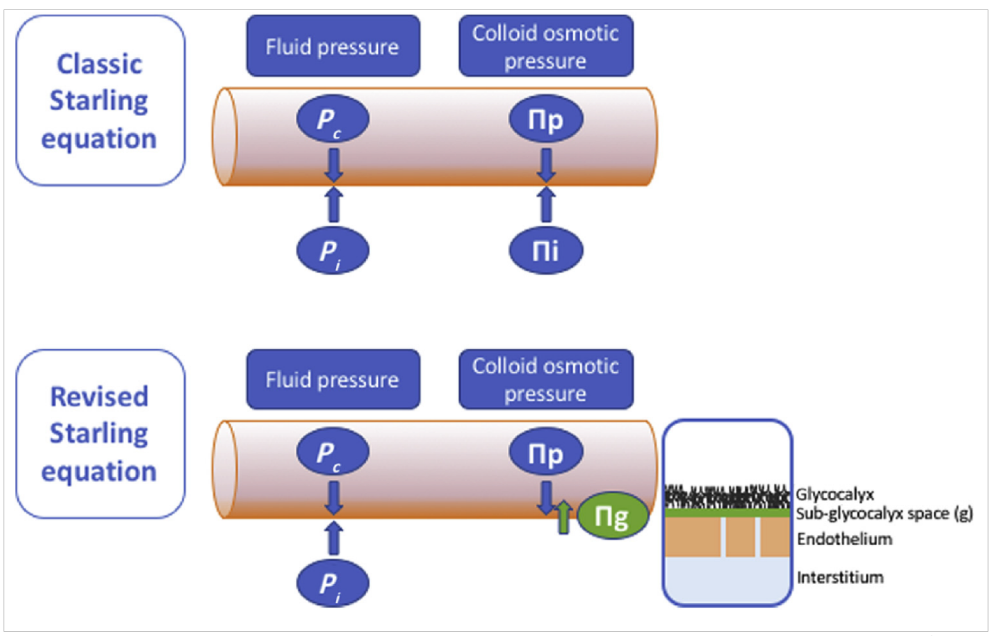

Boer et al. BJA 120:384e396, 2018

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Glycocalyx

- FFP, but not Ringer's lactate, normal saline, or HES, partially restores glycocalyx thickness
- Concomitant benefits for microcirculatory perfusion, after haemorrhagic shock
  - Larger plasma volume expansion?
- Current literature lacks evidence with respect to the clinical impact of fluids on glycocalyx integrity
- Is glycocalyx integrity involved in the regulation of intravascular volume during fluid resuscitation

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Intraoperative Fluid Management

- Restrictive vs. liberal?
- Abdominal surgery: restrictive?
  - Most harm with liberal fluid management (RCT, obs. Studies)
  - Thacker et al. 2016; Shin et al 2017
- No established definition of normovolaemia and fluid requirements vary significantly according to patient and surgical needs
- A large body of evidence aimed at *individualizing fluid management with goal-directed therapy*

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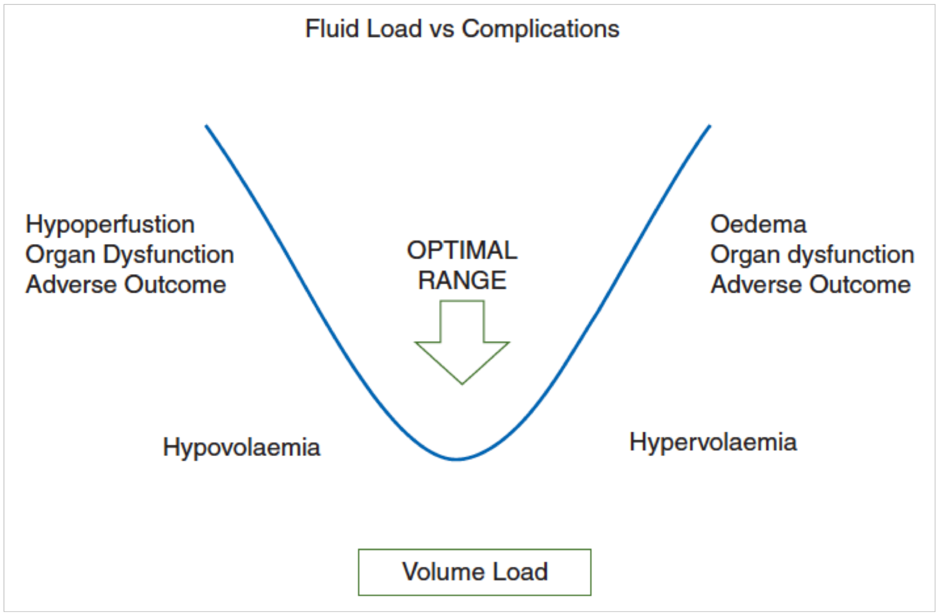

