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Research paper

A retrospective review of fluid balance control in CRRT

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ABSTRACT

Introduction: An effect of severe acute kidney injury (AKI) is the development of oliguria and subsequent retention of fluid. Recent studies have reported an association between fluid overload and increased mortality in critically ill patients. Achieving fluid balance control through haemofiltration is an important part of dialysis dose delivery in continuous renal replacement therapy (CRRT).
Aims: (1) Compare the prescribed dose with the delivered dose of dialysis and haemofiltration for CRRT. (2) Identify how interruptions and delays in treatment delivery impact on fluid balance management.
Method: A retrospective cohort study was undertaken of daily fluid balance and fluid removal for patients who required CRRT. Each observation chart and prescription order for every treatment day was reviewed. Each patient was exposed to the same treatment mode, predilutional continuous veno-venous haemodiafiltration (CVVHDf). A comparison was made of fluid balance control delivered to the patient over 24 h against the dose of fluid removal prescribed.
Results: The observation charts of 46 consecutive patients were reviewed for total of 288 treatment days. Median number of days patients received CRRT was 5 (range 1–31). Median circuit life was 16 h (range 0–66). Fluid removal targets did not occur in 75 (26%) treatment days. Median daily fluid removal shortfall was 300 mL (range 25–3800 mL). Mean number of daily treatment interruptions 1.25, SD ± 0.49. The most frequent cause of treatment downtime was circuit clotting (45%). Mean length of treatment down time was 3.71, SD ± 4.36 h excluding delays attributed to assessment of renal function.
Conclusion: In over a quarter of treatment days prescribed fluid removal was not achieved. Frequency of interruptions and delays in resumption of treatment compromised fluid balance control. Daily targets for fluid removal which are not achieved contribute to fluid overload and may compromise the outcome of patients who require CRRT.

1. Introduction

Critically ill patients are at particular risk of fluid overload due to the effects of systemic inflammation, reduced oncotic pressure and increased capillary leak. In response to hypotension aggressive fluid resuscitation is sometimes required to replace depleted intravascular volume.[1] Over time the initial benefit of fluid therapy can accumulate in the body, exacerbated by the presence of severe acute kidney injury (AKI) and the manifestation of oliguria.[2] Based on several observational studies,[3–7] and at least two randomised control trials,[8,9] the consequences of excess body fluid outside the intravascular fluid compartment has been shown to adversely affect patient outcomes. For this reason there has been renewed interest in the importance of achieving good fluid balance control in patients at increased risk of becoming fluid overloaded.[10,11]

Continuous renal replacement therapy (CRRT) in Australia and New Zealand continues to dominate clinical practice for fluid overload in the management of patients with severe AKI.[12,13] Advocates of CRRT argue this approach offers the advantage of tighter fluid balance control compared with intermittent renal replacement therapies.[14,15] On commencement of CRRT the ability to reach a clinical target or minimum dose of dialysis and haemofiltration is important to minimise the adverse effects of impaired renal function. This is only possible when a degree of treatment continuity

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is maintained.[16] The timing of when treatment should begin and at what level of support is necessary requires further investigation, but is often driven by individual patient characteristics and clinical preference. In support of renal function it is important that the dose of haemofiltration for fluid removal is achieved and should not be considered of lesser importance than reaching the required dose of dialysis for solute clearance. This was illustrated by the RENAL study where patients with a negative mean daily fluid balance were more likely to do better than those with a positive fluid balance in terms of survival and reduced number of days requiring CRRT.[17]

Causes of treatment interruptions and reasons for delays in recommencement of treatment play an important role in determining whether CRRT dialysis and haemofiltration dose treatment targets (including fluid removal) are achieved. The prospect of patient outcomes made worse in the absence of good fluid balance control make meeting fluid removal treatment targets critical. For this reason we undertook a retrospective observational study of dose ordering and delivery of dialysis and haemofiltration for patients who required CRRT. This included a record of daily fluid balances and volume of fluid removed by haemofiltration.

2. Aims

(1) Compare the prescribed dose with the delivered dose of dialysis and haemofiltration for CRRT. (2) Identify how interruptions and delays in treatment impact on fluid balance management.

