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Continuous Renal Replacement Therapy (CRRT) in Critically Ill Children with Multiple Organ Dysfunction Syndromes: A Case Report

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Abstract:

Acute kidney injury (AKI) is a serious and potentially fatal clinical consequence of disease that increases morbidity and mortality in hospitalized children. In the event of AKI and fluid overload, renal replacement therapy (RRT) is a must-have therapy. In critically sick children with multi organ dysfunction syndrome (MODS) who are hemodynamically unstable, CRRT (continuous renal replacement therapy) is the cornerstone of dialysis. Although several hospitals in the country have begun to utilize CRRT in adult patients in the critical care unit, a lack of expertise and high therapeutic costs have prevented widespread adoption of CRRT. We managed a child with CRRT, who had AKI and MODS as a consequence of dengue shock syndrome and also was hemodynamically unstable in our hospital. The child's renal function improved as a result of the CRRT therapy, as did his MODS. We have summarized our experience using CRRT in children for the first time in Bangladesh in this article.

Keywords: *Acute Kidney Injury (AKI), Continuous Renal Replacement Therapy (CRRT), Multiple Organ Dysfunction Syndrome, Pediatric Intensive Care Unit.*

Introduction:

In pediatric critical care acute kidney injury is a key concern that leads to significant morbidity and mortality. Different diagnostic criteria and definitions for acute kidney injury are proposed, and criteria for pediatric or neonatal RIFLE are widely accepted for definition of acute kidney injury in children. The frequency of childhood AKI in critically ill children in an intense care unit was estimated to be about 30-60% (ICU).[1] According to Kaddourah and colleagues, 26.9% of children had AKI within the first seven days after ICU admission, and about 12% of those who developed severe AKI required renal replacement therapy.[2] In another study, reported 60days mortality among the patient with sepsis and shock was three to five times higher among those who developed AKI.[3] Multi-organ failure, which occurs as a consequence of sepsis and shock, is the leading cause of mortality. Therefore, in children with AKI and multi-organ failure, early identification and commencement of proper therapy are critical.

Renal replacement therapy should be started early in children with AKI due to sepsis or multi-organ failure to avoid fluid overload and electrolyte imbalance. CRRT (Continuous renal replacement therapy) is frequently chosen over other modalities of renal replacement therapy, particularly for children with MODS (Multi organ dysfunction syndrome) due to shock and the need for ionotrops to maintain adequate circulation. However, it has been more effective than other modalities of renal replacement therapies, although it is more expensive due to the high amount of replacement fluid required and the longer duration of therapy. It has only been used in adults in Bangladesh thus far, with no reports of CRRT in children. It was not used in children due to technological challenges, a lack of experience, and financial concerns. In our

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hospital, we have initiated CRRT in a child who presented with dengue shock syndrome and later developed MODS and AKI.

Case Report:

A 9-year-old Bangladeshi boy, was referred from a local hospital with complaints of fever for 3 days, followed by afebrile days with abdominal pain and vomiting. He was admitted to a neighboring hospital with an uneventful prenatal, postnatal and prior medical history and diagnosed with Dengue fever with a positive dengue NS 1 antigen. The boy developed shock on the afebrile day, which was managed with IV 0.9%Nacl saline and referred to our PICU for further treatment. He was restless on examination, with a Glasgow coma scale (GCS) of 15/15. He was on circulatory shock with a blood pressure of 60/40mmHg. He was initially managed with IV 0.9%Nacl saline boluses according to the national guideline for dengue syndrome. As he was not responding to the fluid management with 0.9% NaCl saline, he was started on IV 20% Albumin infusion to maintain blood pressure and prevent further fluid overload.

His initial blood reports revealed, Haemoglobin 17.4g/dL, Haematocrit 48.5%, Leukocyte $9.51x10^9$/cmm, Platelet $23X10^9$/cmm; C- reactive protein 8.4mg/L, Procalcitonin 2.93ng/ml, Alanine aminotransferase (SGPT) 2667U/L, Asperate aminotransferase (AST) 2250U/L, Prothrombin time 20.2 sec with INR 1.83, APTT 60.1 Sec, D- dimer 2.07mg/L (Fibrinogen equivalent unit). Because he had acute liver failure, sepsis, and coagulopathy, his dengue shock syndrome was minimally responsive to ongoing treatment; he needed ionotrops to keep his blood pressure stable. With increasing demand for O_2 his breathing work increased progressively; on the same day he required mechanical ventilation. He had bleeding manifestations in the form of fresh blood tint in oropharyngeal secretion, suction, ecchymosis on pierced site, and altered blood in nasogastric suction as the coagulopathy persisted and there was thrombocytopenia. He was managed with an apheresis platelet and fresh frozen plasma transfusion.