Modified from Hahn et al. Clinical Fluid Therapy in the Perioperative Setting, vol. 11. Cambridge: Cambridge University Press, 2011; 91–9

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Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

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

Pearse et al. JAMA 311:2181, 2014

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OPTIMISE-study

- Pragmatic, multicenter, randomized, observer-blinded trial of 734 high-risk patients aged > 50 years
- Major gastrointestinal surgery at 17 acute care hospitals in the United Kingdom
- Patients were randomly assigned to a cardiac output-guided hemodynamic therapy algorithm for IV fluid and inotrope (dopexamine) infusion during and 6 hours following surgery (n=368) or to usual care (n=366)
- An updated systematic review and meta-analysis were also conducted including randomized trials published from 1966 to February 2014

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OPTIMISE-study

- The primary outcome was a composite of predefined 30-day moderate or major complications and mortality
- Secondary outcomes were morbidity on day 7; infection, critical care–free days, and all-cause mortality at 30 days; all-cause mortality at 180 days; and length of hospital stay

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Results

- The primary outcome
  - 36.6%of intervention and 43.4%of usual care participants
  - Relative risk [RR], 0.84 [95%CI, 0.71-1.01]
  - Absolute risk reduction, 6.8% [95%CI, −0.3%to 13.9%]
- No significant difference between groups for any secondary outcomes
- Meta-analysis of 38 trials suggest that the intervention is associated with fewer complications
  - Intervention, 488/1548 [31.5%] vs control, 614/1476 [41.6%]
  - RR, 0.77 [95%CI, 0.71-0.83]

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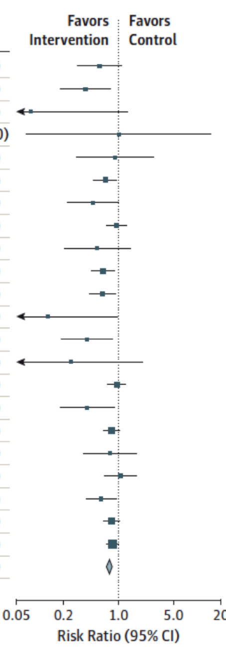
	Intervention		Control			
Source	No. of Events	Total No.	No. of Events	Total No.	Risk Ratio (95% CI)	Weight, %
Shoemaker et al,[20] 1988	8	28	30	60	0.57 (0.30-1.08)	1.7
Berlauk et al,[21] 1991	11	68	9	21	0.38 (0.18-0.79)	1.3
Mythen et al,[22] 1995	0	30	6	30	0.08 (0.00-1.31)	0.1
Sinclair et al,[23] 1997	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)	6.2
Lobo et al,[26] 2000	6	19	12	18	0.47 (0.23-0.99)	1.3
Jerez et al,[27] 2001	53	181	65	209	0.94 (0.70-1.28)	7.6
Conway et al,[28] 2002	5	29	9	28	0.54 (0.20-1.40)	0.8
Pearse et al,[14] 2005	27	62	41	60	0.64 (0.46-0.89)	6.3
Wakeling et al,[29] 2005	24	67	38	67	0.63 (0.43-0.93)	4.8
Noblett et al,[30] 2006	1	51	8	52	0.13 (0.02-0.98)	0.2
Donati et al,[31] 2007	8	68	20	67	0.39 (0.19-0.83)	1.3
Smetkin et al,[32] 2009[a]	1	20	4	20	0.25 (0.03-2.05)	0.2
Jhanji et al,[6] 2010	57	90	30	45	0.95 (0.73-1.23)	10.4
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: $z = 6.22$; $P < .001$



Pearse et al. JAMA 311:2181, 2014

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So?

