Fluid Management in Surgery

IOFM Protocol	Oesophageal Doppler (ODM)	Pulse Pressure Waveform Analysis (PPWA)			Bioimpedance
	SV Optimisation	SV Optimisation	Minimisation of SVV/PPV	Target (other parameters)	Target (other parameters)
RCTs	15 [1-15]	5 [16-20]	9 [21-29] †	3 [30-32]	1 [33]
Number of RCT patients	1,361	1033	751	137	142
Audits	6 [34-39]	-	1 [40]	-	-
Number of audit patients	2,487	-	50	-	-
Reduce complications?	✓✓✓	?	✓†	?	✗
Reduce total LOS?	✓✓✓	✗	? †	?	✗
Reduce ICU stay?	✓✓	✗	?	?	✗
Reduce operating times?	✓ [50]	✗	✗	?	✗
Types of surgery	Cardiac, orthopaedic, colorectal, renal, urological, other abdominal, gynaecological, plastic, vascular, transplant, hepatic (elective, emergency & laparoscopic)	Vascular, orthopaedic, gastroin-testinal, (elective)	Abdominal, high-risk, thoracic, cardiac, orthopaedic (elective & emergency)	Cardiac, vascular, gastrointestinal (elective)	Abdominal
Meta-analyses	5 [36, 41-44]	-			-
Government systematic reviews	6 [45-50] (UK, USA & Spain)	-			-
Non-Government systematic reviews	-	1 [51] (LiDCO given 'C' rating*)			-
Technologies used (RCTs and other trials/audits)	CardioQ-ODM x 19 Hemosonic x 1, TECO x 1	Vigileo/FloTrac x 9 †, LiDCO*plus* x 4, LiDCO*rapid* x 1, PiCCO x 3, ProAQT x 1			NICOM x 1

NOTES † Mayer, Boldt et al [52] study using FloTrac excluded: subject to retraction †† NICE commissioned review concluded CardioQ-ODM is dominant. CardioQ-ODM delivers both better outcomes and lower cost.

KEY ODM, Oesophageal Doppler Monitor; PPWA, Pulse Pressure Waveform Analysis; SVV, Stroke Volume Variation; PPV, Pulse Pressure Variation; DO_2, Delivered Oxygen; CI, Cardiac Index.

✓✓✓ Level 1A evidence: RCTs, meta-analyses, & government sponsored systematic reviews

✓✓ Level 1A evidence: Some RCTs & government sponsored systematic reviews

✓ Individual trials with statistically significant results

? Individual trials with non-significant results or some significant results but contradicted by other trials

✗ Absence of impact reported or not examined

* Potential but unproven benefit. Some published evidence suggests that safety and impact on health outcomes are at least comparable to standard treatment/testing. However, substantial uncertainty remains about safety and/or impact on health outcomes because of poor-quality studies, sparse data, conflicting study results, and/or other concern.

Randomised Controlled Trials for the ODM

Lead author	Type of surgery	Technology	Fluid management strategy	No. of patients	Type of protocol fluid	Additional protocol fluid given	Effect of treatment on postoperative complications	Effect of treatment on hospital stay	Effect of treatment on ICU stay
Mythen, 1995 [1]	Cardiac	ODM (CardioQ-ODM)	SV Optimisation	60	HES	~ 650 mL	↓↓↓(100% fewer major complications)	↓↓↓ (3.7 days)	↓↓↓ (0.7 days)
Sinclair, 1997 [2]	Orthopaedic	ODM (CardioQ-ODM)	SV Optimisation	40	HES	750 mL	NR	↓↓↓ (5 days)	NR
Conway, 2002 [3]	Colorectal	ODM (TECO)	SV Optimisation	57	HES	632 mL	NR	No difference between groups	↓↓↓ (3 days)
Gan, 2002 [4]	General, Urological & Gynaecological	ODM (CardioQ-ODM)	SV Optimisation	100	HES (followed by Lactated Ringers)	565 mL	↓↓↓ (61% less severe PONV)	↓↓↓ (2 days)	NR
Venn, 2002 [5]	Orthopaedic	ODM (CardioQ-ODM)	SV Optimisation	90	Gelofusine	759 mL	↓ (48% lower overall morbidity)	↓↓↓ (6.2 days)	NR
Wakeling, 2005 [6]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	128	Haemaccel/Gelofusine	500 mL	↓↓↓ (69% less gastrointestinal complications; 37% fewer patients with complications)	↓↓↓ (1.5 days)	NR
Noblett, 2006 [7]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	108	Volplex (Gelatin)	131 mL	↓↓↓ (88% fewer intermediate or major complications)	↓↓↓ (3 days)	NR
Senagore, 2009 [8]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	64	HES or Lactated Ringers	NR	No difference between groups	No difference between groups	NR
Challand, 2011 [9]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	179	Voluven (HES)	1,360 mL	↓ (23% fewer major complications)	↑ (2 days)	NR
Pillai, 2011 [10]	Urological	ODM (CardioQ-ODM)	SV Optimisation	66	Colloid (not specified)	~300 mL	↓↓↓ (92% less severe PONV; 80% fewer wound infections; 61% less ileus)	↓ (4 days)	NR
Brandstrup, 2012 [11^]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	150	Voluven (HES)	335 mL	No difference between groups	No difference between groups	NR
Srinivasa, 2013 [12^]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	84	Gelofusine	294 mL	No difference between groups	No difference between groups	NR
Zakhaleva, 2013 [13]	Colorectal	ODM (CardioQ-ODM)	SV Optimisation	74	Crystalloid	NR	↓↓↓ (63% fewer complications)	No difference between groups	NR
McKenny, 2013 [14]	Gynaecological	ODM (CardioQ-ODM)	SV Optimisation	102	Voluven (HES)	500 mL	↓↓↓ (47% fewer complications)	No difference between groups	NR
El Sharkawy, 2013 [15]	Hepatic	ODM (CardioQ-ODM)	SV Optimisation	59	Voluven (HES)	(-700 mL)	↓↓↓ (67% fewer patients with PONV)	↓↓↓ (1.5 days)	NR

