Early Renal Replacement Therapy During Pediatric Cardiac Extracorporeal Support Increases Mortality

Michael J. Wolf, MD, Nikhil K. Chanani, MD, Micheal L. Heard, RN, Kirk R. Kanter, MD, and William T. Mahle, MD

Background. Acute kidney injury is a common comorbidity for children placed on extracorporeal membrane oxygenation (ECMO) because of primary cardiac disease. Continuous venovenous hemofiltration (CVVH) can optimize fluid status and lessen inflammatory response during ECMO. However, published data are derived primarily from children without primary cardiac disease.

Methods. A retrospective analysis of our institutional ECMO database from 2002 to 2011 was performed. To limit the bias that CVVH initiation was after evidence of end-organ injury, we considered “early CVVH” to be instituted within 48 hours of ECMO initiation. Multivariate logistic regression was undertaken to adjust for covariates.

Results. Of 153 cardiac ECMO patients, 59 (39%) received early CVVH. Time from ECMO initiation to CVVH initiation was 1.7 ± 0.7 days (median 1 day). Pre-ECMO and post-ECMO serum creatinine levels were similar in both groups. However, peak serum creatinine was 1.1 ± 0.4 mg/dL (median 1.0 mg/dL) in the ECMO and CVVH group and 0.9 ± 0.4 mg/dL (median 0.8 mg/dL) in the ECMO alone group ($p = 0.003$). Patients who received CVVH had a higher mortality ($p < 0.0001$), were less likely to have had ECPR ($p = 0.004$), and had a longer duration on ECMO ($p < 0.0001$). In multivariate analysis subjects receiving CVVH support within 48 hours of ECMO cannulation were 3 times more likely to die during their hospitalization (odds ratio 3.02; 95% confidence interval 1.32 to 6.9, $p = 0.009$) after adjusting for other significant risk factors.

Conclusions. Early CVVH in pediatric cardiac patients requiring ECMO is associated with increased mortality. Early CVVH in the cardiac ECMO population does not appear justified.


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Extracorporeal membrane oxygenation (ECMO) is frequently deployed as a temporary lifesaving therapy in pediatric patients with cardiac failure secondary to surgical or medical heart disease. Patients on ECMO are prone to develop acute kidney injury (AKI) and fluid overload leading to increased risk of mortality [1–3]. Continuous venovenous hemofiltration (CVVH) has been used successfully in series with ECMO to treat concurrent AKI or fluid overload in both venovenous and venoarterial ECMO [4–7]. The presence of AKI after congenital heart surgery also increases mortality risk, even in the absence of ECMO support [8].

The CVVH, when combined with ECMO, improves fluid overload and treats AKI without compromising future renal function in survivors [9, 10]. In addition, early and aggressive fluid management with CVVH is thought to be beneficial to outcomes in ECMO patients [3, 11, 12]. The addition of CVVH in series with the ECMO circuit allows for tight control of fluid balance and achievement of negative fluid balance early in the treatment course [5]. Additional theoretical benefits of CVVH include decreased diuretic requirements and potential anti-inflammatory effects [3].

The use of CVVH during ECMO support is not universal, with center-specific guidelines driving alternate therapies and the timing of its use. Fluid restriction and aggressive diuretic regimens are among the alternative treatments employed to treat AKI and fluid overload on ECMO. Because of their variable effectiveness and the inability for tight fluid control, these methods are thought less efficient than CVVH [5, 9]. Alternate methods of dialysis, notably peritoneal dialysis, have been employed with varying levels of success in ECMO patients [13, 14].

The presence of renal insufficiency or renal failure and its influence on mortality in the pediatric cardiac patient is well described [8, 15–17]. In addition, the aggressive treatment of fluid overload in these patients may improve morbidity and mortality [18, 19]. We therefore hypothesized that early institution of CVVH in patients requiring ECMO for cardiac failure secondary to congenital or medical heart disease would be beneficial without significantly affecting their long-term renal function.

Material and Methods

Approval for this study was obtained from the Children’s Healthcare of Atlanta Institutional Review Board. Data on
pediatric cardiac patients receiving ECMO from January 2002 through December 2011 were collected from the individual medical record and our institutional ECMO database. Pediatric cardiac patients were defined as those receiving ECMO support because of a cardiac diagnosis, either congenital heart disease or medical heart disease. All patients were treated in the cardiac intensive care unit.