- Large multicentre trials needed, evaluating the effectiveness of different fluid regimens
- OPTIMISE II (n=2500)
- RELIEF (n=3000)
  - Primary endpoint of disability free survival at 1 yr after surgery

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The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 14, 2018 VOL. 378 NO. 24

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*

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Table 2. Blood Loss and Administered Intravenous-Fluid Volumes.*

Variable	Restrictive Fluid (N=1490)	Liberal Fluid (N=1493)	P Value
During surgery			
Median intraoperative blood loss (IQR) — ml	200 (100 to 400)	200 (100 to 500)	0.14†
Median intraoperative fluid administration (IQR) — ml			
Crystalloid	1677 (1173 to 2294)	3000 (2100 to 3850)	<0.001
Colloid‡	500 (250 to 800)	500 (400 to 1000)	0.01
Median infusion rate (IQR) — ml/kg/hr	6.5 (5.1 to 8.4)	10.9 (8.7 to 13.5)	<0.001
In PACU§			
Median administration of fluid (IQR) — ml			
Crystalloid	160 (90 to 302)	300 (160 to 500)	<0.001
Colloid‡	400 (250 to 500)	500 (250 to 500)	0.27
Postoperative day 1, post-PACU			
Median administration of fluid (IQR) — ml			
Crystalloid	1556 (1200 to 1960)	2600 (2052 to 3150)	<0.001
Colloid‡	500 (250 to 1000)	500 (400 to 750)	0.89
Median infusion rate (IQR) — ml/kg/hr	0.9 (0.7 to 1.2)	1.5 (1.2 to 1.7)	<0.001
At 24 hr after surgery			
Median cumulative total for intravenous fluids (IQR) — ml	3671 (2885 to 4880)	6146 (5000 to 7410)	<0.001
Median fluid balance (IQR) — ml¶	1380 (540 to 2338)	3092 (2010 to 4241)	<0.001†
Median weight gain (IQR) — kg‖	0.3 (−1.0 to 1.9)	1.6 (0.0 to 3.6)	ND

Myles et al. NEJM 378:2263, 2018

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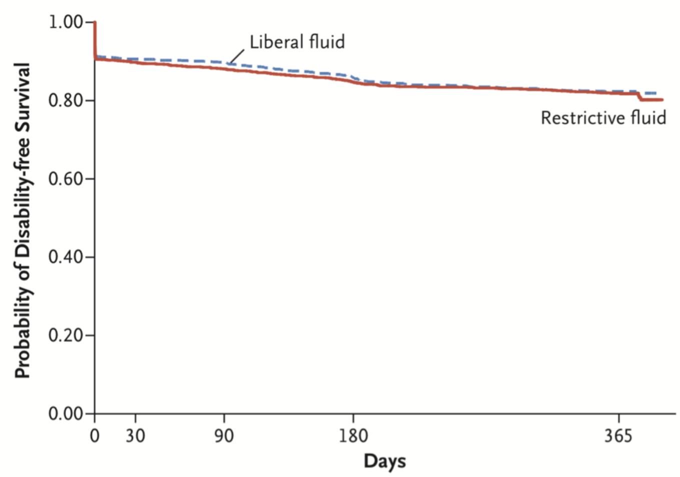

No. at Risk

	0	30	90	180	365
Liberal fluid	1493	1343	1320	1249	859
Restrictive fluid	1490	1323	1292	1228	835

Myles et al. NEJM 378:2263, 2018

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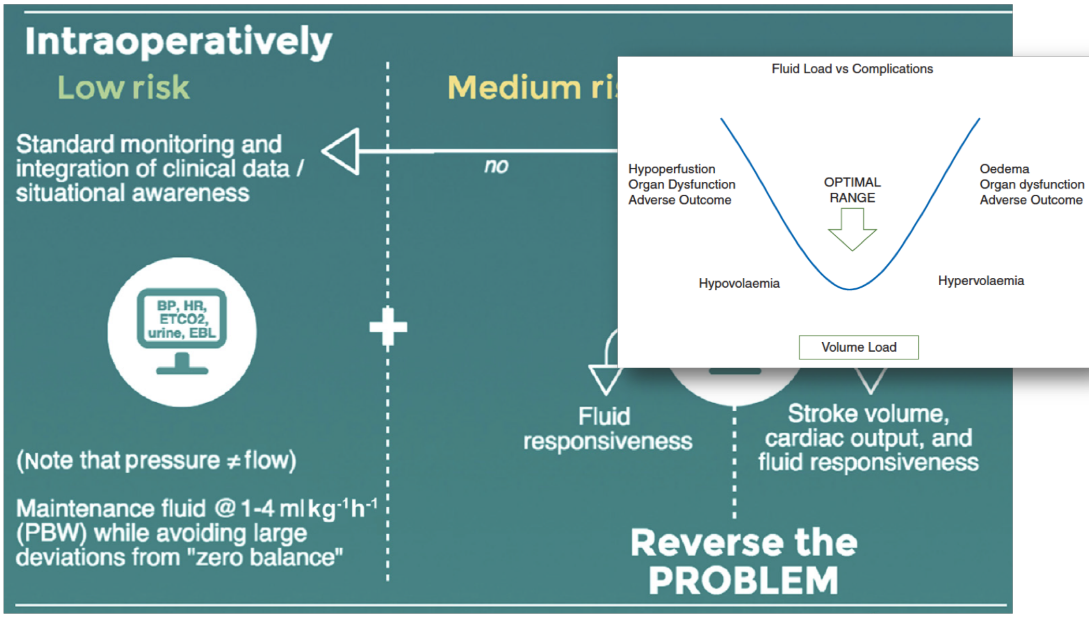

