CLINICAL EVIDENCE

Carpediem™
Cardio-Renal Pediatric
Dialysis Emergency Machine

Clinical Summary Index and Review

Medtronic
Further, Together

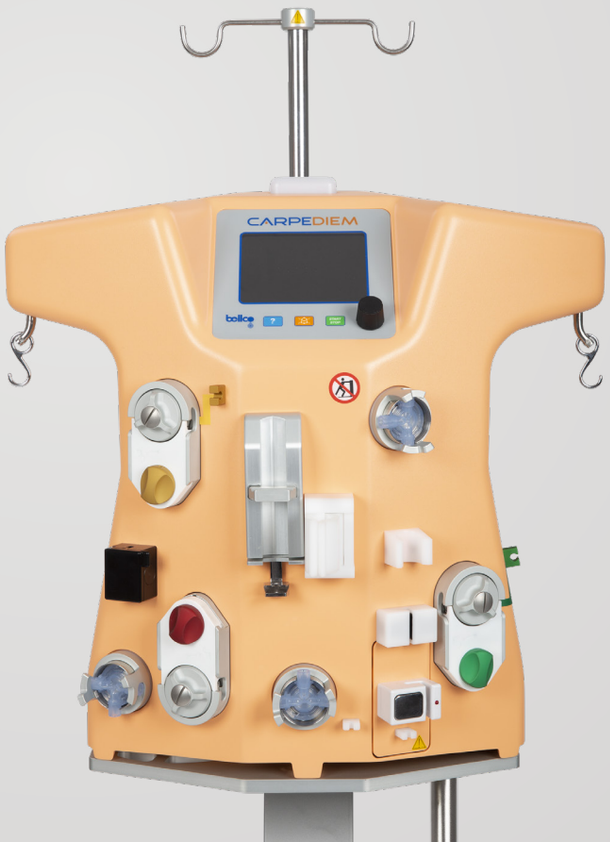
Carpediem™ system

TRANSFORMING PEDIATRIC CARE

Neonatal acute kidney injury (AKI) and fluid overload are under-recognized conditions which often lead to morbidity and mortality. Incidence rates are reported to be as high as 40% and associated to a high mortality of up to 60%.[1,2]

In today's clinical practice, renal replacement therapies performed on low weight patients, include:

- Peritoneal Dialysis, limited by defects involving the abdominal wall, organs, intraperitoneal surgeries, and complications related to fluid balance.[3]
- Hemodialysis mainly to treat hyperammonemia.[4]
- Continuous Renal Replacement Therapy (CRRT) performed with adult CRRT devices used 'off-label' and associated to important complications and limitations.[4]



The Carpediem™ system is intended for continuous renal replacement therapy (CRRT) for pediatric patients weighing between 2.5 and 10 kilograms.

The Carpediem™ system delivers dialysis for those low weight and fragile patients. The system performs as an alternative to peritoneal dialysis (PD) in acute kidney injury or fluid overloaded patients requiring hemodialysis or hemofiltration therapy.

The Carpediem™ system is designed to offer a dedicated extracorporeal CRRT to low weight patients and responds to the needs of the most fragile patient.

< > HOME

THERAPIES

- CVVH
- CVVHD
- SCUF

INDICATIONS

- Acute kidney injury (AKI)
- Fluid overload

AUGMENTED PERFORMANCE

- High-sensitivity air bubble detection alarms (>10µL at blood flows <35mL /min and >15µL in all other operating conditions)
- High-sensitivity blood leakage detector (alarm threshold for 0.15mL of blood in 10mL of ultrafiltrate (hematocrit: 25%) with an effluent flow of 10 mL/min)
- Fluid balance control supervised by high-precision scales with a resolution of 1 g
- Blood flow starting from 2 mL/min allows treatment with dual lumen catheters better suited for the size of the patient[5]
- Heparin Pump, continuous or bolus

HIGH ACCURACY

in pump and weight loss control

TREATING PATIENTS

- Patient weight between 2.5 – 10 kgs
- Total preassembled blood-set priming volumes of 32 or 41mL
- Filter surface area of 0.16 or 0.29 m^2

