

Adrian View-Kim Wong, MBBS, FRCA, EDIC, FFICM

**Fluid Management in Critical Illness:
Redefining Assessment and Therapy with
Point-of-Care Ultrasound**

Dissertation on Doctorate in Medical and Health Sciences
in the discipline of Medical Sciences

Supervisor: dr hab. n. med. Mateusz Zawadka

2nd Department of Anaesthesiology and Intensive Care
Medical University of Warsaw



Defending the doctoral dissertation before the
Medical Science Discipline Council
Medical University of Warsaw

Warsaw 2026

Keywords:

fluid overload, venous congestion, point-of-care ultrasound, de-resuscitation, VExUS, tissue perfusion, urethral perfusion index, critical care

Słowa kluczowe:

przewodnienie, zastój żylny, ultrasonografia przyłóżkowa, de-resuscytacja, VExUS, perfuzja tkankowa, wskaźnik perfuzji cewkowej, intensywna terapia

ABSTRACT

Fluid Management in Critical Illness: Redefining Assessment and Therapy with Point-of-Care Ultrasound

Background. Fluid therapy is a fundamental component of critical care medicine. While timely fluid resuscitation is essential for haemodynamic stabilisation in conditions such as septic shock and hypovolaemia, the accumulation of a positive cumulative fluid balance is independently associated with increased mortality, prolonged mechanical ventilation, and organ dysfunction. Although de-resuscitation- the active removal of accumulated fluid, has emerged as a critical therapeutic concept, randomised controlled trials have consistently failed to demonstrate improved clinical outcomes. This thesis investigates the hypothesis that the failure of de-resuscitation trials is attributable, at least in part, to the use of inadequate assessment tools that are dissociated from the physiological reality of venous congestion and tissue perfusion.

Aim. To investigate the role of point-of-care ultrasound (POCUS) and novel monitoring technologies in the assessment of fluid status in critically ill patients, with a focus on the de-resuscitation phase.

Methods. The thesis comprises one systematic review and three prospective empirical studies: (i) a comprehensive systematic review of ultrasound utilisation in de-resuscitation trials (DERESUS SR); (ii) a cross-sectional observational study of 50 critically ill patients (84% mechanically ventilated) with clinical evidence of fluid overload (INCIVEX); (iii) a prospective observational study of 33 patients with end-stage renal failure undergoing intermittent haemodialysis (ACUVEX); and (iv) a prospective interventional feasibility pilot of 27 critically ill patients evaluating a novel urothelial plethysmography device (TARGET-UP).

Results. The systematic review examined thirteen randomised controlled trials enrolling 2,495 patients. Only four of thirteen studies (30.8%) performed any form of ultrasound assessment, and only one study (7.7%) explicitly used ultrasound to guide de-resuscitation decisions. No study achieved positive hard clinical outcomes. In INCIVEX, cumulative fluid balance (mean $7,135 \pm 4,812$ mL) showed no significant correlation with any ultrasound-based marker of venous congestion, cardiac function, or pulmonary fluid accumulation; right ventricular dysfunction was the strongest predictor of elevated VExUS scores. In ACUVEX, despite all

patients meeting conventional criteria for fluid overload, only 15% had elevated VExUS scores; all patients with elevated scores had biventricular systolic dysfunction, and all demonstrated improvement in VExUS grade during fluid removal. In TARGET-UP, the IKORUS device demonstrated excellent feasibility (median signal quality index 93%). While a moderate correlation between the Urethral Perfusion Index (UPi) and LVOT VTi was observed at baseline (Spearman $r = 0.55$, $p < 0.0001$), changes in LVOT VTi following fluid challenges did not predict changes in UPi ($r = 0.24$, $p = 0.14$), demonstrating macro-micro haemodynamic discordance.

Conclusions. Taken together, these studies demonstrate that conventional fluid assessment methods, often comprising cumulative fluid balance, body weight, clinical signs of oedema, and macrocirculatory haemodynamic parameters, do not adequately capture the physiological complexity of fluid status in critical illness. The findings support a conceptual framework integrating cardiac function assessment, venous congestion evaluation, pulmonary assessment, and tissue perfusion monitoring to guide physiology-based fluid management. The work is hypothesis-generating and establishes the rationale for future POCUS-guided de-resuscitation trials.