ORIGINAL ARTICLES

OUTCOME OF ACUTE PERITONEAL DIALYSIS IN NORTHERN TANZANIA

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Data on the burden of acute kidney injury (AKI) in resource-poor countries such as Tanzania are minimal because of a lack of nephrology services and an inability to recognize and diagnose AKI with any certainty. In the few published studies, high morbidity and mortality are reported. Improved nephrology care and dialysis may lower the mortality from AKI in these settings. Hemodialysis is expensive and technically challenging in resource-limited settings. The technical simplicity of peritoneal dialysis and the potential to reduce costs if consumables can be made locally, present an opportunity to establish cost-effective programs for managing AKI. Here, we document patient outcomes in a pilot peritoneal dialysis program established in 2009 at a referral hospital in Northern Tanzania.

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Acute kidney injury (AKI) is an important cause of morbidity and mortality worldwide (1–3). In resource-poor countries of sub-Saharan Africa such as Tanzania, data on the burden of AKI are minimal because of a lack of nephrology services and an inability

to recognize and diagnose AKI with any certainty. In the few published studies, high morbidity and mortality are reported. In Brazzaville, Congo, 15% of admissions for kidney disease presented with AKI, and among children, mortality was 37% (4). The major causes of AKI in Africa are infectious (either sepsis or dehydration from gastroenteritis), but the use of traditional medicines is also suspected to be an important but poorly documented cause (1,4,5).

Improved nephrology care and dialysis may lower the mortality from AKI in these resource-limited settings. However, hemodialysis is expensive and technically challenging, and it is usually available only to a select few who can both afford and access it in large cities. The technical simplicity of peritoneal dialysis (PD) and the potential to reduce costs if consumables can be made locally present an opportunity to establish cost-effective programs for managing AKI. However, to date, PD is not routinely available across sub-Saharan Africa because of cost and a lack of clinical expertise (6,7).

Tanzania is one of the poorest countries in Africa and faces all the challenges outlined here. There are only 2 certified nephrologists in a country of about 40 million inhabitants. In a similar setting with little availability of nephrologists (eastern Nepal), PD for AKI had favorable outcomes (8). A low mortality rate, with just 4 deaths in 31 treated cases, was achieved by training medical residents to insert peritoneal catheters and to perform intermittent PD (8). Here, we document patient outcomes

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in a similar pilot program established in 2009 at a referral hospital in Northern Tanzania (9).

METHODS

Our pilot intervention was conducted at the Kilimanjaro Christian Medical Center (KCMC). This 457-bed referral hospital, located in a semi-urban setting, serves a population of more than 11 million in the northeastern zone of Tanzania and acts as a teaching hospital for a medical school that has both undergraduate and postgraduate training programs. The presence of postgraduate trainees makes KCMC ideal for the development of a specialized renal center that could have the potential to expand services to the rest of the region through a graduated peer-training program in which one trainee trains the next, and so on.

Initially, 2 senior residents (1 in Internal Medicine and 1 in Pediatrics) and 2 nursing officers (Medicine and Pediatrics with intensive care experience) from KCMC were trained for 5 weeks in May 2009 in Curitiba, Brazil, on peritoneal catheter insertions and processes of care for the acute PD patient. In June and July 2009, after returning from the training, the nurses then trained all the other nurses at the medical intensive care unit and the pediatric ward in conducting PD exchanges. The first patient, a child, was treated in July 2009.

Patients treated in the pilot program were adults and children with a history and clinical investigations suggestive of AKI (for example, ultrasonography showing normal-size kidneys), who were unresponsive to fluid challenge and who had absolute indications for dialysis. Indications included uremic encephalopathy, refractory hyperkalemia (potassium binding resins are not readily available in Tanzania), severe metabolic acidosis, and oliguria with life-threatening fluid overload. Patients with a presentation or history consistent with chronic kidney disease (CKD) but no clear suggestion of superimposed AKI were excluded. Patients with known mild-to-moderate CKD who developed AKI and indications for dialysis would be eligible for dialysis in the program. However, the lack of chronic kidney care often means that patients do not know if they have CKD, and baseline serum creatinine values are often unavailable.

The program attempted to raise awareness of the availability of the new acute PD service through presentations at other health centers in the region and through word of mouth. Patient were selected using this procedure: A patient with a history supportive of AKI, anuria, and other indications for dialysis could be referred. Once identified, the patient would undergo a complete his-

tory and physical examination, with testing for serum creatinine, potassium, and bicarbonate levels; a urine analysis (dipstick and sediment microscopy); and in most cases, renal ultrasonography. The case would then be summarized and sent by e-mail and text message for discussion by a nephrology panel of experts in Canada and United States involved in the program. Eligibility and treatment recommendations were then made after opinions and responses had been received by the KCMC trainees.