PEDIATRIC AKI

Clinical Condition	Key Points	References
Pediatric AKI	After more than 400 hours of extracorporeal treatment in a 2.9 kg neonate, hemofiltration was discontinued and the patient was breathing normally without supplemental oxygen, making adequate amounts of urine, and had normal liver function.	Ronco C, et al. *Lancet* 2014; 383(9931):1807-13
	AKI and multi-organ failure resolved after 5 days of extracorporeal treatment in a full term newborn treated with the Carpediem™ system. The child survived with normal renal function and a normal development at 9 months follow-up.	Peruzzi L, et al. *Case Rep Nephrol Urol* 2014; 4(2):113-19
	Use of daily Kt/V as a measure of CRRT adequacy for critically ill neonates is feasible. The decrease of creatinine concentration was significantly greater during 24 hr treatment sessions with a delivered daily Kt/V > 0.9 than during those with daily Kt/V < 0.9.	Ricci Z, et al. *Pediatr Crit Care Med* 2017; 18(7):623-629.
	The Carpediem™ system successfully delivered diffusive blood purification modality to neonates using small catheters, no blood primes, and excellent concordance between delivered and prescribed treatment duration.	Vidal E, et al. *Blood Purif.* 2018; 31:1–7.
	CRRT may be the right choice for pediatric renal care, but the “adaptation era” of adult machines was far from providing adequate and safe treatment to infants, newborns, and small children. The Cardio-Renal, Pediatric Dialysis Emergency Machine (Carpediem™ system) launched the ‘fitted era’ for pediatric CRRT - a paradigm shift in terms of the provision of adequate and safe CRRT.	Garzotto F, et al. *Nephron Clin Pract.* 2014; 127:172–175
	CRRT in neonates is easy to initiate and conduct when performed with small central vascular accesses coupled with the Carpediem™ machine. A dedicated technology for infant CKRT delivery enables patients to be safely treated — avoiding technical complications.	Garzotto F, et al. *Pediatric Nephrology.* 2020:35: 1699–1705.
In vitro	Dialysate flow plays an essential role in the blood purification process. The use of CVVHD versus CVVH is justified in cases of high dialysis dose requirement and/or limited blood flow rate.	Lorenzin A, et al. *Pedriatic Nephrol* 2016; 31:1659-1665
	First publication on Carpediem™ machine: description of the evolution of CRRT in neonates in the last 30 years.	Ronco C, et al. *Pedriatic Nephrol* 2012; 27(8):1203-11

CLINICAL SUMMARY

TITLE Continuous renal replacement therapy in neonates and small infants: development and first-in-human use of a miniaturised machine (CARPEDIEM).
AUTHORS Ronco C, Garzotto F, Brendolan A, Zanella M, Bellettato M, Vedovato S, Chiarenza F, Ricci Z, Goldstein SL.
JOURNAL *Lancet* 2014; 383(9931): 1807-1813

BACKGROUND

Acute kidney injury (AKI) has been described as a rare disorder in neonates, occurring in 1% to 2% of the hospital-admitted neonatal population. However, more recent single-center systematic investigation into neonatal AKI showed that it occurs in 16% of newborn infants weighing more than 2 kg who are admitted to neonatal intensive care. Previous underappreciation of the prevalence of the disorder has made neonatal AKI an orphan disease and has held back development of technology specifically for renal replacement therapy in infants. Because of the unique nature of AKI in infants and its severe complications, the authors undertook a project to develop a continuous renal replacement therapy (CRRT) machine designed specifically for patients weighing <10 kg body weight (Carpediem™ system), particularly neonates and premature infants.

PATIENTS/METHODS

Development
The aim of the project was to create a new miniaturized CRRT machine for neonates and small infants with reduced priming volumes and the capacity to accurately handle very low blood an ultrafiltration flows. A group of qualified technical and medical personnel completed in vitro laboratory assessments of the functioning prototype machine and conducted several sessions of extensive invitro tests to verify functionality, accuracy and reliability. After 30 months in development, the Carpediem™ machine was approved for human use.

First-in-human-use
The authors treated a female neonate with a subgaleal hemorrhage and consequent hemorrhagic shock. At 72 hours after birth, physicians decided to start CRRT. A 5 cm dual lumen 22 Ga (4 Fr) catheter was placed surgically into the femoral vein. The neonate received post-dilution continuous veno-venous hemofiltration (CVVH) with the Carpediem™ system.

