Peritoneal Dialysis as a Mode of Treatment for Acute Kidney Injury in Sub-Saharan Africa

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Key Words

Acute kidney injury · Developing countries · Pediatric acute kidney injury · Peritoneal dialysis · Sub-Saharan Africa

Abstract

Background: Developing sustainable treatment programs for kidney failure in most countries of sub-Saharan Africa continues to remain an imposing challenge. While long-term renal replacement therapies in end-stage renal disease appear beyond national financial capabilities, there exist opportunities for a short-term and affordable treatment of acute kidney injury (AKI). Peritoneal dialysis (PD) is an effective and simpler modality compared to hemodialysis (HD) and can be performed without the need for machinery or electricity, making it an ideal choice in a low-resource setting. **Methods:** Since cost of treatment is the major obstacle, the goal is to develop a program that is cost effective. Developing an HD program requires a large capital investment by the hospital, needing water treatment systems and machinery and providing for their ongoing repair and maintenance. Gravity-driven PD is a simple, effective modality and can be performed in low-resource locales. **Results:** In a pediatric program that we started in the Komfo Anokye Teaching Hos-

pital in Kumasi, Ghana, 28 patients have been treated with PD for AKI so far. Half of them were treated successfully and were discharged having fully recovered kidney function. Seven patients (25%) were determined to have end-stage renal disease, whereas 7 others (25%) died during hospitalization. In these cases, late presentation for dialysis may have contributed to the inability to recover. **Conclusion:** For individuals and governments alike, who are concerned about the cost of providing or paying for dialysis, using PD to treat AKI is an effective and simpler modality compared to HD and can be performed without the need for machinery or electricity, making it an ideal choice in a low-resource setting.

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Introduction

To date, developing sustainable treatment programs for kidney failure in most countries in sub-Saharan Africa remains an imposing challenge. With 70% of the least-developed countries in the world and no nephrologists in many parts of sub-Saharan Africa [1], finding any treatment for kidney failure at all can be most difficult. For those suffering from kidney failure, the treatment op-

tions are kidney transplant or dialysis with two primary renal replacement modalities: hemodialysis (HD) and peritoneal dialysis (PD). However, developing countries struggle to provide even a minimal amount of dialysis for patients with acute kidney failure. The challenges for developing sustainable HD programs include the lack of equipment and trained nephrology technicians and nurses, poor quality, and insufficient or irregular water and electricity. However, for either modality, the primary and overriding factor for lack of sustainability can be attributed to costs. Since most countries in the region require patients to pay out of pocket for care, it makes supporting a lifelong treatment for a chronic disease most difficult.

Acute kidney injury (AKI) is well established as a common, often underrecognized condition [2] with a high mortality rate. Despite all organizational difficulties, there seems to exist an opportunity to provide an affordable short-term treatment for AKI in developing countries, resulting in restored kidney function for many. For individuals and governments alike, who are concerned about the costs of providing or paying for dialysis, using PD for AKI offers a cost-effective therapy per life saved. PD is equally effective in the short term and is a simpler modality compared to HD, and it can be performed without the need for machinery, electricity or water, making it an ideal choice in a low-resource setting.

Aim

AKI is increasingly prevalent in developing countries and is associated with severe morbidity and mortality [3]. However, this treatable condition is often ignored, unrecognized and undiagnosed. On the other hand, many expend their efforts trying to develop chronic treatment programs. Yet, programs for chronic HD are short lived as the costs of maintaining equipment and consumables have families only affording days to months of treatment before running out of funds [4]. As the chronic programs end so ends treatment for kidney injury in contradistinction to AKI treatment. In fairness to developing countries, without government reimbursement for dialysis services, one would see similar problems even in the richest of nations. The costs of paying for thrice-weekly dialysis would be insurmountable for the vast majority of any population if they needed to pay out of pocket.

Further compounding the problem, the world's focus has been on treating infectious diseases such as HIV/AIDS, diarrheal diseases and malaria due to their high

mortality rates. In reviewing the causes of AKI in the developing world, we find the high mortality rates may be due to AKI as a result of these diseases [5]. This is in stark contrast to AKI in the developed world, where trauma, industrial accidents, drugs, cardiogenic and septic shock, as well as renal transplant rejection are the more common causes [6]. In September 2000, the largest gathering of world leaders held the Millennium Summit where they adopted the United Nations Millennium Declaration, committing their nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets, with a deadline of 2015, which have become known as the Millennium Development Goals [7]. Two of these goals, Goal 4 to reduce childhood mortality under 5 years and Goal 5 to improve maternal health, may be directly and positively impacted by developing AKI treatment programs.

