

Kidney Patient Care in Disasters: Lessons from the Hurricanes and Earthquake of 2005

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The active 2005 hurricane season alerted Americans to the pressing need for a more effective response to mass casualty incidents. The kidney patient community was particularly affected. Ninety-four dialysis facilities in the Gulf Coast states closed for at least 1 wk in the aftermath of Hurricane Katrina, and additional units were affected by evacuation of dialysis patients. Dialysis units along the Gulf Coast were also affected by Hurricanes Rita and Wilma. Existing emergency response plans were inadequate in providing continuity of care for kidney patients. The Kashmir, South Asia, earthquake of October 2005 killed 97,000 individuals. Building collapse was associated with widespread crush injury, and many patients required temporary hemodialysis. Several regions of the United States have the potential for catastrophic earthquakes. The Kidney Community Emergency Response Coalition has recently issued recommendations for patients, dialysis facilities, and providers, with a goal to improve care of kidney patients in future domestic disasters. With suitable planning, the nephrology community can do much to ensure the continuity of medical care for kidney patients in the face of a wide range of possible natural and human-made disasters.

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The 2005 hurricane season exposed deficiencies in the United States disaster response. More than 200,000 people with chronic medical conditions were displaced by Hurricane Katrina, with Hurricanes Rita and Wilma wreaking similar havoc in subsequent months, although on a lesser scale (1). Patients with chronic kidney disease (CKD), especially those who were receiving dialysis or with renal allografts, were shown to be particularly vulnerable. A key lesson was learned: The kidney community was not prepared. In response, the Kidney Community Emergency Response Coalition (KCERC) was formed and has made recommendations. A further reminder of the needs for dialysis care in disasters came with the catastrophic Kashmir, South Asia, earthquake, which killed an estimated 97,000 individuals. The collapse of thousands of buildings was associated with widespread crush injury; some patients required temporary hemodialysis. In this article, we review issues that affect kidney patient care as demonstrated after recent hurricanes and earthquakes, with analysis of ap-

proaches that have worked and current plans that have proved inadequate.

Hurricane Katrina: The View from New Orleans

On August 29, 2005, Hurricane Katrina provoked the worst urban disaster in modern American history (Figure 1). The health care system in metropolitan New Orleans, disrupted by the storm, was destroyed by the flooding that followed. Among 14 specialty and 12 acute care hospitals in New Orleans, all but three (Ochsner Medical Center, West Jefferson Medical Center, and East Jefferson General Hospital) were evacuated and closed during the aftermath of the storm. Most facilities remained closed for months. The loss of regional infrastructure including electrical power, water, sewage, transportation, and telecommunications had catastrophic consequences for patients with chronic illnesses. Isolation and loss of access to health care facilities may have accounted for many of the more than 1800 deaths in the affected Gulf Coast states that have been attributed to Hurricane Katrina. Moreover, this mortality count data does not include additional deaths that occurred among evacuees.

Without electricity and a reliable water supply, dialysis treatments were not available in free-standing dialysis units and in

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Figure 1. Hurricane Katrina: The view from New Orleans. (A) Hurricane Katrina is shown in a satellite image acquired August 27, 2005, 2 d before landfall in Louisiana. The hurricane is located in the middle of the Gulf of Mexico and at this point had sustained winds of 115 mph, reaching a maximum of 165 mph the next day. (B) There was extensive flooding throughout much of New Orleans after the storm arrived, and the levee system failed on September 29. (C and D) Tulane University Health Center experienced severe flooding, which required that patients relocate within the hospital and ultimately required the hospital to close. (E and F) The Dialysis Clinic, Inc (DCI)–Tulane facility on Canal Street in New Orleans was heavily damaged, as seen from the outside and inside in these views taken approximately 3 wk after Hurricane Katrina. Images courtesy of the National Oceanic and Atmospheric Administration (A); CDR Sarah Atanasoff, MD, US Public Health Service (USPHS; B); Dr. Lee Hamm (C and D); and DCI-Tulane dialysis facility (E and F).

most city hospitals in the metropolitan area. Hence, among the most vulnerable victims were the area's nearly 2500 dialysis patients who received care at 43 facilities in the city and surrounding area. Almost all patients who were receiving peritoneal dialysis and hemodialysis were displaced during the storm to urban centers throughout the United States. Most, if not all, dialysis units in hurricane-prone areas had detailed patient evacuation plans, including dietary recommendations, medication supplies, and contact numbers, and this may have helped patients survive. Dialysis patients, as part of the diaspora of New Orleans residents, reported to dialysis centers in Baton Rouge, Houston, and Atlanta. Many of these patients had missed dialysis treatments for 1 wk or more before restarting dialysis.