Data collected included patient age, weight, cardiac diagnosis, risk adjustment for congenital heart surgery (RACHS) score, serum creatinine prior to ECMO initiation, peak serum creatinine, serum creatinine after discontinuation of ECMO, ECMO cannulation via extracorporeal cardiopulmonary resuscitation (ECPR) pathway, duration of ECMO support, duration of CVVH support, time to institution of CVVH, serum pH and lactate prior to ECMO initiation, and survival to hospital discharge.

Intermediate term renal function in survivors of ECMO who required CVVH was determined based upon chart review of subsequent outpatient and inpatient visits. This was completed in order to determine the presence of renal insufficiency or ongoing need for dialysis.

The CVVH initiation during ECMO support in the cardiac intensive care unit at Children’s Healthcare of Atlanta was based upon the discretion of the cardiac intensive care attending physician and the cardiothoracic surgery attending physician. In order to limit the bias that intensive care attending physician and the cardiothoracic surgery attending physician at Children’s Healthcare of Atlanta was based upon the discretion of the cardiac intensive care attending physician and the cardiothoracic surgery attending physician, we considered “early CVVH” to be CVVH instituted within 48 hours of ECMO initiation. The most common indication for institution of early CVVH was fluid overload. The general practice included a trial of diuretic usage and monitoring of response before initiation of CVVH. Without adequate response to diuretics in the first 12 to 24 hours after ECMO cannulation, CVVH was considered for augmentation of fluid removal. Patients who had demonstrated poor diuretic response prior to ECMO cannulation had CVVH added earlier in their ECMO course.

The CVVH prescription was based upon a desired hourly fluid balance and was completed in consultation with the nephrology service. Patients were started with an even fluid balance to insure tolerance and then increased by increments of 5 to 10 mL/hour in smaller children, and 25 to 50 mL/hour in larger children, to the prescribed fluid removal rate. The goal fluid balance was based upon cumulative intake and output, patient weight, and central venous or left atrial pressures when available.

The ECMO circuits during the entire study period utilized standard roller-head pumps (Stöckert S3; Sorin Biomedical Inc, Irvine, CA) and QUADROX oxygenators (MAQUET Medical Systems, Wayne, NJ). Continuous VVH was provided by insertion of a hemofilter inline, with pre-oxygenator blood running to the hemofilter and returning proximal to the ECMO bladder. Blood flow to the hemofilter was driven by the ECMO pump. Ultrafiltrate flow was controlled by a standard intravenous pump and was measured through standard urometer. Replacement fluid was delivered through intravenous pump immediately distal to the hemofilter, proximal to the return line to the ECMO circuit. In cases where ultrafiltration exceeded 2 liters per hour, hemofiltration was provided by the use of an inline stand-alone continuous renal replacement therapy delivery device (Diapact; Braun Medical Inc, Bethlehem, PA) [5, 9].

The primary outcome for this study was survival to hospital discharge. Secondary outcome was the presence of renal insufficiency or chronic renal failure after the use of ECMO and CVVH concurrently.

Statistical analysis was performed using STATA 12.0 software (StataCorp LP, College Station, TX). Univariate analysis was performed using the Student t test or analysis of variance (ANOVA) for continuous data and Fisher exact tests for categoric data. To predict the impact of early CVVH on mortality risk, all variables with p less than 0.1 on univariate analysis (Table 1) were entered into a multivariate logistic regression analysis. A p value less than 0.05 was considered statistically significant.

Results

One-hundred and fifty-three patients received ECMO for a cardiac diagnosis during the study period and 71 patients (46%) survived to hospital discharge. One-hundred and forty-nine (97%) of those were venoarterial ECMO. Of the 153 patients who received ECMO, 94 (61%) were treated with ECMO alone and 59 (39%) were treated with ECMO and CVVH concurrently. The CVVH was instituted within 48 hours of ECMO initiation in all 59 patients included in the analysis. None of the ECMO and CVVH patients demonstrated renal failure, or end-stage renal disease as defined by the pediatric-modified risk, injury, failure, loss of function, and end-stage kidney disease (pRIFLE) criteria at CVVH initiation [20, 21].

Cardiac diagnoses included hypoplastic left heart syndrome (17%), other single ventricle lesions (19%), total anomalous pulmonary venous return (8%), other biventricular lesions (37%), and cardiomyopathy and myocardiopathies (19%). In the ECMO alone group, 75 (80%) were postoperative from cardiac surgery. In the ECMO and CVVH group, 49 (83%) patients were postoperative from cardiac surgery. Specific cardiac diagnoses for the ECMO and CVVH cohort are summarized in Fig 1.