Methods

Using a renal replacement modality which eliminates the need for clean water, machinery requiring electricity and continual maintenance and repair is ideal. In PD, we use the body to perform some of the tasks that HD consumables and machines do for us. Using a catheter, the abdominal cavity is filled with a dialysis solution (electrolyte and glucose water solution); the peritoneum, a lining that covers the organs in the abdomen area, acts like a filter allowing excess fluid and other toxins which accumulate in the blood as a result of kidney failure to pass into the dialysis solution during a 4- to 6-hour dwell time [8]; a 30- to 40 min exchange time follows, during which dialysis solution is drained, thrown away and replaced with a volume of a fresh one. Fluid fluxes are gravity driven and the whole process can be performed even in the resource-poorest locations, making this especially useful in low-resource areas where availability of electricity and water is absent or unreliable. This is also the recommended treatment modality for pediatric patients and, as opposed to HD, can be performed on even the tiniest of babies. In most hospitals in Africa, HD catheters are inserted by surgeons and require the use of the surgical theater, increasing the cost of treatment. Inserting a PD catheter, of which there are many types, depending on how long they will be required, can be done by the nephrologist bedside without the need for a surgical theater and a surgeon, making the procedure less costly. Catheters are available in complete kits providing all the components for a nonsurgical insertion. Using a method such as the Seldinger technique is more feasible and practical for nephrologists and offers similar outcomes to surgical insertion [9]. AKI PD programs were started with support provided by the Sustainable Kidney Care Foundation and international nephrology organizations: the International Society of Nephrology, the International Society for Peritoneal Dialysis and the International Pediatric Nephrology Association to provide training in patient diagnosis, treatment and catheter insertion. These four organizations working together have formed the Saving Young Lives consortium to continue to expand these programs.

Fig. 1. Causes of AKI. ESRD = End-stage renal disease; AGN = acute glomerulonephritis; APIGN = acute postinfectious glomerulonephritis; HUS = hemolytic uremic syndrome; UTI = urinary tract infection.

Results

We have reviewed the results of an ongoing program at the Komfo Anokye Teaching Hospital located in Kumasi, Ghana, approximately 250 km northwest of Accra. A program to treat children with renal failure using PD was started in the Pediatric Unit in 2012 and since that time 28 children were treated with PD. Causes of AKI varied, from septic shock and malaria being leading suspected causes (fig. 1). The children ranged in age from 1 month to 13 years (17 females and 11 males). Catheters (single-cuff, Tenckhoff style) were inserted bedside by the nephrologist for all but the very young ($n = 2$), in whom a general surgeon inserted them. Of the 28 patients, 7 (25%) died (fig. 2). Of these cases, late presentation for dialysis may have contributed to the inability for these patients to recover. Fourteen patients (50%) were treated successfully and left the unit having fully recovered kidney function, whereas 7 children were determined to have end-stage renal disease after undergoing treatment. The patients were stabilized, consoled regarding options for chronic treatment in the local HD clinic, the acute treatment was discontinued and patients were released. Having to end treatment at this point is perhaps one of the most difficult decision any physician can face. However, as mentioned earlier, until such time as governments can include chronic treatment for their citizens in their national healthcare budgets, chronic programs remain un-

Fig. 2. Outcome of patients of the Komfo Anokye Teaching Hospital in 2012.

affordable for most. Treating AKI, whether it is acute on chronic or simply acute, is the ethical course of action, even if availability of chronic treatment is limited or entirely lacking.

