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Monitoring Fluid Therapy in Renal Transplant Patients: The Tale of Two Recently Published Articles

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Judicious fluid management is one of the key factors of successful renal transplantation. Lack of understanding of the importance of adequate maintenance of intravascular volume may lead to graft failure or even patient death in the peri-operative transplant period [1]. We address in this short summary two review articles published recently by two different groups [2,3]. Both manuscripts provided an in-depth review of this vital topic, which remains unfortunately undermined. However, they handled the topic from two different aspects.

Calixto et al. [2] addressed that optimising perioperative fluid management is likely to improve morbidity and mortality, and thereby, health care costs. On the other hand, Aref et al. [3] explored the different opinions in monitoring fluid therapy in the perioperative period of renal transplantation. Although peri-operative fluid management is of crucial importance, yet there are very few well-conducted randomised controlled trials that are powerful enough to define acceptable guidelines [2-5].

Calixto et al. [2] defined fluid responsiveness as a state of improved stroke volume (SV) and cardiac output (CO) in response to increased intravascular volume. The improvement of SV and CO is not linear and is judged by the Frank-Starling law as illustrated in **Figure 1** [6]. On the other hand, fluid overload resulting from overzealous fluid administration will eventually disrupt the endothelial glycocalyx and cause a shift of fluid to interstitium and impaired tissue oxygenation resulting in increased morbidity and mortality in vulnerable patients [2]. In renal transplantation, fluid overload is not a benign condition due to its association with delayed graft function, poor wound healing and protracted recovery of these critically ill patients sailing through a major operation and receiving immunosuppression [3].

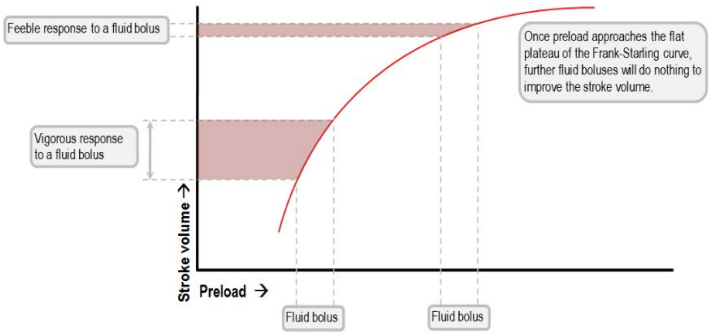

Figure 1. Frank-Starling curve of preload against left ventricular stroke volume (SV) [6].

Calixto et al. [2] also addressed the role of Transoesophageal Echocardiography and technologies relying on pulse contour analysis (PCA) as a more precise alternative to static CO monitoring which was proved to be unreliable and correlate poorly with the intravascular volume. In contrast, Aref et al. [3] focused on the comparison of fluid therapy guided by central venous pressure (CVP) versus novel modern techniques. They also highlighted the limitations in monitoring fluid therapy on the basis of CVP trends in different population groups as shown in **Table 1**. Furthermore, the kidney transplant recipient is exposed to

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several intra-operative confounders that counteract the reliability of CVP measurements like the use of abdominal retractors, the position of the patient (which is not always in flat supine position), in addition to the use of positive pressure ventilation (PPV) during the operation [7,8]. They concluded that CVP should not play any role in monitoring fluid therapy in renal transplantation. They also addressed the alternative non-invasive cardiac output monitoring devices and their specific limitations as summarised in **Table 2** [3].

Table 1. Factors affecting the measured CVP reading [3].

Central venous blood volume	• Venous return/cardiac output • Total blood volume • Regional vascular tone
Compliance of central compartment	• Vascular tone • Right ventricular compliance: – Myocardial disease – Pericardial disease – Tamponade
Tricuspid valve disease	• Stenosis • Regurgitation
Cardiac rhythm	• Junctional rhythm • Atrial fibrillation • Atrio-ventricular dissociation
Reference level of transducer	• Positioning of patient
Intrathoracic pressure	• Respiration • Intermittent positive pressure ventilation (IPPV) • Positive end-expiratory pressure (PEEP) • Tension pneumothorax

Calixto et al. [2] also referred to the work of Ferris et al. [9]. They documented an unexplained drop of CVP readings in the early post-transplant period despite vigorous fluid resuscitation. Undoubtly, this could mislead the clinicians if CVP is used to guid fluid management.

It is worth highlighting those Marik et al. [10] article was the first systematic review that suggested the need to change the traditional glorification of CVP role in perioperative fluid management. Moreover, they also concluded in 2013 in their updated meta-analysis that CVP use to guide fluid resuscitation should be abandoned [11].

We strongly agree that measuring the CVP as a surrogate marker of intravascular volume is a myth in modern medical practice and, therefore, should be abandoned. We also recommend using intra-operative and post-operative cardiac output monitoring devices for guiding fluid therapy in renal transplant recipients.

Table 2. Advantages and limitations of some commercially available (minimally invasive) CO monitoring [3].

Modality	Examples	Advantages	Limitations
Pulse wave analysis	LiDCO*rapid*™ and FloTrac/Vigileo™.	- Requires only arterial line - Beat-by-beat CO monitoring (this may help to evaluate response to IV fluids) - Validated by clinical studies in different medical and surgical conditions	* Presence of arterial line with optimum waveform signal is a prerequisite * Accuracy may be reduced by sever arrhythmia * Needs frequent recalibration during periods of hemodynamic instability
Lithium dilution	LiDCO*plus*™	- Simple technique (can use peripheral arterial line) - Continuous CO monitoring	* Arterial line required * Accuracy affected by some neuromuscular blocking drugs * lithium chloride is contraindicated in patients undergoing treatment with lithium salts
Electrical bioimpedance	BioZ®	- Completely non-invasive	* Numerous mathematical assumptions * Limited validity in patients with dysrhythmias
Partial CO_2 rebreathing	NICO™	- Easy to set up	* Requires intubation and mechanical ventilation with minimal gas exchange abnormalities and fixed ventilator settings * Accuracy decreased with haemodynamic instability
Pulsed dye densitometry	DDG-330®	- Non-invasive	* Intermittent assessment * Accuracy may be affected by vasoconstriction, movement of the sensor and interstitial oedema

CO: Cardiac Output; OR: Operating Room

Finally, we add our voice to Calixto et al. [2] to call for more prospective comparative clinical studies to address the role of the new techniques in the field of renal transplantation.

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