Patient demographics are summarized in Table 1. There were no significant differences in age, weight, pre-ECMO creatinine, post-ECMO creatinine, and pre-ECMO lactate levels between the ECMO and CVVH patients and the ECMO alone patients. The RACHS score was 4.2 ± 1.4 (median 4; range 1 to 6) in the ECMO and CVVH group and 3.7 ± 1.5 (median 4; range 1 to 6) in the ECMO alone group (p = 0.07). Twenty-five percent of patients in the ECMO and CVVH group survived to hospital discharge, and 60% of patients in the ECMO alone group survived to hospital discharge (p < 0.001). Thirty-seven percent of patients in the ECMO and CVVH group were cannulated via the ECPR pathway versus 67% in the ECMO alone group (p < 0.001). The ECMO support duration in the ECMO and CVVH group was 11.2 ± 7.5 days (median 9 days; range 2 to 42 days) compared with 4.8 ± 2.9 days (median 4 days; range 1 to 17 days) in the ECMO
alone group \( (p < 0.001) \). Peak creatinine was 1.1 ± 0.4 mg/dL (median 1.0 mg/dL; range 0.6 to 2.6 mg/dL) in the ECMO and CVVH group versus 0.9 ± 0.4 mg/dL (median 0.8 mg/dL; range 0.3 to 2.1 mg/dL) in the ECMO alone group \( (p = 0.003) \). Pre-ECMO pH was 7.24 ± 0.16 (median 7.24; range 6.95 to 7.57) in the ECMO and CVVH group versus 7.13 ± 0.2 (median 7.17; range 6.6 to 7.59) in the ECMO alone group \( (p < 0.001) \).

In patients receiving ECMO and concurrent CVVH, the time from ECMO initiation to CVVH institution was 1.7 ± 0.7 days (median 1 day, range 0 to 2 days). Information regarding the ECMO and CVVH group is summarized in Table 2. Survivors were aged 21 ± 43 days (median 39 days) versus 5 ± 18 days (median 11 days) in non survivors \( (p = 0.04) \). Survivors and non survivors did not differ significantly in weight, RACHS score, ECMO duration, CVVH duration, time to CVVH institution, cannulation via ECPR pathway, pre-ECMO pH, and lactate level. There was no significant difference between survivors and nonsurvivors in serum creatinine levels before ECMO, before CVVH, after ECMO, or peak creatinine levels. Five patients (33%) from the survivors and 6 patients (14%) from the non survivors were treated with inline standalone CVVH \( (p = 0.12) \); the remainder were treated with an inline hemofilter.

Among survivors from the ECMO and CVVH cohort, all had normal renal function prior to discharge from the hospital. Chart review from subsequent inpatient and outpatient visits did not reveal any evidence of renal insufficiency or failure in the 15 survivors.

Using multivariate logistic regression analysis, after adjustment for ECPR, postoperative status, RACHS score, and pre-ECMO creatinine, early CVVH was independently associated with in-hospital death with an odds ratio (OR) of 3.02 (95% confidence interval 1.3 to 6.9) \( (p = 0.009) \). Patients who were cannulated via the ECPR pathway were more likely to survive to hospital discharge with an OR for death of 0.49 (95% confidence interval 0.2 to 0.99; \( p = 0.05 \)). Multivariate logistic regression results are summarized in Table 3.