RESULTS

- During in vitro testing, circuits were run for 24 hours. No substantial differences in flow accuracy were noted when different sizes of dual lumen catheters (4 and 7 Fr) were used. Tests suggested excellent accuracy of blood-pump flow rate, with a consistent error of <10%. Reinfusion or dialysis flow errors ranged from –8.0% to 7.5%. Importantly, whereas the accuracy of ultrafiltration always remained within the limit of 1 g/h, no substantial variation in relation to different transmembrane pressure and filtration rates was noted.
- The baby developed severe hyperbilirubinemia because of liver dysfunction and massive subgaleal hemorrhage reabsorption; because there was an urgent need to rapidly decrease bilirubin concentration, the hemofiltration treatment was subsequently alternated with three sessions of blood exchange (BE), two sessions of single-pass albumin dialysis (SPAD), and finally four sessions of plasma exchange (PE). CVVH with the additional bilirubin-targeted treatments led to a progressive normalization of fluid overload, creatinine concentration, and bilirubin concentration. In fact, the ability to combine extracorporeal treatments, such as PE, BE, and SPAD, with CRRT extends the range of supportive treatments for critically ill infants.
- After 7 days of CRRT, urine output had partly recovered to 1.2 mL/kg/h and had reached 3.2 mL/kg/h at 26 days. At 25 days after birth and after more than 400 hours of extracorporeal treatment, hemofiltration was discontinued. The patient was then extubated, and she started to advance to complete oral alimentation. After 30 days, the patient was breathing normally without supplemental oxygen, was making adequate amounts of urine, and had normal liver function; at 39 days, she was discharged from the ICU.

CONCLUSIONS

The Carpediem™ system is the first CRRT platform designed and developed for small pediatric patients; it could change clinical practice with respect to the management of neonates with AKI.

The Carpediem™ system can be used to support multiple organ dysfunction, it could reduce the range of indications for peritoneal dialysis and widen the range of indications for CRRT, and it could make the use of CRRT less traumatic and expand its use as supportive therapy even when complete renal replacement therapy is not indicated.

CLINICAL SUMMARY

TITLE Neonatal sepsis with multi-organ failure and treated with a new dialysis device specifically designed for newborns.
AUTHORS Peruzzi L, Bonaudo R, Amore A, Chiale F, Donadio ME, Vergano L, Coppo R.
JOURNAL *Case Rep Nephrol Urol* 2014; 4(2): 113-119.

BACKGROUND

Neonatal sepsis due to E. coli is often complicated by multiple organ failure (MOF) and a high mortality risk (50%). In this article, the authors described the case of a male newborn admitted in July 2013 for septic shock due to E. coli on the 11th day of life. He rapidly developed MOF with anuric acute kidney injury (AKI). The child could not be treated with peritoneal dialysis due to severe intestinal bleeding.

CASE REPORT

A male newborn weighing 3,710 g with an Apgar score of 2/10/10 was discharged in good condition 3 days from birth. After 10 days of breastfeeding, he was transported to the ICU because he developed diffuse cyanosis, hypotonia, and areflexia. His general condition was extremely critical, and he presented with severe metabolic acidosis, hypoglycemia, and a slightly increased C-reactive protein value. The child showed extreme hemodynamic instability, rapidly developing oligoanuria, impaired gas exchange, and a positive hemoculture for E. coli. Nephrological consultation defined a situation of anuric AKI secondary to septic shock and MOF, indicating continuous renal replacement therapy (CRRT). A double-lumen central venous dialysis catheter (diameter 5 Fr, length 6 cm) was surgically placed in the internal jugular vein; continuous veno-venous hemofiltration (CVVH) was started with the new neonatal device Carpediem™ system (Cardio-Renal Pediatric Dialysis Emergency Machine). The neonatal dialysis kit used included a 0.25 m^2 dialyzer medisulphone polysulphone. The dialysis parameters were blood flow (Qb) of 26 mL/min, net weight loss of 40 mL/h, and reinfusion (QRf) in post-dilution of 255 mL/h. During the first 8 hours, the clinical situation was extremely critical.