Discussion

Why choose PD over HD? As discussed, costs being our major obstacle, we must develop a program that is as cost effective as possible. Developing an HD program requires a large capital investment by the hospital. For

Table 1. Approximate costs (in USD) of dialysis in the private sector

Country	Costs for day 1 includes treatment and catheter	Costs for individual treatments	Total costs for 6 treatments
Uganda	600	100	1,100
Ethiopia	260	100	760
Nigeria	260	125	885
Ghana	300	100	800
Kenya	500	90	900
Tanzania	500	150	1,250

Table 2. Estimated dialysis fluid needed per patient

	Exchanges/ per day, n	Fluid/ exchange, liters	Length of treatment, days	Total fluid, liters
Child	4	0.5	10	20
Adult	4	2	10	80

example, HD requires approximately 150 liters of pure water per treatment and a reverse osmosis system that can cost tens of thousands of dollars, which is especially difficult to install in areas where water is scarce or of poor quality and electricity is intermittent. Building improvements are required for delivering the water to the HD machines and removing the waste and water, and of course, electricity to run the machines, a resource which can be rarer still than water in many areas. The HD machines are expensive and require skilled technicians for maintenance and repair. Some programs have tried to offset the initial high costs with donated equipment, but this option presents many of its own challenges. We must consider how the equipment came to be donated. New machines are generally purchased after current equipment has reached its useful life: that is when repair and maintenance of existing machines becomes more expensive than buying a new machine. This basic fact does not change upon donation of the machine, and hospitals in developing countries constantly struggling to find operating dollars will find it extremely difficult to keep machines running. Beyond this, proper performance is essential, as studies have shown that optimal dialysis is only reached when machines are performing properly and periodic maintenance is an essential com-

ponent to delivering the prescribed dialysis treatment [10]. Therefore, donation of the machine in itself is not sufficient unless plans are in place for continued supply of repair parts and trained technicians are readily available. This task is far more difficult than finding a donated machine.

The cost of HD treatments for AKI must also be taken into consideration. In a survey of 6 countries in sub-Saharan Africa (table 1), we have found that the average cost of an HD treatment is fairly consistent, with each individual session costing approximately USD 100, although we have some countries reporting as high as USD 150. The 1st day of treatment, which includes surgical insertion of a catheter into a suitable blood vessel, is a more invasive procedure than is required for PD, and costs can range from USD 260 to 600. The actual number of treatments that a patient may undergo will vary depending on the patient's condition and family finances. In addition, the course of treatment for AKI may vary from what is performed in developed countries due to the patient's inability to sufficient number of treatments. For discussion purposes, if a patient underwent treatment every other day for 2 weeks, the total cost would range from USD 760 to 1,250. The cost per treatment should not vary from patient to patient. It must be noted that HD is not a recommended treatment for pediatric patients, especially in very young children.

Unlike HD, where the cost of an individual treatment is fixed, the cost of an individual treatment day of PD will vary depending on the size of the patient, as this factor will determine the amount of PD fluid required. PD fluid is predominantly delivered in a 2-liter bag. The amount used per exchange will be individualized by the physician, however, historically approximately 40 ml/kg per exchange have been the general guideline [11] for adults. For children generally a lesser amount will be used, especially during the initial days. In studies from India in children, Mishra et al. [12] reported 5–10 ml/kg of PD fluid for the initial 1–2 cycles, and, thereafter, the fill volume was increased to 25–30 ml/kg in younger children and 30–40 ml/kg in older children. Table 2 reflects the estimated amount of PD fluid that would be required for 10 days of treatment for a child or an adult. The 1st day of treatment, which would include placement of a catheter, is usually less expensive than HD. Based on these estimates of fluid needs and costs of catheter and required consumables, PD treatment costs range from as little as USD 300 for a child to USD 600 for an adult, well below our ranges for HD treatment of USD 760–1,260.

Conclusion

Measures to prevent kidney failure are important and need to be addressed. However, we cannot ignore those patients that are currently inflicted. Using PD to treat AKI as outlined can bring life-saving treatment to a large percentage of the affected population in many developing countries. It is more affordable than HD, can be started in the low-resource settings and is more desirable as a treatment option for children. While we will continue to strive to bring treatment for all with any form of kidney

disease, we must not allow those with AKI to go untreated while waiting for the ability to treat everyone. Starting programs such as these can allow for many to go on and live productive and fulfilling lives.

Disclosure Statement

John Callegari, Mary Carter and Nathan Levin own stock in Fresenius Medical Care; Nathan Levin is also a consultant to Aethlon Medical Inc. All other authors have nothing to disclose.

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