### Table 1. Patient Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>ECMO/CVVH</th>
<th>ECMO</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>59</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Age (days)</td>
<td>9 ± 27 (13)</td>
<td>21 ± 54 (57)</td>
<td>0.11</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>6.1 ± 9.5 (3.3)</td>
<td>8.7 ± 12.4 (3.8)</td>
<td>0.17</td>
</tr>
<tr>
<td>RACHS</td>
<td>4.2 ± 1.5 (4)</td>
<td>3.7 ± 1.4 (4)</td>
<td>0.07</td>
</tr>
<tr>
<td>Survived hospitalization (%)</td>
<td>15 (25%)</td>
<td>56 (60%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ECPR (%)</td>
<td>22 (37%)</td>
<td>63 (67%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ECMO duration (days)</td>
<td>11.2 ± 7.5 (9)</td>
<td>4.8 ± 2.9 (4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pre-ECMO creatinine (mg/dL)</td>
<td>0.9 ± 0.4 (0.7)</td>
<td>0.7 ± 0.3 (0.6)</td>
<td>0.08</td>
</tr>
<tr>
<td>Post-ECMO creatinine (mg/dL)</td>
<td>0.8 ± 0.3 (0.7)</td>
<td>0.8 ± 0.4 (0.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>Peak creatinine (mg/dL)</td>
<td>1.0 ± 0.4 (1.0)</td>
<td>0.9 ± 0.4 (0.8)</td>
<td>0.003</td>
</tr>
<tr>
<td>Pre-ECMO pH</td>
<td>7.24 ± 0.16 (7.24)</td>
<td>7.13 ± 0.2 (7.17)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pre-ECMO lactate (mg/dL)</td>
<td>94 ± 52 (91)</td>
<td>100 ± 48 (97)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Values expressed as mean ± SD (median).

CVVH = continuous venovenous hemofiltration; ECMO = extracorporeal membrane oxygenation; ECPR = extracorporeal cardiopulmonary resuscitation; RACHS = risk adjustment for congenital heart surgery.
Table 2. ECMO and CVVH Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Survivors</th>
<th>Non Survivors</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>15 (25%)</td>
<td>44 (75%)</td>
<td></td>
</tr>
<tr>
<td>Age (days)</td>
<td>21 ± 43 (39)</td>
<td>5 ± 18 (11)</td>
<td>0.04</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>9.3 ±14 (4)</td>
<td>5 ± 7.2 (3)</td>
<td>0.13</td>
</tr>
<tr>
<td>RACHS</td>
<td>4.4 ± 1.5 (4)</td>
<td>4.2 ± 1.4 (4)</td>
<td>0.71</td>
</tr>
<tr>
<td>ECMO duration (days)</td>
<td>9.7 ± 9.6 (8)</td>
<td>11.7 ± 6.7 (10)</td>
<td>0.37</td>
</tr>
<tr>
<td>CVVH duration (days)</td>
<td>14.6 ± 19.1 (5)</td>
<td>10.1 ± 7.8 (8.5)</td>
<td>0.2</td>
</tr>
<tr>
<td>Time to CVVH (days)</td>
<td>1.4 ± 0.5 (1)</td>
<td>1.8 ± 1.4 (1)</td>
<td>0.7</td>
</tr>
<tr>
<td>ECPR (%)</td>
<td>6 (40%)</td>
<td>15 (34%)</td>
<td>0.7</td>
</tr>
<tr>
<td>Pre-ECMO pH</td>
<td>7.22 ± 0.18 (7.23)</td>
<td>7.25 ± 0.16 (7.25)</td>
<td>0.55</td>
</tr>
<tr>
<td>Pre-ECMO lactate (mg/dL)</td>
<td>96 ± 56 (97)</td>
<td>93 ± 51 (90)</td>
<td>0.8</td>
</tr>
<tr>
<td>Pre-ECMO creatinine (mg/dL)</td>
<td>0.8 ± 0.4 (0.7)</td>
<td>0.8 ± 0.4 (0.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>Pre-CVVH creatinine (mg/dL)</td>
<td>0.9 ± 0.3 (0.9)</td>
<td>0.9 ± 0.4 (0.9)</td>
<td>1.0</td>
</tr>
<tr>
<td>Post-ECMO creatinine (mg/dL)</td>
<td>0.8 ± 0.3 (0.8)</td>
<td>0.8 ± 0.4 (0.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>Peak creatinine (mg/dL)</td>
<td>1.1 ± 0.4 (1.0)</td>
<td>1.1 ± 0.4 (1.0)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Values expressed as mean ± SD (median).

CVVH = continuous venovenous hemofiltration; ECMO = extracorporeal membrane oxygenation; ECPR = extracorporeal cardiopulmonary resuscitation; RACHS = risk adjustment for congenital heart surgery.

Comment

Acute kidney injury is an independent risk factor for increased in-hospital mortality in pediatric patients requiring ECMO [2]. In addition, fluid overload during ECMO support has also been associated with increased mortality risk [3, 11]. Continuous VVH is an important and efficient therapy that can be used concurrently with ECMO to treat AKI and fluid overload [22, 23]. This is the first study to our knowledge to examine early CVVH utilization during ECMO support in pediatric cardiac patients. The utilization of early CVVH in ECMO patients who often received large volumes of fluid and blood products during and after cannulation would seem prudent in light of the evidence that fluid overload worsens their outcomes [3]. There remains variability of practice across centers regarding the use of early CVVH in ECMO patients.