Makaryus et al. BJA 120:376e383, 2018

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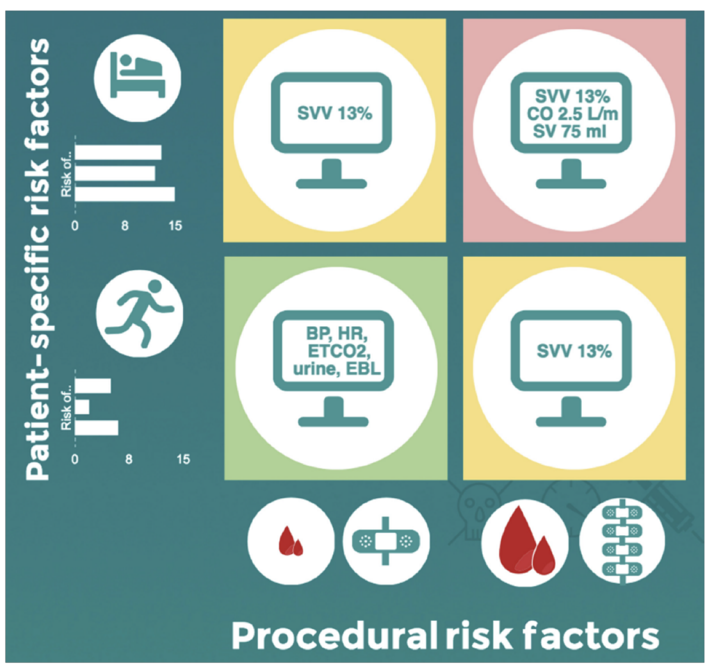

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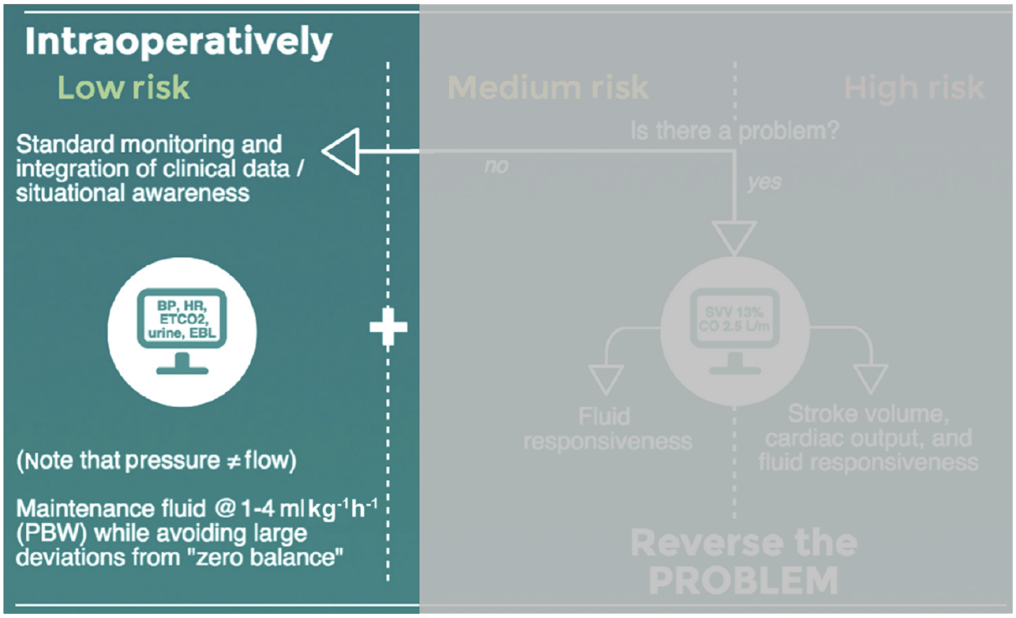