Catheter insertion was performed using a blind technique in adults and using direct insertion by a general surgeon in the operating theater in children less than 5 years of age. In all but 5 adults, the blind catheter insertion used the Y-Tec system (Y-Tec VP-210 Std Pac; Medigroup, Oswego, IL, USA). Catheters were inserted surgically by the open method in 2 pediatric patients; later in the program, a reusable trocar of surgical steel (manufactured in Brazil) was used to insert the catheter blindly in 3 adult patients following the technique observed and acquired in Curitiba. Surgical insertion was also performed in 2 adult patients.

Once a catheter was inserted and tested, dialysis exchanges were started immediately and repeated every 2 hours. For adults, 1 L of 1.5% dextrose solution every 2 hours was prescribed for the first day, thereafter 2 L was exchanged every 2 hours if no catheter leakage was observed. For children, 10 mL/kg of 1.5% dextrose every 2 hours was the starting dose. The frequency of exchanges and types of fluids were then varied according to individual clinical response and ultrafiltration needs.

Clearances were not measured because of regular changes in the frequency of exchanges depending on the biochemical and ultrafiltration requirements of the patients.

RESULTS

Between July 2009 and June 2011, 20 patients were selected for acute PD. One patient was dialyzed on 2 separate occasions, and 2 patients died shortly after catheter insertion because of complications of uremia.

DEMOGRAPHICS

Most of the 20 dialyzed patients were from the local Kilimanjaro region. Most were adults (16 of 20), with slightly more than half being men (9 of 16). Almost one third of the patients were peasant farmers (6 of 20). Table 1 shows the risk factors for AKI that were recorded for the patients at the time of the presentation.

Most patients had decreased urine output at presentation (19 of 20). Other common presenting features were shortness of breath (7 of 20), decreased level of consciousness with coma (6 of 20), and body swelling (6 of 20). Figure 1 shows other symptoms and signs described or noted by the patients or their families at the time of presentation.

On examination, most patients had edema (14 of 20), which was observed as facial, sacral, or lower-limb edema. Pallor was found in half the patients (10 of 20). The mean duration of symptoms at presentation was 15 days, but the mode was 3 days. In only 5 patients was the duration of symptoms more than 10 days.

Table 2 shows the most common indications for dialysis. Oliguria or complete anuria was the most frequent (15 of 17), followed by uremia, hyperkalemia, and severe metabolic acidosis.

Most cases of AKI were presumed to be attributable to either acute tubular necrosis (8 of 20, with various causes of volume contraction) or acute glomerulonephritis (7 of 20, with some suspicious for hemolytic uremic syndrome based on history, and others suggestive of acute interstitial nephritis (AIN) because of the use of traditional medicines). Of the 20 cases, 3 were eventually recognized as being AKI imposed on a background of chronic disease.

METABOLIC CHANGES WITH TREATMENT

Serum creatinine levels varied widely. Mean serum creatinine at the time of dialysis initiation was 1198 $\mu\text{mol/L}$ (range: 3674 – 233 $\mu\text{mol/L}$). The average potassium level was 5.67 mmol/L on admission (18 patients), which dropped to an average of 4.4 mmol/L after treatment. On average, patients were dialyzed for 10 days using an average 75 L of fluid.

OUTCOMES

Technique Survival: Technique survival was good. Catheter obstruction occurred in 3 patients and was attributed to fibrin ($n=2$) or omental entrapment ($n=1$). Flushing was successful in clearing the fibrin-obstructed catheter in 1 patient; catheter replacement was performed in the other patients. All 3 patients survived to discharge.

Infections: Low infection rates were achieved, with peritonitis being suspected in only 2 patients. One had cloudy dialysate, and the other had the classical signs and symptoms. Both patients were successfully treated with antibiotics. In one, intraperitoneal ceftriaxone 1 g with each 2-hourly dwell was used; in the other, the

TABLE 1
Risk Factors for Acute Kidney Injury

Risk factor	Patients
Vomiting	5
Traditional herbal medicine	4
Diabetes	3
Diarrhea	3
HIV infection	2
Hypertension	2
Eclampsia	2
Skin infection	1
Furosemide	1
Eye infection	1
Sickle cell disease	1
Malaria	1
Hemolysis	1
Postpartum bleeding	1
Previous AKI	1
Blunt trauma	1
Sepsis	1

Figure 1 — Distribution of symptoms and signs described or noted by the patients or their families at the time of presentation.