The patient required high-pressure ventilation because of fluid overload; he also needed high dosage of norepinephrine and epinephrine for persistent hypotension. He showed hemodynamic instability and unsatisfactory control of acidosis and lactic acid, which remained persistently above 8 mmol/L. During the first 2 days of tratment, continuous plasma infusions and repeated platelet transfusions were required because of persistent disseminated intravascular coagulation. In the following 3 days, treatment was intermittent for 12 hours per day. Progressive improvement of bleeding parameters, hepatic function, and general condition allowed the progressive tapering of inotropic drugs as well as plasma and platelet infusions. Diuresis reprisal occurred on day 4, and diuresis normalization, which allowed a treatment interruption, occurred on day 5. During the 5 days of treatment, no anticoagulation was required and no bleeding events occurred.

After 10 days, the patient was released from the ICU. His renal function normalized within 15 days even though his kidneys remained hyperechogenic. At day 60, his neurological condition was almost normal. At 9 months follow-up, the child had normal neurological development without any clinical, ultrasonic, or electroencephalographic abnormalities; he also showed normal growth and development. His blood pressure and renal function were normal without any urinary abnormalities.

CONCLUSIONS

The prompt treatment of this patient with CRRT allowed a rapid and uneventful removal of fluid overload, as well as of sepsis-associated cytokines. The ability to promptly reduce fluid overload through an extremely precise control of ultrafiltration contributes to more efficient treatment of critically ill newborns (as in septic shock), allowing proper plasma, calorie, and therapy supply and less stressful ventilatory support with a better outcome and survival rate. The availability of a ready-to-use extracorporeal circuit with an easy-to-use dialysis machine, specifically designed for newborns, can extend the use of this therapeutic option — not only to expert pediatric nephrologists but also to intensive care neonatology units — to provide prompt treatment of sepsis and fluid overload and therefore better survival rates for patients.

CLINICAL SUMMARY

TITLE Dose prescription and delivery in neonates with congenital heart diseases treated with continuous veno-venous hemofiltration.
AUTHORS Ricci Z, Guzzi F, Tuccinardi G, Di Chiara L, Clark W, Goldstein S, Ronco C.
JOURNAL *Pediatr Crit Care Med* 2017; 18(7):623-629.

BACKGROUND

Acute kidney injury (AKI) in newborns frequently occurs after complex cardiac surgery. Renal Replacement Therapy (RRT) may be needed for a part of these cases (5%) and it has been shown that continuous veno-venous hemofiltration (CVVH) can be used safely in neonates with congenital heart diseases. The aim of the present study was to evaluate the technical and clinical effects of a relatively small dialysis dose on critically ill neonates with severe fluid overload and oligo-anuria requiring CVVH.

MATERIAL AND METHODS

- All patients included were treated with equipment specific for pediatric CRRT.
- The primary objective was evaluation of effective dialysis delivery (daily Kt/V).
- The main endpoints were the determination of the correlation between daily Kt/V and serum creatinine deltas, as well as between daily Kt/V and urea deltas.

RESULTS

- A total of 10 neonates (median weight of 2.6 kg and age of 3 days) with congenital heart diseases were received in the pediatric cardiac intensive unit.
- CVVH (7 patients treated with Carpediem™ system, two with Prismaflex, and one with both monitors) was generally delivered as pre-dilution or as combined pre- and post-dilution mode. The anticoagulation method used was heparin.
- The delivered Kt/V of each 24-hour dialytic session correlated with creatinine differences measured between the end and the start of the same session. A correlation between daily Kt/V and delta creatinine was also shown. In addition, daily Kt/V was significantly associated with the difference between starting and ending blood urea nitrogen levels.
- Solute marker concentrations increased during all 24-hour sessions in which daily Kt/V values less than 0.9 were delivered.

CONCLUSIONS

There was an association between dialytic efficiency expressed as daily Kt/V and changes in serum creatinine and urea concentration in newborns with congenital heart disease treated with CVVH. The findings suggest that the delivery of a Kt/V of approximately 1 allowed an adequate clearance of these small solutes.