Makaryus et al. BJA 120:376e383, 2018

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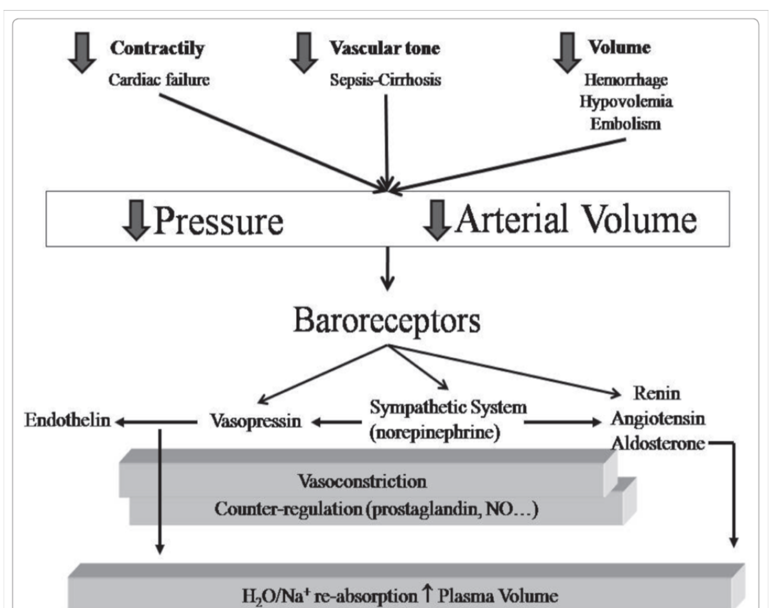

Figure 1. Independent variables and the sequence of events leading to water and sodium retention.

Gattinoni et al. Crit Care 17 (Suppl 1) :S4, 2013

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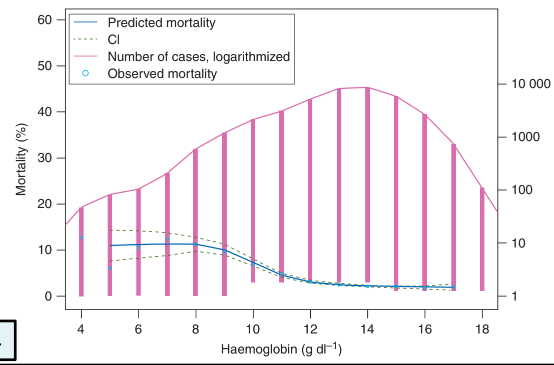
Table 2 Perioperative outcomes according to preoperative Hb concentrations. ICU, intensive care unit; MV, mechanical ventilation; NIV, non-invasive ventilation

	Severe anaemia		Moderate anaemia		Mild anaemia		Normal haemoglobin		Normal *vs* anaemia
	n	%	*n*	%	*n*	%	*n*	%	*P*-value
Number of patients	637	1.6	3427	8.7	7231	18.4	27 439	69.8	
Age (yr)	60 (18)		65 (17)		63 (19)		56 (18)		
In-hospital mortality		11.3		8.6		4.0		2.2	<0.001
Admitted to ICU		25.6		22.0		11.2		5.4	<0.001
NIV within 24 h		1.1		2.2		1.4		0.7	<0.001
MV within 24 h		17.6		12.1		5.0		1.8	<0.001
Inotrope/vasopressor use		13.0		9.6		4.4		1.4	<0.001
Central venous catheter		22.1		19.7		11.5		4.5	<0.001
Cardiac output monitor		12.9		9.4		7.5		4.3	<0.001



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Postoperatively

0-12 h:

- 1 ml/kg/h iv and switch to immediate oral intake as tolerated
- Continue intraoperative strategy with medium and high risk patients

>12 h:

- DREAMS: dring, eat, analgesia, move, sleep -> home

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