TABLE 2
Indication for Dialysis

Indication	Patients (n)	
	Total	Data available
Uremia ^a	20	10
Hyperkalemia	18	9
Metabolic acidosis	13	8

^a Includes convulsions, loss of consciousness, chest pain, and bleeding tendency.

catheter was removed because kidney recovery had been achieved. The latter patient was prescribed intravenous ceftriaxone 1 g every 12 hours. In both cases, ceftriaxone was used because ceftazidime and vancomycin were unavailable in the region. Microbiology cultures were also not available.

During the course of therapy, 6 patients were clinically suspected of having exit-site infection. They were treated with oral cloxacillin.

Mortality: Of the 20 patients, 4 died before discharge, typically very early in the course of therapy. Of those 4 patients, 2 presented late, in a moribund state, and because of the severity of kidney failure, died shortly after catheter insertion, just as PD was being initiated. The other 2 patients died suddenly on PD: one from

unknown causes, and one from a suspected myocardial infarction against a long-standing background of diabetes mellitus.

All 16 surviving patients were referred for follow-up at a newly established kidney outpatient clinic. At 3 months after discharge, 4 were lost to follow-up, and 9 were alive and well. No follow-up information was yet available for another 3 patients who were dialyzed less than 3 months before the time of writing. At discharge, serum creatinine levels in those patients were 130 $\mu\text{mol/L}$, 282 $\mu\text{mol/L}$, and 302 $\mu\text{mol/L}$. Table 3 summarizes outcomes and follow-up.

Lack of follow-up for some patients is a result of their residence in regions a long distance from KCMC, with financial challenges that prevent travel to the hospital clinic.

TABLE 3
Dialysis Dose, Presumed Diagnosis, and Survival

Age (years)	Sex	Days of dialysis	PD fluid volume (L)	Dose	Presumed diagnosis ^a	Survival at discharge	Follow-up at 3 months
1	Male	10	16	1.1	Acute tubular necrosis	Yes	Lost to follow-up
2	Male	6			Acute tubular necrosis/pyelonephritis	Yes	Lost to follow-up
8	Female	7	14	0.9	Glomerulonephritis	Yes	Alive and well
9	Male	40	53.5	0.4	Chronic glomerulonephritis, ESRD	Yes	Alive and well
17	Female	14	118	1.1	Acute tubular necrosis	Yes	Alive and well
19	Female	5			Eclampsia	Yes	Lost to follow-up
23	Female	7	56	0.9	Acute glomerulonephritis	Yes	Alive and well
24	Female				Lupus nephritis	Yes	Alive and well
26	Female	6	79		Acute tubular necrosis	Yes	Alive and well
26	Female	7	50		Acute tubular necrosis	Yes	Lost to follow-up
30	Male	12	72	0.5	Acute tubular necrosis, toxic	Yes	Alive and well
31	Male	15			Acute tubular necrosis, diabetic ketoacidosis	Yes	Lost to follow-up
31	Female	21	148	0.9	HEELP	Yes	Lost to follow-up
37	Male	13	119	0.8	ESRD	No	Died
37	Male	0	0		Idiopathic thrombocytopenic purpura, hemolytic uremic syndrome	No	Died
42	Male	10	79		ESRD	Yes	Lost to follow-up
45	Male	7	69	1.1	Acute tubular necrosis	Yes	Alive and well
47	Male	23	262	1.1	Glomerulonephritis, HIV related	Yes	Alive and well
54	Male	3			Acute tubular necrosis	No	Died
54	Male	1	2		Rhabdomyolysis	No	Died

PD = peritoneal dialysis; ESRD = end-stage renal disease; HEELP = hemolysis, elevated liver enzymes, and low platelets.

^a Characteristics leading to presumed diagnosis: acute tubular necrosis: based on the urine microscopy (granular casts); pyelonephritis: fever, pus cells on microscopy; end-stage renal disease: uremic with small kidneys or chronic kidney disease; chronic glomerulonephritis: chronic kidney disease picture, with red blood cell casts; eclampsia: history of seizures, proteinuria, and high blood pressure in pregnancy; diabetic ketoacidosis: high blood glucose with ketonuria and clinically acidotic; lupus or vasculitis-related nephritis: suspected on a constellation of lupus manifestations and red blood cell casts on urine microscopy; idiopathic thrombocytopenic purpura or hemolytic uremic syndrome: acute kidney injury with compatible history and low platelets; rhabdomyolysis: history of crush injury with acute kidney injury; HIV-related glomerulonephritis: kidney failure with red blood cell casts in HIV patient.