CLINICAL SUMMARY

TITLE CVVHD treatment with CARPEDIEM: small solute clearance at different blood and dialysate flows with three different surface area filter configurations.
AUTHORS Lorenzin A, Garzotto F, Alghisi A, Neri M, Galeano D, Aresu S, Pani A, Vidal E, Ricci Z, Murer L, Goldstein SL, Ronco C.
JOURNAL *Pediatr Nephrol* 2016; 31(10):1659-1665.

BACKGROUND

The Carpediem™ system (Cardio Renal Pediatric Dialysis Emergency Machine) was originally designed to perform only continuous veno-venous hemofiltration (CVVH). However, in cases when increased dialysis efficiency is needed or adequate convective clearance may not be reached due to limited blood flow rate, the convective clearance achievable in neonatal patients may be insufficient to control uremic solutes. In many conditions, such as hypercatabolic diseases, the application of diffusive clearance (continuous veno-venous hemodialysis [CVVHD]) would help optimize blood purification via increased urea and creatinine removal. In this study, the authors modified the Carpediem™ system to enable the circulation of dialysis through the filter to test the performance of the Carpediem™ system in CVVHD.

METHODS

- Three different polyethersulfone hemodialyzer prototypes (surface area of 0.1 m^2, 0.2 m^2, and 0.35 m^2, respectively) equipped with two ports in the ultrafiltrate/dialysate compartment were developed to allow the CVVHD modality.
- CVVHD treatments were performed in vitro with a scheduled combination of plasma flow rates (Qp = 10-20-30 mL/min) and dialysis fluid flow rate (Qd = 5-10-15 mL/min).
- Three sessions were performed in co-current configuration and one in counter-current configuration (as control) for each filter size. Clearance was measured from the blood and dialysate sides, and results with mass balance error >5% were discarded.
- Urea and creatinine clearances for each plasma/dialysate configuration were collected.

RESULTS

The authors observed an incremental increase in clearances for every filter as plasma flow increased. Similarly, clearances increased progressively with dialysate flow rates at a given plasma flow. The clearance curve presented a steep increase for small increases in plasma flow below 10 mL/min, while the curve tended to plateau for values averaging 30 mL/min. As expected, the plateau was reached earlier with the smaller filter, showing the effect of membrane surface-area limitation. They showed that complete saturation of effluent dialysate was not achieved in any of the experimental conditions tested. The authors also performed an analysis using whole blood instead of plasma or using co-current versus counter-current dialysate flow configuration, and they observed no differences.

CONCLUSIONS

The results obtained in this in vitro study indicate that dialysate flow plays an essential role in the blood purification process, justifying the use of CVVHD versus CVVH in cases of high dialysis dose requirement and/or limited blood flow rate. The data provide a framework that allows the clinician to select the best dialysate flow and hemodialyzer prescription for specific patients according to size and clinical requirements.

Medtronic

CLINICAL SUMMARY

TITLE CA.R.PE.DI.E.M. (Cardio-Renal Pediatric Dialysis Emergency Machine): evolution of continuous renal replacement therapies in infants. A personal journey.
AUTHORS Ronco C, Garzotto F, Ricci Z.
JOURNAL *Pediatr Nephrol* 2012; 27(8): 1203-1211.

BACKGROUND

Pediatric acute kidney injury (AKI) is a well-described clinical syndrome that is dominated by an abrupt decrease in renal function with a reduction of urine output, hypertension, vomiting, edema, and lethargy. Moreover, AKI in critically ill babies is frequently associated with multiple organ dysfunction (MODS). In the last years, a dramatic increase in the incidence of AKI in the pediatric population has been observed. Unfortunately, the absence of sufficiently effective preventive and therapeutic measures has limited significant improvements in AKI care. Mortality in patients with severe AKI remains unacceptably high (>50%), with renal replacement therapy (RRT) remaining the most effective form of support for critically ill infants. Some recent epidemiological studies have confirmed that the presence of AKI in these patinets represents an independent risk factor associated with mechanical ventilation, increased length of stay in the ICU and hospital, and mortality. In this article, the authors the authors report on AKI management in infants and children, based on their 30-year experience of research in the field. They describe the evolution of pediatric RRT and the development of the Carpediem™ system (Cardio Renal Peditric Dialysis Emergency Machine) project, which has recently been established to finally provide neonates and infants with a reliable dialysis machine specifically designed for this age group.

