INTRODUCTION

Continuous renal replacement therapy (CRRT) is the preferred mode of renal support for critically ill patients with acute kidney injury. CRRT provides more stable hemodynamic stability than conventional intermittent hemodialysis and minimizes the risks of infection associated with peritoneal dialysis. Also, CRRT can be used to correct electrolyte imbalance and to manage metabolic acidosis and fluid clearance. CRRT was inspired by the limitation in the use of intermittent hemodialysis in hemodynamically unstable patients and has been demonstrated to improve hemodynamic and cerebrovascular stability compared with intermittent hemodialysis in patients with acute renal failure who also have liver failure or cerebral edema.(1,2) CRRT usually have been used in the intensive care unit for treatment of postoperative acute renal failure in the anesthesia, but it is becoming a more commonly used therapy in the perioperative period because of the demonstrated value and advantages of CRRT.

We report the successful use of CRRT during the anesthesia for nephrectomy in acute emphysematous pyelonephritis at the operating room and the following use of CRRT in intensive care unit (ICU).

CASE REPORT

A 48-year-old, 147 cm, 60 kg woman presented to the Emergency Department (ED) complaining of a 1 week history of fever, which had got progressively worse over the days with unresponsiveness to antipyretics and right side flank pain associated vomiting. Past medical history included hepatitis B virus carrier for 8 years associated with liver cirrhosis (Child-Pugh criteria C), which was diagnosed one year ago and uncontrolled diabetes mellitus, which was diagnosed one year ago, but stopped to take insulin by herself one month ago due to mood depression. On admission she was alert and oriented but lethargy, presented dyspnea and chilling tremor. Her vital sign was BP 80/50 mmHg, HR 100 bpm, body temperature 39.2°C, oxygen saturation 85-90%. Oxygen with nasal prong was supplied and 0.9% normal saline was injected with intravenous line. Preoperative investigations were:
hemoglobin 12.6 g/dL, hematocrit 37.1%, platelet 139x10^3/mm^3, activated partial thromboplastin time 34.8 sec, prothrombin time 21.7 sec, INR 2.15, aspartate aminotransferase 49 IU/L, alanine aminotransferase 50 IU/L, blood urea nitrogen 27.9 mg/dL, creatinine 1.9 mg/dL, albumin 2.3 g/dL. Electrolyte was Na/K/Cl 130/5.7/104 mM/L. Arterial blood gas analysis revealed pH 7.194, pCO2 38.4 mmHg, pO2 79.8 mmHg, with base excess -13.7. Abdominal computer tomography revealed emphysematous acute pyelonephritis with abscess in right kidney. Emergent right nephrectomy was planned. Dopamine as vasopressor was started with continuous infusion and left radial artery was catheterized and central venous catheter was placed in the right jugular vein in ED. Also right femoral vein was catheterized with a single dual-lumen venous cannula as a port for CRRT and managed by capping the catheter to minimize the risk of dislodgement.

Because of aggravating metabolic acidosis with sepsis and acute renal failure, medical team decided to use "Continuous renal replacement therapy (CRRT)" during the surgery. On arrival at operating room, the patient was seemed to be drowsy mental status without any anesthetic premedication. Heart rate was around 140 bpm, blood pressure was 100/60 mmHg under continuous dopamine infusion and respiration was quite shallow and rapid (30~40 per minute). Oxygen saturation by pulse oximetry was 82% under 8 L/min with oxygen mask. Monitoring was done with electrocardiogram, continuous arterial blood pressure in radial artery cannulation, pulse oximetry, end tidal CO2, central venous pressure, hourly urine output and blood glucose.

After preoxygenation, midazolam 5 mg, fentanyl 200 ug was injected for the induction of anesthesia. Following rocuronium 50 mg for muscle relaxation after checking of unconsciousness, trachea was intubated with reinforced endotracheal tube. Anesthetic maintenance was done through 100% oxygen 3 L/min with low concentration of sevoflurane (under 1 vol%) and continuous infusion of remifentanil (0.04-0.1 ug/kg/min).

Before starting of operation, we installed hemofilter with semipermeable membrane to preheparinized CRRT circuit. We used HEMOSOL B0 dialysis fluid (5 L, [Calcium chloride, Magnesium chloride, Sodium bicarbonate, Sodium Chloride, Sodium lactate], Gambro, Korea) as a dialysate, and the port of right femoral vein was connected with CRRT equipment. We selected CVVHDF (Continuous Veno Venous hemodiafiltration) as CRRT mode. The blood flow rate (BFR) 80-100 ml/min, the dialysate flow rate (DFR) 1000-1800 ml/hr and the patient removal rate (PRR) 55-80 ml/hr were controlled within the range following the patient’s hemodynamic status during the operation.