Concurrent CVVH and ECMO use in pediatric patients continues to increase because of the ability for close titration of fluid balance without the potential for less predictable volume shifts that can accompany diuretic administration. The results of this study question the practice of early CVVH in cardiac patients requiring ECMO support. Despite the potential benefits of CVVH, its emergence as an independent risk factor for mortality is concerning. We question whether the ease of fluid removal by CVVH may create an ongoing cycle of intravascular depletion, and despite the rapid reversal of fluid overload patient outcomes may be adversely impacted. While more efficient than diuretics, this intravascular depletion in CVVH patients may precipitate pre-renal azotemia, subsequent AKI, thereby lengthening the duration of ECMO support and increase mortality.

This intravascular depletion and pre-renal azotemia may be reflected by the higher peak creatinine level in our ECMO and CVVH group (median 1.0 mg/dL versus 0.8 mg/dL). While this did not necessarily predict intermediate or long-term renal dysfunction, this likely represents over-diuresis by means of aggressive early fluid removal with CVVH. The intravascular depletion caused by aggressive fluid removal comes at a time of maximal capillary leak and inflammatory response after ECMO cannulation.

There has been some evidence that inline hemofiltration is inferior to standalone hemofiltration in ECMO patients [3]. At our institution ultrafiltration rates less than 500 mL/hour can be achieved by traditional CVVH by an inline hemofilter, while higher ultrafiltration rates require inline standalone CVVH. The proportion of patients receiving each mode of CVVH did not differ between survivors and non survivors.

Being that the majority of patients in this cohort had undergone congenital heart surgery prior to ECMO cannulation we chose RACHS score to measure severity of illness. The RACHS score has been shown to correlate with morbidity and mortality after congenital heart surgery [21, 23, 24]; RACHS scores were available for 75% of patients from each cohort. The mean RACHS scores were slightly higher in the ECMO and CVVH group, but the median score was the same in both groups. Though

Table 3. Multivariate Logistic Regression

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVVH</td>
<td>3.02</td>
<td>1.32-6.9</td>
<td>0.009</td>
</tr>
<tr>
<td>ECPR</td>
<td>0.49</td>
<td>0.24-1.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Postoperative</td>
<td>3.68</td>
<td>1.55-8.75</td>
<td>0.003</td>
</tr>
<tr>
<td>Pre-ECMO creatinine</td>
<td>4.94</td>
<td>1.33-18.3</td>
<td>0.02</td>
</tr>
<tr>
<td>RACHS score</td>
<td>0.98</td>
<td>0.53-1.79</td>
<td>0.95</td>
</tr>
</tbody>
</table>

CI = confidence interval; CVVH = continuous venovenous hemofiltration; ECMO = extracorporeal membrane oxygenation; ECPR = extracorporeal cardiopulmonary resuscitation; RACHS = risk adjustment for congenital heart surgery.
approaching statistical significance ($p = 0.07$) on univariate analysis, RACHS score did not emerge as significant in the multivariate model.

There were a number of other risk factors identified in our analysis. The ECMO and CVVH patients were younger than ECMO alone patients (median 13 days versus 57 days), though this difference did not reach statistical significance. A greater percentage of patients in the ECMO alone group were cannulated via the ECPR pathway. The ECPR at our institution is available in the cardiac intensive care unit and patients with a potentially reversible process are eligible. There is a designated ECPR circuit available at all times. Cardiac ECPR patients at our institution have comparable survival rates to patients cannulated for ECMO electively or urgently [25]. In multivariate logistic regression analysis ECPR was predictive of lower mortality risk. We felt this was due to the etiology of the cardiac arrest precipitating ECMO cannulation, with survivors of ECPR having surgically or medically reversible conditions. In the ECMO and CVVH cohort the percentage of ECPR patients did not differ between survivors and non survivors (40% vs 34%; $p = 0.7$).

Interestingly, patients in the ECMO alone group had significantly lower pH at ECMO initiation despite their superior survival. We attributed this to the large number of ECPR patients in the ECMO alone cohort, who typically had lower pH levels at ECMO cannulation, due to ongoing cardiopulmonary resuscitation. Despite the lower pH, there was no difference in the pre-ECMO serum lactate level between the 2 groups. Serum lactate levels, as opposed to pH, have been shown to correlate with adverse outcomes after pediatric cardiac surgery [26].