REVIEW

The modern practice of continuous RRT in infants
The indications for RRT in pediatric patients with AKI have changed over the years, and the current trend is toward a wider spectrum of applications, including the prevention of fluid accumulation and MODS. In fact, critically ill infants with AKI are at the highest risk of water accumulation and inflammation, especially in the post-heart surgery phase. Until recently, peritoneal dialysis (PD) has been the RRT treatment of choice in neonates, except when specific contraindications are present (i.e., peritonitis, abdominal masses, or bleeding). Extracorporeal dialysis in children can be managed with a variety of modalities, including intermittent hemodialysis and continuous hemofiltration or hemodiafiltration. The choice of dialysis modality is influenced by several factors, including the goals of the dialysis, the unique advantages and disadvantages of each modality, and institutional resources. Critically ill children generally are treated with CRRT, which allows for slow fluid removal, solute re-equilibration, and the likely removal of pro-inflammatory mediators.

AKI in neonates and infants is an "orphan disease"
Pediatric AKI is a dramatic syndrome requiring careful clinical management, but to date a truly pediatric CRRT system has never been developed. Consequently, dialysis/hemofiltration in critically ill children is currently performed by adapting adult systems to much smaller pediatric patients. In these cases, most machines are used off-label when patients with a body weight of <15 kg are being treated. The small number of cases — together with the limited interest of industry to develop a fully integrated device specifically designed for the pediatric population — have made AKI in infants and neonates an "orphan disease."

The Carpediem™ system project
Because of the need to create RRT equipment specifically dedicated to newborns and small infants in the weight range of 2.0 to 9.9 kg, the Carpediem™ system project was developed by the Department of Nephrology and International Renal Research Institute of the San Bortolo Hospital in Vicenza.
The goal of the project was to design the first neonatal CRRT monitor with the help of modern miniaturization engineering skills. In particular, they aimed to reduce priming volumes of the circuits to a minimum level (three preassembled circuits with new polysulphone membranes, with a surface area of 0.075, 0.147, and 0.245 m^2 and priming volumes of 27.2, 33.5, and 41.5 mL, respectively) and allow roller pumps to run at a slow speed, thereby guaranteeing the integrity of the lines and maintaining an excellent level of flow and balance accuracy.

CONCLUSIONS

AKI is a severe clinical condition that is further complicated in small children by the different problems of these patients. Outcomes may vary significantly depending on the underlying disease, the severity of illness, and the time of intervention. To date, outcomes of critically ill children with AKI are poor, and a strategy for improvement is needed urgently. In this scenario, new technological advances — such as miniaturized circuits and membranes and accurate CRRT machines, as well as effective prescription schedules — promise to improve the quality of clinical treatment.

CLINICAL SUMMARY

TITLE Continuous veno-venous hemodialysis using the Cardio-renal Pediatric Dialysis Emergency Machine: first clinical experiences
AUTHORS Vidal E, Cocci E, Paglialonga F, Zaccaria R, Garzotto F, Peruzzi L, Murer L, Ronco C.
JOURNAL *Blood Purification,* 2018; 31:1–7. DOI: 10.1159/000494437

BACKGROUND

We report the first worldwide experiences with continuous veno-venous hemodialysis (CVVHD) in children using the last generation Carpediem™ system.

CLINICAL EXPERIENCE

Thirteen children received 1,008 hours of CVVHD during 95 sessions, using a 0.15 (n = 7) or a 0.25 m^2 (n = 6) hemofilter. The median patient weight was 3 kg (interquartile range [IQR] 2.5–6.2). In 10 patients, CVVHD was conducted using a 5 Fr double-lumen central vascular access. In three children, however, bigger sizes were used (6.5 and 8 Ch). The median prescribed Q_b was 17 mL/min (IQR 10–29.5), with a median Q_d of 10 mL/min. Circuits were primed with five percent (5%) albumin in 12 out of 13 patients, using anticoagulation with heparin in all 13 cases. The median delivered-prescribed time ratio yielded a 100 percent result (95–100 percent).

RESULTS

The most common cause for "downtime" was clotting that occurred in only three percent (3%) of all treatments. Survival rates for continuous renal replacement therapy discontinuation and ICU discharge were 100 percent and 69 percent respectively. The Carpediem™ system successfully delivered diffusive blood purification modality to neonates using small catheters, no blood primes, and excellent concordance between delivered and prescribed treatment duration.