^ Both studies are comparisons of ODM-guided fluid management vs. 'restrictive'/'zero-balance' fluid administration. These differ from the previous ODM RCTs where the control groups received 'routine' fluid administration (typical of the more traditional definition of a 'control' group). ↓↓↓ ,statistically significant (P<0.05) reduction; ↓ , reduction (>20% difference in complications, or >1 day difference in hospital stay) but not statistically significant; ↑, increase but not statistically significant; NR, not reported; PONV, postoperative nausea and vomiting.

Randomised Controlled Trials for PPWA

Lead author	Type of surgery	Technology	Fluid management strategy	No. of patients	Type of protocol fluid	Additional protocol fluid given	Effect of treatment on postoperative complications	Effect of treatment on hospital stay	Effect of treatment on ICU stay
Cecconi, 2011 [16]	Orthopaedic	PPWA (Vigileo/FloTrac)	SV Optimisation (+ dobutamine)	40	HES (followed by Lactated Ringers)	1,544 mL	↓↓↓ (20% fewer patients with complications)	No difference between groups	NR
Bartha, 2012 [17]	Orthopaedic	PPWA (LiDCOplus)	SV Optimisation (+ dobutamine)	149	Colloid (not specified)	430 mL	No difference between groups	No difference between groups	No difference between groups
Bisgaard, 2012 [18]	Vascular	PPWA (LiDCOplus)	SV Optimisation	70	Voluven (HES)	72 mL (intra-op) + 262 mL (first 6 h post-op)	No difference between groups	No difference between groups	No difference between groups
Bisgaard, 2012 [19]	Vascular	PPWA (LiDCOplus)	SV Optimisation	40	Voluven (HES)	250 mL (intra-op) + 500 mL (first 6 h post-op)	↓↓↓ (55% fewer patients with complications)	No difference between groups	No difference between groups
Pearse, 2014* [20]	Gastrointestinal	PPWA (LiDCOrapid)	SV Optimisation (+ dopexamine)	734	Colloid (not specified)	1,250 mL	↓ (15% fewer patients with 30-day complications or mortality)	No difference between groups	NR
Harten, 2008 [21]	Abdominal	PPWA (LiDCOplus)	Minimisation of SVV/PPV	29	Voluven (HES)	750 mL	↑ (43% more patients with complications)	↑ (5.5 days)	NR
Buettner, 2008 [22]	Abdominal	PPWA (PiCCO)	Minimisation of SVV/PPV	80	Voluven (HES) and balanced crystalloid	500 mL	NR	No difference between groups	↓ (0.7 days)
Benes, 2010 [23]	Abdominal	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	120	Voluven (HES)	425 mL	↓↓↓ (56% fewer complications)	No difference between groups	No difference between groups
Ramsingh, 2012 [24]	Abdominal	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	38	Albumin (followed by crystalloid)	122 mL	NR	↓↓↓ (2.5 days)	NR
Goepfert, 2013* [25]	Cardiac	PPWA (PiCCO)	Minimisation of SVV/PPV	100	HES	413 mL	↓ (21% fewer patients with complications)	↓↓↓ (1 day)	↓↓↓ (20 hours)
Scheeren, 2013 [26]	High-risk surgery	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	64	Voluven (HES)	662 mL	↓↓↓ (100% fewer wound infections; trend towards fewer patients with complications)	NR	No difference between groups
Zhang, 2013 [27]	Thoracic	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	80	Voluven (HES)	(-310 mL)	↓↓↓ (50% fewer patients with PONV)	No difference between groups	NR
Peng, 2014 [28]	Orthopaedic	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	80	Voluven (HES)	(-500 mL)	No difference between groups	No difference between groups	NR
Salzwedel, 2013 [29]	Abdominal	PPWA (ProAQT)	Minimisation of SVV/PPV (with additional CI target)	160	NR	NR	↓↓↓ (42% fewer patients with complications)	No difference between groups	NR
Smetkin, 2009 [30]	Cardiac	PPWA (PiCCO)	Target ITBVI/MAP/ScvO2/CI	40	HES	500 mL	No difference between groups	↓↓↓ (3 days)	↓↓↓ (3 hours)
Van der Linden, 2010 [31]	Vascular	PPWA (Vigileo/FloTrac)	Target CI	37	HES	250 mL	No difference between groups	↑ (4 days)	NR
Zheng, 2013 [32]	Gastrointestinal	PPWA (Vigileo/FloTrac)	Target CI/MAP	60	Crystalloid (followed by HES)	NR	↓ (39% fewer adverse cardiac events)	↓↓↓ (4 days)	↓↓↓ (15 hours)

