Continuous Renal Replacement Therapy: The Rise of the New Machines

By Lakhmir S. Chawla

Continuous renal replacement therapy (CRRT) is relatively young; the first continuous venovenous CRRT systems were deployed widely in the late 1990s. The early machines were an enormous improvement over continuous arteriovenous systems. However, the early machines did not have the corresponding accessories available, and many nephrologists can recall “brewing” lactate-buffered dialysis and replacement solutions to operate CRRT in the early days. Some of us even resorted to using peritoneal dialysate in CRRT. In the past 15 years, the need for customized fluids has been rare, and multiple bicarbonate buffered commercial solutions are now available. In addition, the accessories for short-term dialysis such as double-lumen catheters, anticoagulation options, and replacement fluid solutions have all been upgraded over the past 15 years. Now, CRRT, which was once a laborious and complex procedure, has become much easier and safer. So what does the field need now? Next-generation machines.

The first-generation CRRT machines were the Prisma and the Diapact. At the time, these machines were embraced because of their ability to perform venovenous procedures more safely. During this time, the primary goal was to get control of the patient’s volume and electrolytes without hemodynamic instability. The publication of the “Ronco paper” in *The Lancet* in 2000 pushed many clinicians to try to achieve a higher dose of CRRT.

These first-generation machines did not have flow capacities for blood or effluent flow rates that met the needs of many clinicians, and the second-generation machines were brought into the intensive care unit with the capacity to achieve these higher flow targets. After publication of the Randomized Evaluation of Normal versus Augmented Level of Replacement Therapy trial and Acute Renal Failure Trial Network, the consensus dose for CRRT was set at 20 to 25 mL/kg/h. However, questions about hemofiltration versus diffusion remain unanswered, and some still believe that extended daily dialysis is adequate compared with CRRT.

In any case, for most clinicians in the United States, CRRT is performed with the PrismaFlex (Baxter Medical), the NxStage System One (NSO, NxStage Medical), or the Diapact System (B-Braun). Both PrismaFlex and NSO have the ability to run much higher effluent flow rates. Both platforms can also perform plasmapheresis, and the PrismaFlex can be used with the MARS system (Gambror) to conduct albumin dialysis. The key technological differentiator of the NSO compared with the PrismaFlex and the Diapact System is its use of a disposable cartridge containing all of the blood and fluid pathways, including a volumetric fluid management system. This volumetric system balances fresh replacement fluid or dialysate with effluent coming from the dialyzer and removes excess fluid (net ultrafiltration) from the patient. The PrismaFlex and the Diapact System both use gravimetric scales. The PrismaFlex machine features five pumps (blood, dialysate, pre-blood pump replacement solution, post-blood pump replacement solution, and effluent), four scales (one each for effluent and dialysate, two for replacement solutions) and a disposable set with preconnected high-flow dialyzers and fluid circuitry. The Diapact system has three pumps with a wide range of blood flows and dialysate flows. Fluid handling and ultrafiltration control is gravimetric, with one scale.

But now the new machines are coming. A looming question is whether these current platforms are sufficient or whether new capabilities and features are required. The names and timelines of the new machines have not been officially announced, but at the bedside we can expect new versions of the PrismaFlex and the NSO in the next 24 months. In addition, Spectral Medical, Inc., has indicated its intention to introduce a CRRT machine to the North American market in the next 18 months, called the S.A.M. (Spectral Apheresis Machine). The S.A.M. system uses a synchronized piston pump system run by four internal cam shafts that also run the pump clamps. The S.A.M. system is a small, easy-to-use, open platform for CRRT and hemoperfusion. In the pediatric world, the CARPEDIEM machine (Belloco), which debuted in Europe, looks to enter the US market. CARPEDIEM was specifically designed for neonatal CRRT and has very low priming volumes, blood flow rates as low as 5 mL/min, and incredibly accurate scales (error < 1 g), making it appealing for use in low-weight children as well.

What features can we expect with these new machines, and will the next machines bring features to the bedside to improve only delivery of the therapy or will they also have new capacities to improve outcomes? Inasmuch as the new machines and their new features remain unknown, I conducted an informal poll at the Critical Care Nephrology meeting in Vicenza, Italy, in June 2015 and asked which new features were most desirable. The top answers were reduced cost, smaller footprint, increased versatility, and portability. Interestingly, many thought leaders said the addition of an online monitor for hematocrit, calcium, or both would be an important advancement. In short, the new machines are coming soon, and we can hope that the manufacturers of the new devices will deliver more

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