CONCLUSION

CVVHD with the Carpediem™ system appeared to be a safe and effective method in a heterogeneous group of critically and noncritically ill neonates. Applying CVVHD instead of CVVH with the device may improve blood purification in cases that require a timely CRRT start, such as:

- Fluid balance control
- Hyperammonemia
- Drug intoxication
- Short transient oliguric states with hypercatabolic complications

It may also improve blood purification patients with extreme clinical conditions, including those with severe fluid overload and peritoneal dialysis failure.

Medtronic

CLINICAL SUMMARY

TITLE The evolution of pediatric continuous renal replacement therapy
AUTHORS Garzotto F, Zanella M, Ronco C.
JOURNAL *Nephron Clin Pract.* 2014; 127:172–175. DOI: 10.1159/000363204

BACKGROUND

CRRT prescription for younger and smaller children has unique considerations due to problems, including:

- Extracorporeal blood volume
- The need for circuit blood priming
- The adaptation of machines designed for adult-sized patients

Moreover, the provision of renal replacement therapy to neonates presents a unique problem: no more than 10–15 percent of their blood volume should be removed by the extracorporeal circuit to prevent hypotension and anemia. In 2012, the Carpediem™ cardio-renal pediatric dialysis emergency machine was developed — launching the "fitted era" for pediatric CRRT.

CASE REVIEW

In 2012 — 24 years after creating the first CAVH — the Department of Nephrology and International Renal Research Institute of San Bortolo Hospital created the Carpediem™ system. Their aim was to develop a CRRT platform specifically for newborns and small infants (2.0–10 kg) with an approximate BSA of 0.15–0.5 m^2. As a result, the Carpediem™ cardio-renal pediatric dialysis emergency machine launched the "fitted era" of pediatric CRRT.

RESULTS

Three circuits with surface areas of 0.075, 0.15, and 0.25 m^2 are available. The three small roller pumps move blood into a 27 ml total volume circuit (34 and 45 ml with the bigger filters, respectively). The solute clearance may reach two (2) liters/h/1.73 m^2 of BSA or 25–35 ml/kg/h in patients weighing less than 10 kg. To ensure accurate fluid balance, the Carpediem™ system has gravimetric controls and scale sensitivity of 1 g for both infusion and effluent bags.

The first in-vivo application of the Carpediem™ system suggested a paradigm shift in the provision of adequate and highly safe CRRT to infants. Catheters (4–7 F) tested in vitro have shown excellent results in terms of circuit longevity. For example, a four-french dual-lumen catheter has been used for more than 400 hours in patients with conditions such as:

- Multiple organ failure
- Fluid overload of 63 percent
- Acidosis
- Hyponatremia
- Thrombocytopenia
- Oliguria

No hypotension or complications related to CRRT were reported. The treatment led to the control of fluid balance, metabolic waste products, bilirubin, and other humoral disorders. The neonate recovered for multiple organ dysfunction was discharged from the hospital.

CONCLUSION

In the last decade, the indications for renal replacement in the pediatric patients have changed to include a wide spectrum of diseases. The so-called 'nonrenal indications' have contributed to the increase in the number of CRRT applications mainly in critically ill infants and neonates. The renal replacement therapy of choice for this particular population is still PD. However, limitations in terms of efficiency call for the use of a more suitable therapy (i.e. one with higher UF rates and better solute clearance). CRRT may be the right choice for pediatric renal care, but the technology to adequately perform this therapy has never been developed. The Carpediem™ system — specifically designed for neonates and small infants — may be the missing element in pediatric renal replacement.

Medtronic

CLINICAL SUMMARY

TITLE Continuous kidney replacement therapy in critically ill neonates and infants: a retrospective analysis of clinical results with a dedicated device

AUTHORS Garzotto F, Vidal E, Ricci Z, Paglialonga F, Giordano M, Laforgia N, Peruzzi L, Bellettato M, Murer L, Ronco C.

JOURNAL *Pediatric Nephrology,* 2020:35: 1699–1705

BACKGROUND

Description of a multicenter experience in continuous kidney replacement therapy (CKRT) delivery to small infants using a device specifically designed for this age group.