*Perioperative fluid management protocol, ↓↓↓, statistically significant (P<0.05) reduction; ↓, reduction (>20% difference in complications, or >1 day difference in hospital stay) but not statistically significant; ↑, increase but not statistically significant; ITBVI, intrathoracic blood volume index; NR, not reported; PONV, postoperative nausea and vomiting.

Randomised Controlled Trials for Bioimpedance

Lead author	Type of surgery	Technology	Fluid management strategy	No. of patients	Type of protocol fluid	Additional protocol fluid given	Effect of treatment on postoperative complications	Effect of treatment on hospital stay	Effect of treatment on ICU stay
Pestaña, 2014* [33]	Abdominal	Bioimpedance (NICOM)	Target CI/MAP	142	Colloid (not specified)	~250 mL	No difference between groups	No difference between groups	No difference between groups

*Perioperative fluid management protocol, ↓↓↓, statistically significant (P<0.05) reduction; ↓, reduction (>20% difference in complications, or >1 day difference in hospital stay) but not statistically significant; ↑, increase but not statistically significant; NR, not reported.

Non Randomised Trials

Lead author	Type of surgery	Technology	Fluid management strategy	No. of patients	Type of protocol fluid	Additional protocol fluid given	Effect of treatment on postoperative complications	Effect of treatment on hospital stay	Effect of treatment on ICU stay
Kuper, 2011 (NHS Technology Adoption Centre) [34]	Colorectal, Urological, Vascular, Orthopaedic, Transplant, [other]	ODM (CardioQ-ODM)	SV Optimisation	1,307	NR	252 mL	↓ (fewer reoperations, and critical care and hospital readmissions)	↓↓↓ (3.6 days)	↓↓↓ (5.3 days)
Figus, 2011 [35]	Plastic	ODM (CardioQ-ODM)	SV Optimisation	104	Volulyte (HES)	NR	↓ (44% fewer flap-related complications)	↓ (1.9 days)	NR
Feldheiser, 2012 [36]	Non-cardiac	ODM (CardioQ-ODM)	SV Optimisation (with additional maintenance of MAP >70 mm Hg, and Cardiac Index >2.5 L/min/m2)	658	NR	NR	Not reported, although 97% fewer patients in the Doppler group required postoperative ventilator therapy	↓↓↓ (8.2 days)	NR
Chattopadhyay, 2013 [37]	Gynaecological	ODM (CardioQ-ODM)	SV Optimisation	198	Predominantly crystalloid	~150 mL	↓↓↓ (73% less PONV in advanced stage disease patients)	↓↓↓ (Earlier 'time to fitness for discharge': odds ratio = 2.81)	NR
Mannova, 2013 [38]	Vascular	ODM (Hemosonic)	SV Optimisation	140	NR	NR	↓↓↓ (62% fewer complications)	↓↓↓ (1 day)	↓↓↓ (2 days)
McKenny, 2014 [39]	Colorectal (Laparoscopic)	ODM (CardioQ-ODM)	SV Optimisation	80	Voluven (HES)	593 mL	↓↓↓ (38% fewer complications)	↓ (1 day)	NR (but 83% fewer unplanned ICU admissions)
Wang, 2012 [40]	Transplant	PPWA (Vigileo/FloTrac)	Minimisation of SVV/PPV	50	Lactated Ringers	144 mL	No difference between groups	NR	NR

↓↓↓, statistically significant (P<0.05) reduction; ↓, reduction (>20% difference in complications, or >1 day difference in hospital stay) but not statistically significant; ↑, increase but not statistically significant; NR, not reported; PONV, postoperative nausea and vomiting.

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