West Jefferson Hospital (on the west bank of the Mississippi), East Jefferson Hospital, and Ochsner Medical Center principally on the basis of topographic good fortune were not flooded and retained sufficient function to provide vital services (Table 1). By virtue of planned backup systems, Ochsner Medical Center had no interruption of services despite the complete loss of municipal power and water supply. Care for acutely ill patients, including intensive care patients, and dialysis patients continued without interruption.

After Hurricane Katrina, 94 dialysis facilities closed for at least 1 wk, including 54 in Louisiana (out of a state total of approximately 150 facilities), 31 in Mississippi, and nine in Alabama (Figure 1, E and F). As of June 2007, 17 dialysis facilities remained closed, including 16 in Louisiana and one in

Table 1. Systems support at Ochsner Medical Center during Hurricane Katrina

System	Examples	Functionality
Telecommunications	Landlines, cell phones, and SpectraLink wireless phone system	SpectraLink and landline phones usable in hospital; cell phones limited as a result of loss of system towers
Electricity	Three generators (kept above ground); supply of diesel fuel was sufficient for 2 wk	Loss of one generator led to loss of air conditioning; however, emergency power, electrical lights, and computer systems remained usable
Data networks	Bell South and Ochsner electronic networks remained fully functional	Data network functionality was maintained by switching servers to remote location (Baton Rouge), enabling web access, e-mail, and electronic medical records
Water	Ochsner provided a well for backup water supply; reverse osmosis water tank supply available	With availability of reverse osmosis tank and deionizers, there was sufficient purified water available for dialysis
Laboratory	i-STAT portable chemistry analyzers	Autoanalyzer use was limited as a result of loss of air conditioning; i-STAT was used for acid-base and serum potassium analysis
Medical records	Electronic medical record (Ochsner Clinical Workstation)	Ochsner Clinical Workstation remained functional, providing continuous access to patient records

Mississippi. In Louisiana, the number of patients who had ESRD and were receiving dialysis fell from 7557 patients on July 31, 2005 (before the storm), to 6213 on August 31, 2005, immediately after the storm (an 18% reduction). By December 31, 2005, the Louisiana ESRD population had grown to 6731 (89% of the prehurricane census).

Of the 5849 Gulf Coast dialysis patients who were affected by Hurricane Katrina (including those in Louisiana, Mississippi, Alabama, and northern Florida), 148 deaths occurred in the first month after the storm (mortality rate 2.5%; CMS claims data, provided by ESRD Network 13, 2005). However, morbidity and mortality related to Hurricane Katrina are difficult to establish for two reasons. First, patients with ESRD have high rates of morbidity and mortality, particularly from cardiovascular disease, for which mortality rates are 10- to 30-fold higher for dialysis patients compared with similarly aged patients from the general US population (2). Under these circumstances, identifying “storm-related” deaths may be difficult. Second, many patients remain permanently displaced after the hurricane and securing information on their health remains a challenge.

In Louisiana, before August 29, 2005, 2921 patients with ESRD were treated in dialysis units that closed after Hurricane Katrina. Of these, 589 died during the ensuing 12 mo, resulting in an unadjusted mortality rate of 20.2% (CMS claims data, provided by ESRD Network 13). Overall unadjusted ESRD mortality for Louisiana in 2005 (27.5%) was not significantly higher than in 2004 (26.8%). Nonetheless, an effect of Hurricane Katrina might be demonstrated by an apparent increased mortality rate (expressed as a standard mortality ratio) in the months after Hurricane Katrina, followed by a later decrease, as demonstrated in Figure 2.

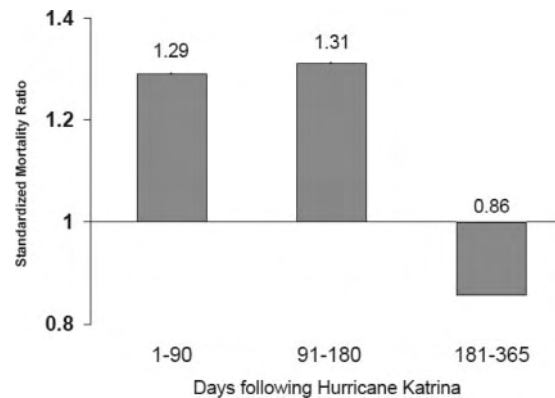


Figure 2. Standardized mortality ratios after Hurricane Katrina. Expected rates were based on 2003 ESRD mortality rates in Louisiana of 201 deaths per 1000 patient-years. Data for 2003 were abstracted from the 90-d data set in USRDS Render (http://www.usrds.org/odr/xrender_home.asp; Accessed September 23, 2006).