During the surgical procedure, massive bleeding was drained due to big abscess pocket with severe adhesion and collateral circulation with the advanced liver cirrhosis. Intermittent ephedrine and phenylephrine injection, continuous dopamine infusion and fluid therapy were actively used to maintain adequate blood pressure. Overall anesthesia time was 4 hours and 55 minutes, the patient received 4,600 mL of normal saline, 8 units of packed red blood cell, 10 units of fresh frozen plasma, and had an estimated blood loss of 3,500 mL and urine output of 95 mL during the nephrectomy.

After the operation, the patient was transferred to the ICU in the sedated state with endotracheal tube and controlled mode ventilation was maintained. For about 9 days after surgery, CRRT was continuously performed (Table 1), and after that, intermittent hemodialysis
Table 1. Metabolic Changes during the Surgery and Postoperative Period

<table>
<thead>
<tr>
<th>Time from anesthesia</th>
<th>pH</th>
<th>PaO&lt;sub&gt;2&lt;/sub&gt; mmHg</th>
<th>PaCO&lt;sub&gt;2&lt;/sub&gt; mmHg</th>
<th>BE mmol/L</th>
<th>Standard bicarbonate mmol/L</th>
<th>Na mEq/L</th>
<th>K mEq/L</th>
<th>Creatinine mg/dL</th>
<th>Glucose mg/dL</th>
<th>HCT %</th>
<th>INR</th>
<th>AST IU/L</th>
<th>ALT IU/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preop</td>
<td>7.194</td>
<td>79.8</td>
<td>38.4</td>
<td>-13.7</td>
<td>14.5</td>
<td>130</td>
<td>5.7</td>
<td>1.9</td>
<td>37.1</td>
<td>335</td>
<td>2.15</td>
<td>49</td>
<td>50</td>
</tr>
<tr>
<td>60 min</td>
<td>7.149</td>
<td>176.0</td>
<td>46.0</td>
<td>-13.2</td>
<td>15.6</td>
<td>142</td>
<td>4.6</td>
<td>21.1</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 min</td>
<td>7.162</td>
<td>93.4</td>
<td>45.2</td>
<td>-12.8</td>
<td>15.8</td>
<td>141</td>
<td>4.3</td>
<td>16.4</td>
<td>121</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240 min</td>
<td>7.189</td>
<td>98.6</td>
<td>46.8</td>
<td>-10.8</td>
<td>17.4</td>
<td>144</td>
<td>4.5</td>
<td>21.8</td>
<td>101</td>
<td>2.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>480 min</td>
<td>7.136</td>
<td>105.4</td>
<td>43.5</td>
<td>-14.7</td>
<td>14.3</td>
<td>141</td>
<td>4.7</td>
<td>1.8</td>
<td>34.4</td>
<td>86</td>
<td>2.60</td>
<td>67</td>
<td>28</td>
</tr>
<tr>
<td>POD #1</td>
<td>7.318</td>
<td>92.1</td>
<td>39.6</td>
<td>-6.7</td>
<td>18.5</td>
<td>140</td>
<td>5.0</td>
<td>1.8</td>
<td>31.7</td>
<td>176</td>
<td>3.95</td>
<td>123</td>
<td>61</td>
</tr>
<tr>
<td>POD #2</td>
<td>7.404</td>
<td>86.4</td>
<td>39.9</td>
<td>-0.4</td>
<td>24.4</td>
<td>136</td>
<td>4.8</td>
<td>1.4</td>
<td>26.2</td>
<td>104</td>
<td>2.88</td>
<td>131</td>
<td>61</td>
</tr>
<tr>
<td>POD #3</td>
<td>7.444</td>
<td>95.9</td>
<td>37.2</td>
<td>0.8</td>
<td>24.9</td>
<td>136</td>
<td>4.4</td>
<td>1.1</td>
<td>24.4</td>
<td>153</td>
<td>2.42</td>
<td>113</td>
<td>59</td>
</tr>
<tr>
<td>POD #4</td>
<td>7.415</td>
<td>109.4</td>
<td>39.7</td>
<td>0.4</td>
<td>24.0</td>
<td>137</td>
<td>3.7</td>
<td>1.0</td>
<td>29.4</td>
<td>115</td>
<td>2.41</td>
<td>71</td>
<td>44</td>
</tr>
</tbody>
</table>


