Enhancing Recovery after Cardiac Surgery

Randomized controlled trials showing a benefit from goal-directed therapy (GDT) in cardiac surgery

Collectively, more than 14,000 patients have been enrolled in these 17 positive RCTs and QIPs.

#	Title, author, year, publication	n	Parameters optimized	Surgery	Tool	Main benefits of GDT
1	Efficacy of intraoperative hemodynamic optimization using FloTrac/EV1000 platform for early goal-directed therapy to improve postoperative outcomes in patients undergoing coronary artery bypass graft with cardiopulmonary bypass: A randomized controlled trial. ***Tribuddharat, et al. 2021 Medical Devices: Evidence and Research***	86	SVV, SVI, CI, SVRI	CABG on CPB	FloTrac, EV1000	Reduced length of hospital stay (mean difference -1.1d) Reduced length of ICU stay (mean difference -29.5h) Reduced ventilator time (mean difference -11.3h) Reduced AFib with RVR Reduced ARDS Reduced AKI Less inotropic & vasopressor support
2	Perioperative individualized goal-directed therapy for cardiac surgery: A historical prospective, comparative effectiveness study. ***Ramsingh, et al. 2021 Journal of Clinical Medicine***	550	CI, MAP, BP, SV	CPB	FloTrac EV1000 TEE	Reduced length of ICU stay 4d vs 5.88d (2019 vs 2018) 4d vs 6.19d (2019 vs 2017) Reduced total inotropic medication
3	Prevention of cardiac surgery–associated acute kidney injury by implementing the KDIGO guidelines in high-risk patients identified by biomarkers: The PrevAKI-multicenter randomized controlled trial. ***Zarbock, et al. 2021 International Anesthesia Research Society***	278	CO, CI, MAP, PLR	Cardiac	Functional HD monitors	Reduced occurrence of moderate to severe AKI* (14.0% vs 23.9%) * Overall, AKI rates were not significantly different between groups
4	Goal-directed haemodynamic therapy (GDHT) in surgical patients: systematic review and meta-analysis of the impact of GDHT on post-operative pulmonary complications. ***Dushianthan, et al. 2020 Perioperative Medicine***	9,548	CO, SV, DO_2, VO_2, O_2ER, SVR, CI, MAP, PAOP, SVV, FTc, GEDI, $SCvO_2$, SVI, SI, CVP, PPV, PCWP	Abdominal, vascular, orthopedic, cardiac, thoracic, mixed groups	Minimally invasive, Oesophageal doppler, non-invasive, PAC	Reduced total pulmonary complications Reduced pulmonary infections Reduced pulmonary edema (Benefits were seen in general, mixed, abdominal and cardiac surgeries but not in orthopedic or vascular surgery)

Edwards

#	Title, author, year, publication	n	Parameters optimized	Surgery	Tool	Main benefits of GDT
5	Goal-directed resuscitation following cardiac surgery reduces acute kidney injury: a quality initiative pre-post analysis. ***Johnston, et al. 2020 Journal of Thoracic and Cardiovascular Surgery***	1,979	CI, MAP, PVI, SvO_2, PLR	Cardiac	PAC, TTE, Pleth	37% reduction in odds of AKI as well as reduced RIFLE injury or failure post-surgery (7.8% vs 12.4%)
6	Prevention of cardiac surgery-associated AKI by implementing the KDIGO guidelines in high risk patients identified by biomarkers: the PrevAKI randomized controlled trial. ***Meersch, et al. 2017 Inten Care Med***	276	SVV, CI, MAP	Cardiac	PICCO	Reduced occurrence of AKI (55.1 vs. 71.7%) Reduced rate of moderate to severe AKI (29.7% vs. 44.9%) Reduced occurrence of hyperglycemia (50.7% vs. 75.4%) and use of ACEi/ARBs (10.9% vs. 30.4%)
7	Goal-directed therapy improves the outcome of high-risk cardiac patients undergoing off-pump coronary artery bypass. ***Kapoor, et al. 2017 Ann Card Anaesth***	142	CI, SVRI, DO_2I, SVV, $ScVO_2$, GEDV, EVLW	High-risk OPCAB	FloTrac, EOCVC , EV1000	Reduced length of hospital stay (5.61d vs. 7.42d) Reduced length of ICU stay (2.53d vs. 4.2d) Reduced duration of inotropes (2.89h vs. 3.24h)
8	Perioperative utility of goal-directed therapy in high-risk cardiac patients undergoing coronary artery bypass grafting: "a clinical outcome and biomarker-based study." ***Kapoor, et al. 2016 Ann Card Anaesth***	130	CI, SVI, $ScvO_2$, SVRI, SVV, DO_2I	CABG on CPB	FloTrac, EOCVC, Vigileo	Shorter average duration of ventilation (18.05h vs. 19.89h) Shorter hospital stay (7.17d vs. 7.94d) Shorter ICU stay (3.41d vs. 3.74d) Earlier decline of lactate levels (6h vs. 12h) Lower levels of brain natriuretic peptide, neutrophil gelatinase-associated lipocalin levels
9	Effect of perioperative goal-directed hemodynamic resuscitation therapy on outcomes following cardiac surgery: a randomized clinical trial and systematic review. ***Osawa, et al. 2016 Crit Care Med***	126	CI, SVI	CABG, valve repair	LiDCO rapid	Reduced composite endpoint of 30-day mortality and major postoperative complications (27.4% vs. 45.3%) Reduced infection rate (12.9% vs. 29.7%) Reduced cardiac output syndrome (6.5% vs. 26.6%) Reduced ICU cumulative dosage of dobutamine (12mg/kg vs. 19mg/kg) Reduced ICU length of stay (3d vs. 5d) Reduced hospital length of stay (9d vs. 12d)
10	A randomised feasibility study to assess a novel strategy to rationalise fluid in patients after cardiac surgery. ***Parke, et al. 2015 BJA***	144	SVV	Cardiac	FloTrac, EV1000	Less bolus fluid and less total overall fluid volume administered from ICU admission to extubation
11	Early goal-directed therapy based on endotracheal bio-impedance cardiography: a pro-spective, randomized controlled study in coronary surgery. ***Fellahi, et al. 2015 J Clin Monit Comput***	100	SVV, CI	Elective primary CABG	ECOM	Reduced time to extubation (approx. 1h)