Reports from state and local officials in Louisiana suggest that the total number of fatalities related to Hurricane Katrina was 1577. As noted, these data do not account for the additional deaths that occurred among evacuees. On the basis of a survey that was conducted in Houston evacuation shelters in the immediate aftermath of Hurricane Katrina, more than 40% of Hurricane Katrina evacuees had chronic disease, including 12% with diabetes, 23% with hypertension, and 9% with a history of heart disease (3). Only 43% of evacuees reported having health insurance. Lack of access to medication and health care com-

pounded by stress among evacuees undoubtedly may have contributed to additional deaths that are not included currently in published statistics.

Kidney transplant services in Louisiana were also affected. After several years of increasing activity, there was a 21% decline in transplant activity in 2005, as compared with 2004, largely owing to the closure of two of three major transplant centers in New Orleans (Figure 3). As of September 2006, all three transplant centers are operational, although one has relocated to Lafayette, LA.

The disaster exacerbated underlying problems on the Gulf Coast and in Louisiana, in particular. In 2005, Louisiana had the lowest per capita income among all 50 states and the District of Columbia. One quarter of New Orleans' citizens lived in households with incomes below the federal poverty level. Louisiana consistently ranks among states with the highest proportion of uninsured citizens. An extensive survey in 2003 demonstrated that 21% of adults in Louisiana were uninsured (4), and among the uninsured, patients with ESRD were disproportionately represented (5). US Renal Data Systems data indicate that the state and region have the nation's highest prevalence of CKD and ESRD (6). Hence, the impact of this catastrophe fell on a socially and medically vulnerable population without the necessary resources to evacuate before the storm or to secure medical services in the days that followed.

More data collection and analysis will be necessary to assess the full impact of this urban catastrophe and its effects on chronically ill populations. However, even in the first year after Hurricane Katrina, important lessons have been learned (Table 2).

Kidney Patients and the Hurricanes: The View from Surrounding Areas

In the immediate aftermath of Hurricane Katrina, the focus of the nephrology community in Baton Rouge, 75 miles northwest of New Orleans and well inland from the Gulf of Mexico,

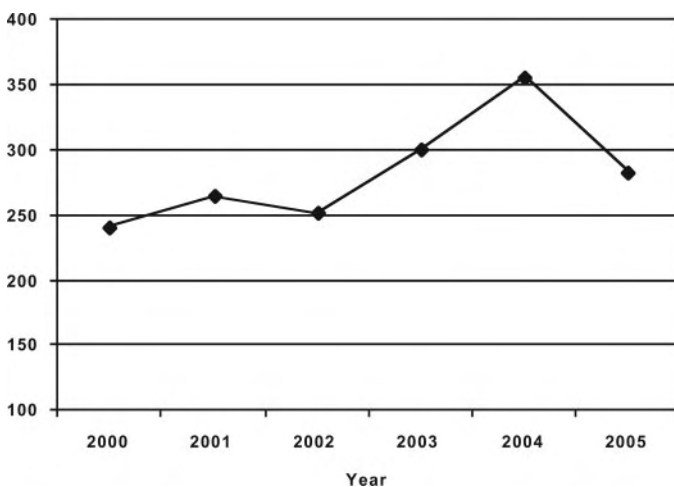


Figure 3. Kidney transplants in Louisiana, by year. The number of renal transplants rose during the years 2000 and 2004 and then declined in 2005 as a result of the disruption of medical care associated with Hurricane Katrina (arriving August 29) and its aftermath.

centered on preparing for evacuees who were in need of dialysis. The 17 Baton Rouge–area outpatient dialysis facilities all were equipped with generators and felt well prepared. Water availability was not a problem thanks to astute planning on the part of the Baton Rouge Water Company after Hurricane Betsy in 1965. The Louisiana Department of Public Health established a surge hospital/triage center in the athletic facilities at Louisiana State University; medical care was provided by a team of US Public Health Service officers, medical emergency response teams from various states, and countless volunteers from the region and across the nation (Figure 4). It was at this facility that the largest numbers of evacuees who needed dialysis were identified. Despite ongoing challenges in the first week after Katrina's landfall, approximately 700 patients who had ESRD and were evacuated from New Orleans and surrounding communities, along with the usual 1000 local patients, received dialysis treatments in the Baton Rouge area. This could not have occurred but for the hard work and dedication of the entire dialysis care community. No one is believed to have died in Baton Rouge from lack of dialysis, a remarkable accomplishment considering the magnitude of the disaster and the vulnerability of this population.