The duration of ECMO support was significantly longer in the ECMO and CVVH group (median 9 days versus 4 days). We felt this represented severity of illness rather than an independent risk factor for mortality. Survivors in the ECMO and CVVH cohort had median length of ECMO duration of 8 days and it did not differ significantly from the duration of ECMO in non survivors from that cohort. In addition, nonsurvivors from the ECMO alone cohort had a median duration of ECMO of 5 days, supporting our attribution of the longer duration of ECMO in the ECMO and CVVH group to severity of illness.

The only parameter that reached statistical significance in the ECMO and CVVH group was age, with survivors being older than non survivors (median 39 days versus 11 days). The CVVH duration was longer in non survivors, but did not reach statistical significance.

This study has several important limitations. This is a single center retrospective analysis and CVVH practices in ECMO patients differ across institutions. Although we were able to determine renal function at ECMO and CVVH initiation, we could not accurately determine fluid balance. The use of electronic medical records to record fluid balance started in 2008 at our institution, and net fluid balance at ECMO cannulation before that time period was not available. For the same reason diuretic use and patient response to diuretics in both cohorts could not be accurately analyzed. Target CVVH prescription for individual patients was not available as this is managed by bedside orders as dictated by clinical variation in patient status. In addition, other comorbidities such as intrinsic lung disease or infection were not included.

We demonstrate an association with early CVVH and increased in-hospital mortality in pediatric cardiac patients requiring ECMO support. This calls into question a strategy of early CVVH in the cardiac ECMO population. While useful for aggressive fluid removal, a strategy of early CVVH in pediatric cardiac patients on ECMO may precipitate intravascular depletion at a time of maximal capillary leak, compromising renal perfusion and precipitating AKI. When CVVH is used early in ECMO support, judicious fluid removal should be considered to avoid early intravascular depletion. Further evaluation by a randomized control trial would be warranted.

References


INVITED COMMENTARY

A generally accepted essential element for successful separation from extracorporeal membrane oxygenation is the removal of excess body water. What remain controversial are when and how to remove the fluid: early or late, with diuretics or with hemofiltration techniques. In this series, the authors [1] demonstrate increased acute kidney injury and death when early continuous venovenous hemofiltration (CVVH) is used during pediatric cardiac support and conclude that “early” CVVH is not justified.

To understand the implications, we must reexamine the goals and strategies for fluid removal. After congenital heart operations, we observe a variable inflammatory response to cardiopulmonary bypass and cooling, with equally variable recovery. Some infants make large volumes of urine the night of the operation, and others may make minimal urine for 24 to 48 hours before beginning to diurese. Shouldn’t we expect the same variability in patients on extracorporeal membrane oxygenation, particularly after cardiopulmonary bypass? If so, it is not surprising that the routine practice of early ultrafiltration will remove fluid from some patients who still have capillary leaks, cannot yet mobilize interstitial fluid into their intravascular compartment, and thus become intravascularly depleted, leading to acute renal injury. “Early” should not be defined by the clock or calendar, however, but by the patient’s preload and ability to mobilize excess body water into the intravascular space after reestablishing integrity at the capillary level.

Although the data are valid and significant, we must be cautioned not to over-interpret the results or conclusions. The observed increased mortality rate is likely related to the timing of the fluid removal as much as to the method. Hemofiltration and diuretic-augmented native renal function may both be safely used once the physiologic conditions are appropriate. However, it is important to recognize that the risk of excessive fluid removal, with resultant acute renal injury, is higher with extracorporeal fluid removal than with native renal function, because even with diuretics, diuresis only occurs when there is sufficient preload to allow it and will automatically wane as the preload decreases.

Thus, although CVVH clearly has a role and is more “efficient” than diuretics in fluid removal, it must be used with caution and only when the body is capable of mobilizing its excess body water. So rather than concluding that “early” CVVH is unjustified or inappropriate, we can conclude that the use of CVVH that is “too early” for an individual patient is where the risk exists, and thus individualize our clinical judgment in the applications of these techniques.

Michael H. Hines, MD
University of Texas Medical School at Houston
6431 Fannin St, MSB 6.264
Houston, TX 77030
e-mail: michael.h.hines@uth.tmc.edu

Reference