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12	Individually optimized hemodynamic therapy reduces complications and length of stay in the intensive care unit: a prospective, randomized controlled trial. ***Goepfert, et al. 2013 Anesthesiology***	100	CI, SVV, GEDI, MAP, ELWI	CABG, aortic valve replace-ment	PiCCO plus	Decreased intraoperative need for norepinephrine (9.0 ± 7.6µg/kg vs. 14.9 ± 11.1µg/kg) Reduced postoperative complications (40 vs. 63) Reduced time to reach ICU discharge criteria (15 ± 6h vs. 24 ± 29h) Reduced length of ICU stay (42 ± 19h vs. 62 ± 5h)
13	Single transpulmonary thermodilution and continuous monitoring of central venous oxygen saturation during off-pump coronary surgery. ***Smetkin, et al. 2009 Acta Anaesthesiol Scand***	40	Intratho-racic blood volume index, MAP, HR, $ScvO_2$, CI, CVP	OPCAB	PiCCO plus	Decreased time to "fit for discharge" status 15% Decreased post-operative hospital stay 25%
14	Early goal-directed therapy in moderate to high-risk cardiac surgery patients. ***Kapoor, et al. 2008 Ann Card Anaesth***	30	CI, CVP, MAP, SVI, $ScvO_2$, SVRI, SVV, DO_2I	CABG on CPB	FloTrac, EOCVC, Vigileo	Shorter average duration of ventilation (13.8h vs. 20.7h) Fewer days of inotropic agent use (1.6d vs. 3.8d) Shorter ICU stay (2.6d vs. 4.9d) Shorter hospital stay (5.6d vs. 8.9d)
15	Randomised controlled trial assessing the impact of a nurse delivered, flow monitored protocol for optimisation of circulatory status after cardiac surgery. ***McKendry, et al. 2004 BMJ***	174	SVI	Cardiac	Esopha-geal Doppler	Reduced postop morbidity and mortality (p=0.08) Reduced median hospital stay (9d vs. 7d) Reduced mean hospital stay (13.9d vs. 11.4d, 18% savings in hospital bed days) ICU bed use reduced by 23%
16	A prospective, randomized study of goal-oriented hemodynamic therapy in cardiac surgical patients. ***Polonen, et al. 2000 Anesth Analg***	403	SvO_2, Lactate	Elective cardiac	TD PAC, radial arterial	Shortened median hospital stay (6d vs. 7d, P=0.05) Faster discharge (P=0.05) Reduced morbidity at time of discharge (1.1% vs. 6.1%)
17	Perioperative plasma volume expansion reduces the incidence of gut mucosal hypoperfusion during cardiac surgery. ***Mythen, et al. 1995 Arch Surg***	60	SV	Elective cardiac	Esopha-geal Doppler	Reduced incidence of gut mucosal hypoperfusion at the end of surgery (7% vs. 56%) Reduced major complications (0 vs. 6) Reduced mean hospital stay (6.4d vs. 10.1d) Reduced mean ICU stay (1d vs. 1.7d)

CABG: Coronary artery bypass graft
CPB: Cardiopulmonary bypass
ECOM: Endotracheal cardiac output monitor
EOCVC: Edwards oximetry central venous catheter
OPCAB: Off-pump coronary artery bypass
RIFLE: Risk, injury, failure, loss of kidney function, end-stage kidney disease
TD PAC: Thermodilution pulmonary arterial catheter

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