WHAT'S NEW IN INTENSIVE CARE

Can this patient be safely weaned from RRT?

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Introduction

The timing of initiation of renal replacement therapy (RRT) in the critically ill with acute kidney injury (AKI) has been widely studied and discussed in detail recently [1–3]. However, there is limited information and few recommendations for when to discontinue RRT in patients who appear to be improving.

Weaning from RRT in AKI: the evidence

Sadly, between 40% and 60% of critically ill patients with AKI treated with RRT have their treatment discontinued because of withdrawal of life support or death. In those patients who appear to be improving clinically, RRT discontinuation should be considered promptly given that RRT carries an additional risk of morbidity and mortality [4, 5] as it exposes the patient to several complications including catheter-related bloodstream infections or thrombosis, bleeding favored by anticoagulation, and hemodynamic instability. The prolonged continuation of RRT could also be deleterious for renal recovery particularly in cases of intradialytic hemodynamic instability [6]. Moreover, RRT represents a significant additional cost in the patient's care. However, premature cessation of RRT may re-expose the patient to all the complications of AKI, including fluid overload with delayed weaning from the ventilator, electrolyte and acid–base disorders, and uremia. Uchino et al. [7] found that patients who failed RRT weaning had a significantly longer ICU length of stay and mortality; however, whether failure of weaning of RRT is harmful by itself or just a marker of severity of illness remains questionable.

To date several studies have been performed on the predictors for successful discontinuation of RRT in critically ill patients with AKI (ESM Table).

Wu et al. [8] performed a retrospective observational case–control study involving 304 patients who were predominantly treated with intermittent RRT (IRRT). Ninety-four (31%) were weaned for at least 5 days and only 64 of these (21.1%) for more than 30 days. The predictors for failure to wean from RRT at 30 days were a longer duration of renal support, a higher SOFA score, diuresis (less than 300 ml/24 h), and age greater than 65 years. Successful weaning was associated with a falling SOFA score plus increase in urine output.

In the multicenter prospective BEST kidney study (Beginning and Ending Supportive Therapy for the kidney) [7], 529 of 1000 (52.6%) AKI patients treated by RRT survived; and of those, 313 required no further support for at least 7 days and demonstrated a lower observed mortality than the 216 patients who required reintroduction of dialytic support (28.5% vs 42.7% $p < 0.0001$). Importantly, a greater 24-h urine volume was observed in those who weaned successfully with an area under the receiver operating characteristic curve (AUROC) for the predictive ability of urine output to identify successful weaning being 0.81 where diuretics were not used. The authors concluded that patients with more than 400 ml/day of urine without diuretic use or more than 2300 ml/day with diuretics have more than an 80% chance to successfully discontinue RRT. Besides urine output, the kidney concentrating ability in terms of urine chemistry may be of more interest but thus far it has been poorly examined.

In a retrospective study including 85 patients, 53 of whom remained RRT-free 7 days after continuous RRT (CRRT) cessation [9], a 2-h creatinine clearance above a level of 23 ml/min, performed within 12 h of CRRT cessation, had a sensitivity, specificity, and positive predictive

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Fig. 1 Weaning a AKI patient from renal replacement therapy

value for remaining CRRT-free at day 7 of 75.5%, 84.4%, and 88.8%, respectively. It was a useful and better guide for considering CRRT cessation than urine output, serum creatinine, or age.

More recently, Viallet et al. [10] studied 54 patients with normal premorbid renal function who survived severe AKI. Successful weaning was defined as being RRT-free at day 15 after cessation. Interestingly, it was demonstrated that 24-h urinary creatinine excretion (despite diuretic use) was a predictive factor for successful weaning from RRT with a 24-h urinary creatinine of at least 5.2 mmol associated with success in 84% of cases.

In a similar study on patients treated with IRRT the daily urinary urea rather than creatinine was found to be the best indicator for weaning with greater than 1.35 mmol/kg/24 h having an impressive AUROC of 0.96 and a urine output of greater than 8.5 ml/kg/h having an AUROC of 0.86 [11]. However, importantly the patient groups were somewhat different with a third of patients having chronic kidney disease (CKD) as defined by a GFR of less than 30 ml/min compared to the GFR greater than 60 ml/min in the study by Viallet. Unsurprisingly 39% failed to recover renal function.

Several urinary biomarkers including NGAL, HGF, KIM1, Cys-C, and [TIMP-2] $\times$ [IGFBP7] that correlate with renal cell injury or function could potentially predict renal recovery and outcome from AKI. Indeed, studies in critically ill patients with AKI treated with RRT have shown that lower initial levels of biomarkers of inflammation, tissue or kidney injury, or whose levels of these biomarkers decrease over time are more likely to recover kidney function [12–15]. Also, plasma NT-pro-BNP at the initiation of CRRT has been found to be a weaning-related factor [15]. However, these studies focused more on the differentiation between transient and persistent AKI and on renal recovery than on predictive value on successful RRT cessation.

So, can my patient be weaned off RRT?

For the clinician at the bedside, when consideration is being given to stopping acute RRT the following factors should be considered:

1. Has the original precipitant for the AKI resolved?
2. Is there evidence of some degree of recovery of kidney function?
3. Has any fluid overload been resolved?

If these factors have not been achieved, it is unlikely that RRT can be successfully discontinued. Nonetheless, the most important initial “test” is to measure urine output. Where oliguria exists then the ability to clear the solute load is impaired and so weaning should be

postponed. However where urine output is over 400 ml/day or 8.5 ml/kg/day or approaches 30 ml/h then a urine collection could be commenced in order to assess creatinine excretion which may aid decision-making (Fig. 1).

It is ironic that the role of urine biochemistry in the diagnosis of AKI has become less important and yet now we are faced with urinary volume/chemistry providing the best guide to date for successful weaning. In the future, however, it is likely that biomarkers of renal recovery together with real-time GFR estimation will provide further insights into this relatively neglected area of critical care nephrology.

Electronic supplementary material

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Compliance with ethical standards

Conflicts of interest

LF has received honoraria from Fresenius and Baxter for lecturing and consultancy. KK reports no conflicts of interest regarding this paper. NG has received honoraria from Baxter for speaking engagements.

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