Emphysematous pyelonephritis is a severe necrotizing infection by gas-forming uropathogens within the renal parenchyma and/or perirenal tissues. Emphysematous pyelonephritis is a rare condition, but preferentially affects persons with diabetes, especially poorly controlled diabetes, with high levels of glycosylated hemoglobin or high levels of blood sugar and clinical course can be severe and life-threatening if not recognized and treated promptly.(3) The predictors of poor outcome is serum creatinine levels >1.4 mg/dL, platelets counts <60,000/mm³, disturbance of consciousness and shock that are associated with higher risk of mortality. Nephrectomy as a surgical intervention is a treatment of choice for most patients.(4-6) Our patient presented severe type of emphysematous pyelonephritis, and underwent emergency nephrectomy following rapid deterioration of hemodynamic state. In addition, patient had hepatic dysfunction due to liver cirrhosis, elevated serum creatinine and potassium, untreated diabetes and septic shock as a result of progressed emphysematous pyelonephritis was presented because of late visiting on the hospital. This seriously ill state was the basis of using CRRT to prevent of renal failure, to correct metabolic acidosis and electrolyte imbalance, and to remove of toxic material from blood.

CRRT have been used to manage a variety of clinical problems in patients with or without acute renal failure. The nonrenal indications for CRRT include sepsis, congestive heart failure, cerebral edema and fluid overload, particularly in critically ill patients, in patients with end-stage liver disease. Gotloib et al. suggested additional beneficial effects of hemofiltration in septic lung injury resulting from the removal of inflammatory mediators.(7) The removal of several cytokines such as interleukin-1, interleukin-6, tumor necrosis factor-alpha and myocardial depressant substance has been demonstrated in animal and human studies, although improved outcome of CRRT in severe sepsis or systemic inflammatory response syndrome remains a subject of debate.(8) CRRT has evolved...
rapidly and continuous venovenous hemodiafiltration is the most efficient CRRT modality. Diffusion is a type of solute transport across a semipermeable membrane generated by a concentration gradient and convection is a process in which solutes are transported across a semipermeable membrane along with movement of solvent. Therefore, when both convective and diffusive clearance is used, it means hemodiafiltration, a form of CRRT that has pump-driven devices with venovenous access to circulate blood through a dialysis hemofilter, and thus the inherent risks with arterial access are avoided.(9) Continuous venovenous hemofiltration was originally designed as a substitute for lost renal function in critically ill patients with acute renal failure.(10)

Because of the advantages of CRRT in the management of surgical patients, it is becoming a more commonly used therapy in the perioperative period. However, most often CRRT is discontinued during transfer to the operating room or during a surgical procedure because of the large amount of equipment that needs to be transported and the technical problems with unfamiliar to the anesthesiologist and medical persons for management of CRRT in the operating room. In this case, because it was expected to use CRRT for correction of severe metabolic acidosis, septic shock and acute renal failure during and after surgery, physicians decided to start CRRT in the operating room and CRRT had been continued in the ICU for 9 days after surgery.

When CRRT is to be instituted in the operating room, anesthesiologist must pay attention to the electrolyte composition of the CRRT replacement fluid. Because the replacement fluid includes a buffer, citrate, acetate or lactate, that requires hepatic metabolism to bicarbonate, paradoxical academia is resulted in the compromise of intraoperative hepatic blood flow or function. Therefore, bicarbonate based buffer is preferred in any procedure which is anticipated the compromise of liver function. Careful monitoring of arterial blood gases and electrolytes is requires to ensure normal acid-base balance.

In this case, CRRT resulted in resolution of severe metabolic acidosis and electrolyte imbalance in septic shock due to emphysematous pyelonephritis during general anesthesia and ICU after emergent nephrectomy. One should consider earlier application of CRRT during the surgical intervention to reduce mortality in life-threatening case of emphysematous pyelonephritis.

**ABSTRACT**

**Continuous Renal Replacement Therapy during Anesthesia in Critically Ill Patient**

Jae Woo Lee, Hyoseok Kang, Yong Soo Lee, So Jin Shin

Anesthesia and Pain Medicine, Eulji General Hospital, Eulji University, Seoul, Korea

A 48 yrs old woman with high fever, untreated diabetes and liver cirrhosis underwent emergency nephrectomy following rapid deterioration of hemodynamic state due to acute emphysematous pyelonephritis with abscess in right kidney, complicated with septic shock. To correct metabolic acidosis and electrolyte imbalance, to prevent renal failure, and to remove of toxic material from blood, CRRT (continuous renal replacement therapy) was applied during surgery and continued in intensive care unit after surgery. CRRT usually have been used in the intensive care unit for treatment of postoperative acute renal failure in the anesthesia. Other uses of CRRT include correcting metabolic acidosis and electrolyte imbalance and
removing toxins in sepsis.

**Key Words:** Pyelonephritis, Renal replacement therapy, Sepsis

**REFERENCES**