3. Method

A retrospective chart review was undertaken of daily fluid balances using a convenience sample of patients who were admitted to ICU and required CRRT between January and April 2013. Patients were exposed to the same treatment mode, predilutional continuous veno-venous haemodiafiltration (CVVHDf), and treated using the Prismaflex CRRT machine (Gambro AB, Stockholm, Sweden) with a Hospal 100ST haemofilter (Lyon, France). Vascular access was achieved using (1) a soft silicone double-lumen 13.5F short-term dialysis catheter (Edward Lifesciences, Irvine, CA, USA), or (2) Palindrome 14.5F long-term dialysis catheter (Covidien, Lane Cove, Australia) for tunnelled vascular access, or (3) blood lines attached directly through an extracorporeal membrane oxygenation (ECMO) circuit to achieve blood flows of between 120 and 200 mL per minute. Duration of circuit life was matched with type of vascular access and choice of strategies for circuit anticoagulation. Four agents were used or withheld if the patient was at high risk of bleeding (platelets $<150 \times 10^9$/L, aPTT > 60 s, <48 h post-surgery, major haemorrhage within last 48 h):

- Low dose unfractionated heparin delivered through the circuit pre-filter (≤600 IU/h) adjusted to a systemic activated partial thromboplastin time (aPTT) target of 40–50 s.
- Intravenous unfractionated heparin for systemic anticoagulation when prolongation of aPTT was required for other reasons (5–10 IU/kg/h).
- Regional citrate anticoagulation (Modified Alabama Protocol)[18] delivered via an extracorporeal circuit blood citrate level of 3–6 mmol/L and $iCa^{2+} < 0.35$ mmol/L.
- Epoprostenol (if patient was suspected of heparin induced thrombocytopenia or regional citrate anticoagulation was contraindicated) diluted to a concentration of 2000 nm/mL and delivered pre-filter with a starting dose of 1–2 nm/kg per minute titrated to maintain a systolic pressure ≥ 110 mmHg.

Determination of dialysis dose prescription (mL/kg/h) for CRRT was based on severity of biochemical imbalance and admission body weight using a Hill-Rom bed with built-in weighing scales (Batesville, IN, USA). The degree of fluid balance control was based according to daily inputs and outputs and the ordered hourly fluid removal target (neutral or negative balance). This was determined by comparing the actual volume of fluid removed by haemofiltration against the predicted volume based on available hours without treatment interruptions. Paper-based documentation of ICU observation charts and a prescription order for each treatment day was reviewed up to the day treatment was stopped, or after a maximum of 14 days was reached without treatment interruptions >48 h. Medical records were reviewed for CRRT prescription orders (including fluid balance) and ICU observation charts reviewed for number of dialysis/haemofiltration hours delivered to the patient.

It was standard practice for the balance of daily inputs and outputs to be checked every six hours and totalled at midnight by the bedside nurse manually. Daily end totals of individual inputs and outputs were checked for accuracy by the research nurse (author HD), but the sum of daily fluid balance totals were not revised retrospectively. Standard practice for patients receiving CRRT also involved weighing patients on alternate treatment days until CRRT was no longer required. As an indicator of whether a patient had adequate circulatory volume the lowest mean arterial pressure (MAP) and the highest concentration of vasopressor support was recorded for each treatment day.

Information on the number of days a patient required CRRT was obtained from the ICU observation chart and reference to the patient's medical records. Treatment was considered to have started after vascular access insertion and end of treatment when the circuit was ceased and a medical decision made not to continue treatment. Causes of interruptions and delays in treatment were based on information documented on the ICU observation chart. Confirmation of procedures performed outside ICU were crossed referenced with the patient's medical record.

4. Setting

The recruitment of patients occurred within a Level III ICU,[19] at a metropolitan tertiary-referral hospital in Western Australia.

5. Ethical considerations

Approval was granted by the institutional Ethics Committee (EC2012/121). The study was considered low risk and written consent was not required.

6. Results

A total of 46 patients required CRRT out of 568 patients (8%) admitted to ICU over the study duration of 4 months. Patient characteristics are displayed in Table 1. The median age of patients was 56.5 years (range 19–86) and 23 (50%) were male. Median length of ICU stay was 7.5 days (range 1–77) and mean Acute Physiology and Chronic Health Evaluation (APACHE) II score was 22 SD ± 8. Fifteen (33%) patients did not survive to ICU discharge.

A total of 288 24 hour ICU observation charts were reviewed for the use of 227 circuits. The median number of days each patient required CRRT was 5 (range 1–31). The mean CRRT start time (number of hours between insertion of vascular access and commencement of CRRT) was 3.1 h (SD ± 4.83). The most common vascular access site was the internal jugular vein (55%, $n = 124$). Out of 227 circuits, 154 (68%) were anticoagulated with pre-filter heparin. Median circuit life as the result of clotting was 15.5 h (range 2–61). A summary of circuit life associated with anticoagulation strategies and other factors influencing how CRRT was delivered is shown in Tables 2 and 3.

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