DISCUSSION

Patient demographics reflect the catchment area of the KCMC hospital, in that most patients came from the local Kilimanjaro region. Patients from other regions likely could not afford transportation costs. Poverty might also explain the low number of referred patients with AKI. Many families would have been informed that the service had an associated cost that would have to be borne by the patient or the family. Relocation of family members from their home village to KCMC while their loved one received care would represent a loss of income that could have devastating effects on the remaining family members.

Significantly more adults (16 of 20) than children were treated. In an African setting, with a high prevalence of infectious diseases that cause vomiting and diarrhea, more children might be expected to develop acute tubular necrosis or hemolytic uremic syndrome as a complication. Does the low referral of pediatric cases reflect improved care of children in the region? That hypothesis might be a possibility, because the previously very busy diarrhea ward at KCMC has recently been able to shrink in size. Those observations reflect the results of a Tanzanian demographic and health survey, which suggested an increase in the treatment of diarrheal disease to 53% in 2010 from 46% in 2005 (10–13). Furthermore, child mortality rates are tending to decline. The rate was 81 in 1000 live births in 2010; it had been 143 per 1000 live births in 2000 (10–13).

In children and adults alike, the most common risk factors for AKI are prolonged vomiting and the use of traditional herbal medicines. Use of herbs in Tanzania is very common. In the management of HIV disease, 90% of the patients in Bukoba rural district depend on traditional medicine (1). Use of traditional medicine in Africa is a form of care that is belief-based, cheaper, and more accessible. It has no proven benefit and is felt to be harmful in many cases because patients delay accessing acute care. Some herbal traditional medicines have also been linked to development of acute interstitial nephritis, but the types of herbs used vary so greatly that it is difficult to collect accurate information.

Challenges in access to care in this setting were also illustrated by 2 patients who developed AKI associated with diabetic ketoacidosis and severe extracellular fluid volume contraction. One of the patients could not afford insulin injections, and the other resorted to herbal remedies for management. Opportunities to deal with preventable outcomes such as these are therefore lost at the primary level of care because of limited resources.

It was not surprising that most patients presented very late to the AKI program, with oliguria or anuria and with severe biochemical abnormalities. A significant number arrived comatose and with shortness of breath either because of severe metabolic acidosis or pulmonary edema.

The peritonitis rate was gratifyingly and unexpectedly low in our environment, but only slightly less so than in other studies (2). Also unexpected was the low mortality rate (20%) compared with that in other reports (2). Gabriel *et al.* and others treated high numbers of patients with septicemia as the underlying cause of AKI; in our series, the underlying cause of AKI in most patients was volume depletion stemming from a variety of causes. Also, our series included a number of CKD patients.

LIMITATIONS AND CHALLENGES

The ratio of nurses to patients was very low, and so some of the required information (for example, ultrafiltration) was incomplete. Not all biochemical data were available every day, because financial considerations (patients are responsible to pay for all laboratory tests) and, at times, a lack of reagents for laboratory testing presented challenges.

The low number of patients treated could be a result of an inadequate level of awareness in the KCMC's catchment area. Most patients could not afford the entire cost of treatment. Sustainability without government support will be challenging. However, with patients, the hospital, and the government sharing the costs of the treatment, the program could become more sustainable.

Underlying diseases were not known in some patients. No renal biopsies were possible, given limitations with the histopathology expertise at KCMC. Hence, some of the cases may have had a chronic, progressive underlying renal disease that resulted in stage 5 CKD and eventual death from complications. That may be the reason that some patients did not seek follow-up.

CONCLUSIONS

We have demonstrated that, in a setting of low resources, optimal results from PD are possible. Our program is based on strong training of interested and capable trainees and ongoing support for case review and decision-making from nephrologists who reside on other continents, but who are committed to mentorship and support. Despite the program's success, capacity building (that is, nursing ratio and ability to diagnose

and treat underlying causes) and increased awareness at neighboring hospitals to increase referrals are recognized needs. Sustainability (because of the cost of therapy) remains a challenge, but may be resolved through combined investment from the medical center, patients, and government funders.

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DISCLOSURES

The authors have no financial conflicts of interest to declare.

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