His initial renal function test showed blood urea 37mg/dL with serum creatinine 0.7mg/dl. As there was sepsis and shock, his renal function was deteriorating; his urine output was gradually dropping to 1ml/kg/hr on day 1 of admission and 0.8 ml/kg/hr on day 2 of admission. Along with Oligouria his serum creatinine was creeping up to 2.8 mg/dL on day 2 and 3.8mg/dL on day 3. And he becomes anuric on day 3 mornings. The renal team decided on RRT; because the patient has coagulopathy and shock, continuous renal replacement therapy (CRRT) was chosen as the preferred technique of providing RRT in this condition.

The patient was started on CRRT with continuous veno-venous hemodialysis (CVVHD) using the Dipact® CRRT system. The blood flow for the patient was 150- 200ml/min, dialysate was 2000 ml/hour (equivalent to 34ml/min), and anticoagulation was given with heparin at a dose of 200 units/hour with an aim to maintain activated coagulation time (ACT) between 150-200 seconds. Without any notable adverse effects, the patient's renal function steadily improves, with urine output increasing to 1.5 ml/kg/hour after 12 hours and serum creatinine decreasing to 1.6 mg/dL from 3.8 mg/dL after 24 hours of CRRT. After 24 hours, the CRRT was stopped, and his blood pressure and urine output gradually improved. He was out of respiratory support from the ventilator after 48 hours of discontinuation of CRRT as there was good urine output and improvement in sepsis and liver failure. The patient eventually improves with a residual consequence of dengue encephalopathy and was discharged with instructions to follow up at the OPD.

His dengue shock was barely responsive to the ongoing therapy as there was concomitant sepsis and coagulopathy evidenced by raised leucocyte count of $15.5x10^9$/L, deranged coagulation profile as prothrombin time 31.3 sec with INR 2.92 and D-Dimer of 2.62 mg/L (Fibrinogen Equivalent Unit) on day 2 of admission, he required ionotrops support to maintain his blood pressure. His work of breathing was progressively increasing with increasing O2 demand; he required mechanical ventilation on the same day. As the coagulopathy was persisting and there was thrombocytopenia, he developed bleeding manifestation in the form of fresh blood tinge in the oropharyngeal secretion, suction, ecchymosis on punctured site, and altered blood in the nasogastric suction. He was managed with an apheresis platelet and fresh frozen plasma transfusion. As there was sepsis and circulatory shock, his renal function was deteriorating. On the day 3 of admission, he developed Oligouria with a urine output of 0.8ml/kg/hour. His renal function test showed serum creatinine of 3.8mg/dL from 0.7mg/dL from the day of admission with anuria for 6 hours. The renal team decided to go for renal replacement therapy (RRT); as the patient has coagulopathy and shock, continuous renal

replacement therapy (CRRT) was chosen as the preferred method of delivering RRT in this situation.

The patient was given CRRT in the form of continuous venovenous hemodialysis (CVVHD) using Dipact® CRRT system. The blood flow for the patient was 150-200ml/min, dialysate flow was 2000ml/hour, and anticoagulation was given with heparin at a dose of 200units/hour with an aim to maintain activated coagulation time (ACT) between 150-200 seconds. Without any major adverse events, renal function of the patient gradually improves with improvement in the urine output to 1.5ml/kg/hour after 12 hours and his serum creatinine improves to 1.6mg/dL from 3.8mg/dL after 24 hours of CRRT. CRRT was discontinued after 24 hours and gradually his blood pressure improves and urine output normalized. He was out of respiratory support from the ventilator after 48 hours of discontinuation of CRRT as there was good urine output and improvement in sepsis. The patient gradually improves with a residual effect of encephalopathy related to dengue syndrome and discharged thereafter with a plan to continue to follow at the OPD.