METHODS

A retrospective cohort analysis of all patients treated with the Carpediem™ system (Bellco-Medtronic, Mirandola, Italy) in six centers between June 2013 and December 2016

RESULTS

Twenty-six neonates and small infants received 165 CKRT sessions in convective modality. Median age at neonatal intensive care unit admission was one day (IQR 1–11); median body weight was 2.9 kg (IQR 2.2–3.6). Median circuit duration was 14 h (IQR 10–22), with delivered/prescribed time ratio of 84 percent. CKRT was conducted using 4 Fr (27 percent) 5 Fr (35 percent), 6.5 Fr (11 percent), and 7 Fr (three percent) vascular access. Umbilical and peripheral accesses (11 percent each) were used, allowing overall median blood flow of 4.5 ml/kg/min (IQR 3.4–6) and median effluent flow rate 35 ml/kg/h (IQR 28–42). Circuits were primed with normal saline in 58 percent of treatments, colloids in 31 percent, and packed red blood cells in 11 percent. None of the centers reported serious adverse events directly related to machine application. Twenty-five (96 percent) patients survived their CKRT course and 13 patients (50 percent) survived to ICU discharge.

CONCLUSION

The largest case series observing infants treated with a new machine specifically designed for performing CKRT in low body weight patients (Carpediem™ machine). Our results confirm that CKRT is feasible even with relatively small venous catheters. In our experience, the new blood pump coupled with a 5 Fr catheter represents the best compromise between low vascular impact and adequate extracorporeal treatment.

< > HOME

Medtronic

Indications for use: The Carpediem™ system is indicated for use in acute kidney injury or fluid overloaded patients requiring hemodialysis or hemofiltration therapy. It is intended to provide continuous renal replacement therapy (CRRT) to patients weighing between 2.5 and 10 kilograms.

Limitations for Use: Do not use the Carpediem™ system if patient treatment requires performance outside its operating and accuracy range as well as the operating limits specified in the Carpediem™ system operator's manual. The Carpediem™ system allows anticoagulation method with heparin only.

Contraindications: Patients with a history of allergic reactions to polyethersulfone should not be treated using the Carpediem™ system. The choice to perform CRRT must consider the balance between risk and benefit for patients that have general contraindications to using an extracorporeal therapy. These factors include: hemodynamic instability, contraindication to suitable anticoagulation, low platelet count, lack of suitable placement for vascular access.

Warnings: Replacement fluid for hemofiltration should be prescribed by a physician and should be commercially available or prepared in the hospital pharmacy, labeled sterile and for intravenous injection. The device is intended to be used by trained clinicians who are experienced in administrating and managing continuous renal replacement therapy (CRRT) in in critically ill pediatric patients .

Cautions: Read all Instructions for Use carefully prior to use.

For complete details of the system, including product and important safety information such as indications, contraindications, warnings and precautions associated with the system and its components, refer to the Carpediem™ system operator's manual and the respective system component's Instructions for Use. Rx Only.

1. Sutherland S, et al. AKI in Hospitalized Children Comparing the pRIFLE, AKIN, and KDIGO Definitions. *CJASN*. 2015; 10(4)554-61.
2. Zappitelli M., Ambalavanan N., Askenazi D. et al. Developing a neonatal acute kidney injury research definition: a report from the NIDDK neonatal AKI workshop. *Pediatric Res.*2017; 82(4):569-573.
3. Hothi DK. Designing technology to meet the therapeutic demands of acute renal injury in neonates and small infants. *Pediatr Nephrol.* 2014;29(10):1869-1871.
4. Ronco C, Garzotto F, Ricci Z. CA.R.PE.DI.E.M. (Cardio-Renal Pediatric Dialysis Emergency Machine): evolution of continuous renal replacement therapies in infants. A personal journey. *Pediatr Nephrol.* 2012;27(8):1203-1211.
5. Ronco C, Garzotto F, Brendolan A, et al. Continuous renal replacement therapy in neonates and small infants: development and first-in-human use of a miniaturised machine (CARPEDIEM). *Lancet*. 2014;383:1807-1813.

15 Hampshire Street
Mansfield, MA 02048

800.962.9888
508.261.8000

medtronic.com

< HOME

Medtronic