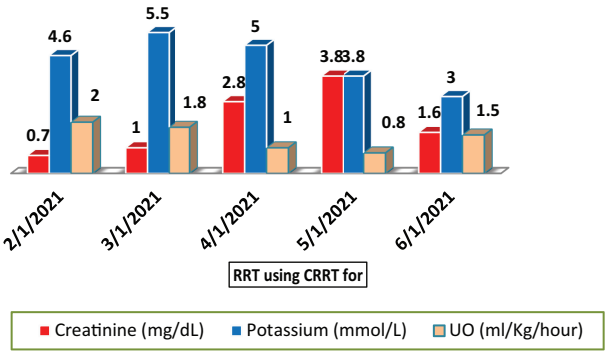

Fig.-1: *Sequence of lab parameters and urine output of the patient during ICU stay before and after renal replacement therapy.*

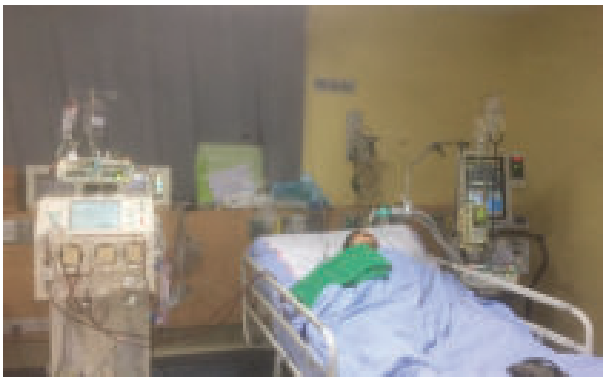

Fig.-2: *Patient in the renal replacement therapy using CRRT and on mechanical ventilator.*

Discussion:

We have summarized our experience treating a child with MODS using CRRT. He recovered completely, demonstrating the usefulness of CRRT in the treatment of children who are severely ill and hemodynamically unstable due to MODS. Renal replacement treatment is started in patients who have severe AKI. However, there is no single criterion for initiating RRT, and physicians may consider conditions such as electrolyte imbalance such as hyperkalaemia and acidosis, fluid overload with symptoms of pulmonary edema in the context of oliguria, and the presence of other conditions before initiating RRT.[4]

For acute care, three types of RRT are available: continuous RRT, intermittent RRT (in the form of intermittent hemodialysis and sustained low efficiency dialysis), and peritoneal dialysis.[5-7] However, the choice of renal replacement therapy is still debatable and is determined by availability and affordability. Because peritoneal dialysis is a therapy for acute care with limitations in clearance and difficulty in fluid removal, it is usually utilized in resource-limited countries because it is less expensive than other forms of RRT. No clearly demonstrated superiority between intermittent or CRRT, but meta-analysis implies that the use of intermittent RRT may be linked with delayed renal recovery.[8] However, in two large multicenter trials (the ATN study and the RENAL project), CRRT was considered for patients who were hemodynamically unstable and on vasopressor support.[9]

Filters and tubing with a low pre-filled volume should be used to reduce the blood volume in extracorporeal circulation and help alleviate the decrease in effective circulating blood volume due to the physiological and anatomical characteristics of children, including low body weight, small blood flow volume, and hemodynamic instability. Filters with a high molecular weight polymer membrane, high permeability, biocompatibility, and minimal coagulation system influence should be used. In general, blood volume in extracorporeal circulation should be less than 10% of body weight, i.e. 30mL in neonates, 50mL in babies, and 100mL in children. Tubing can be pre-filled with plasma, whole blood, or 5% albumin for infants weighing less than 2.5 kg.[10] For successful CRRT in children, establishing vascular access is critical. The femoral and internal jugular veins are the most commonly used veins in children. Double-lumen hemodialysis catheters are typically used for operational ease and to assist keep blood flow

consistent. In critically sick children, determining the therapeutic dose for continuous venovenous hemofiltration or hemodialysis is difficult. Individual doses should be determined based on the disease conditions, taking into account metabolic status, fluid volume, and dialysis duration. The transmembrane pressure should be monitored and kept below 200 mmHg (note: a transmembrane pressure of more than 250 mmHg may suggest filter clotting). Warming the replacement fluid should be given special attention. The recommended flow rates are as follows. Blood flow: 30mL/min in neonates; 30-40mL/min in infants/ young children; 50-75mL/min in children weighing <20kg; and 75-100mL/min in children weighing >20kg. Ultrafiltration rate: 8-10 mL/min/m^2 in neonates and infants; 8-15 mL/min/m^2 in children (note: daily fluid input/output, cardiac function, and edema should all be taken into account when determining ultrafiltration goal). In neonates/infants/children, the flow rate of dialysate 15-20mL/min/M^2 should maintain.[11]

When considering CRRT in circumstances like the ones discussed here, we believe there are a few crucial considerations to keep in mind. Particular attention should be paid to water and sodium retention, as well as blood nitrogen levels, in instances involving AKI or acute renal failure, since all of these have a substantial impact on the treatment and survival of newborns and young children, as well as the rate of improvement. We feel that the success of this treatment is based on various grounds. First and foremost, the choice to use CRRT was taken early on. Our approach is consistent with that proposed by Wolf et al., who contend, that starting treatment as soon as possible improves survival after extracorporeal circulation.[12] In addition, CRRT enables a prompt and rapid correction of water and sodium retention and electrolyte imbalances. Furthermore, an early CRRT therapy may have reduced cytokine/systematic inflammatory response and the inflammatory damage associated with that.[13] The high permeability of this membrane may aid to increase the anti-inflammatory cytokine to proinflammatory cytokine ratio, down-regulate the body's inflammatory response, and mitigate the systemic inflammatory response. Finally, we must emphasize the need of a multidisciplinary team's involvement and collaboration in order to successfully salvage MODS. When it comes to stopping CRRT, it can be done if water and sodium retention has subsided, urine production has returned to normal, and renal function has improved.

Conclusion:

CRRT has become widely employed in children during recent decades, in particular in children with severe disease such as acute renal insufficiency with MODS from dengue shock syndrome. We hope that sharing our experience would aid in the advancement of pediatric renal care in Bangladesh.

References:

1. Lameire NH, Bagga A, Cruz D, De Maeseneer J, Endre Z, Kellum JA et al. Acute kidney injury: An increasing global concern. Lancet 2013; 382:170-79.
2. Kaddourah A, Basu RK, Bagshaw SM, Goldstein SL. AWARE Investigators. Epidemiology of Acute Kidney Injury in Critically Ill Children and Young Adults. NEJM 2017; 376: 11-20.
3. Kellum JA, Chawla LS, Keener C, et al. The effects of alternative resuscitation strategies on acute kidney injury in patients with septic shock. Am J Respir Crit Care Med 2016; 193: 281-87.
4. Forni LG, Chawla L, Ronco C. Precision and improving outcomes in acute kidney injury: personalizing the approach. J Crit Care 2017; 37: 244-45.
5. Villa G, Neri M, Bellomo R, et al. Nomenclature for renal replacement therapy and blood purification techniques in critically ill patients: practical applications. Crit Care 2016; 20: 283.
6. Neri M, Villa G, Garzotto F, et al. Nomenclature for renal replacement therapy in acute kidney injury: basic principles. Crit Care 2016; 20: 318.
7. Chionh CY, Soni SS, Finkelstein FO, Ronco C, Cruz DN. Use of peritoneal dialysis in AKI: a systematic review. Clin J Am Soc Nephrol 2013; 8: 1649-60.
8. Schneider AG, Bellomo R, Bagshaw SM, et al. Choice of renal replacement therapy modality and dialysis dependence after acute kidney injury: a systematic review and meta-analysis. Intensive Care Med 2013; 39: 987-97.
9. Kellum JA, Ronco C, Bellomo R. Acute kidney disease and the community. Lancet 2016; 387: 1974-76.
10. Kendirli T, Ekim M, Ozçakar ZB, Yüksel S, Acar B, Oztürk-Hiismi B, et al. Renal replacement therapies in pediatric intensive care patients: experiences of one center in Turkey. Pediatr Int. 2007; 49: 345-8.
11. Bunchman TE, Brophy PD, Goldstein SL. Technical considerations for renal replacement therapy in children. Semin Nephrol. 2008; 28: 488-92.
12. Wolf MJ, Chanani NK, Heard ML, Kanter KR, Mahle WT. Early renal replacement therapy during pediatric cardiac extracorporeal support increases mortality. Ann Thorac Surg. 2013; 96: 917-22.
13. Splendiani G, Mazzarella V, Cipriani S, Zazzaro D, Casciani CU. Continuous renal replacement therapy: our experience in intensive care unit. Ren Fail. 2001; 23: 259-64.