In Baton Rouge, some things went right, whereas others warrant improvement. There was an outpouring of helpfulness and charity. People everywhere wanted to know what they could do to help. Drug companies offered donations of medications and money. Locally, the dialysis administrators were empowered to act by their parent companies, and the value of local knowledge of resources was clearly evident. Virtually all of the patients who needed routine dialysis received treatments as outpatients, which made scarce inpatient hospital beds available for acutely ill patients. Also, renal professionals orchestrated the care of the dialysis patients who were living in the shelters, allowing other health care personnel to focus their attention elsewhere.

Despite many successes, there were myriad frustrations. Failure of communications technologies produced major roadblocks. The Baton Rouge landline and cellular telephone networks were overwhelmed and functioned poorly. There existed no designated shelter for dialysis patients, who were often moved from one shelter to another. Dialysis staff members were often left unaware of the location of their new patients and had no way to contact them. No easily accessible dialysis patient database for New Orleans existed; therefore, there was no accurate estimate of the numbers of patients who were likely to arrive. Misinformation was rife. For example, dialysis facilities that were to receive patients in Louisiana and Texas would be told to expect a certain number of patients only to find a much different number arriving or none at all.

Approximately 250,000 individuals were evacuated to Houston as a result of Hurricanes Katrina and Rita. Houston, as the fourth largest city in the United States with more than 4 million people, has more than 60 dialysis units. Dialysis patients were asked to identify themselves upon arrival at the large shelters so that dialysis assignments could be quickly accomplished (Figure 4G). Unfortunately, some patients arrived in Houston quite ill as a result of having missed medications or dialysis

Table 2. Nephrology response to the 2005 hurricanes^a

Function	What Worked, with Varying Degrees of Implementation and Success	What Did not Work or Was Problematic for Clinical Care
Evacuation	Louisiana Disaster Emergency Evacuation Plan: Accelerated dialysis or voluntary relocation of existing dialysis patients in surrounding areas to prepare for evacuees Early hospital discharge for dialysis patients (when appropriate) in perimeter areas, in anticipation of a surge of evacuees	Limited early evacuation for vulnerable individuals, including dialysis and transplant patients and those with mobility limitations No DIPP for dialysis patients to get updated specific information along evacuation routes leading to perimeter dialysis facilities Disorderly evacuation led to long patient waits in some perimeter dialysis units that experienced patient surge Absence of patient personal evacuation plans resulted in scant information about medication, comorbidities, and infection status
Shelters	Special-needs shelters had regular nephrology presence to facilitate referrals Unique bracelets to identify dialysis patients in shelters and indicate urgency of resuming regular dialysis Support from volunteers: Universities, faith-based organizations, service organizations	Particular special-needs shelters were not designated for dialysis patients, leading to dispersal of patients to many shelters, which created tracking and transportation difficulties Some dialysis patients without acute medical needs were delivered to emergency departments in nearby areas, competing for medical resources Insufficient laboratory support to facilitate evaluation of arriving dialysis patients Insufficient oxygen and wheelchairs Lack of shelter guidelines for care of dialysis patients, including infection control guidelines and dietary instruction Insufficient psychological and social work services
Patient transfers	Transplant patients and pediatric dialysis patients transferred ahead of the storm to other regional transplant centers, facilitated by UNOS, CMS, and National Association of Children's Hospitals	Impaired communication between inpatient and outpatient facilities Nursing homes in the periphery that accepted dialysis patients in some cases were slow in seeking dialysis care
Dialysis patient care	Dialysis patient evacuees to nearby areas were treated rapidly, effectively, and compassionately by local dialysis facilities Free medications provided by physicians, pharmacies, and Louisiana state program Mobile medical specialty team from Mayo Clinic Lifeline with nephrology and other medical services Advance prescriptions with patients and/or pharmacy chains maintained medication continuity, even when patients evacuated to other states	Limited time for in-depth assessment of evacuee dialysis patients No region-wide system for retrieving patient medical records, medication list, dialysis prescription, and infection status Vascular access problems: Infection and thrombosis of vascular accesses, lack of care for vascular access complications Lack of translators for non-English-speaking dialysis patients, particularly those sent to rural areas
Dialysis unit function	Many dialysis units had stocked extra supplies, generators, and fuel; extra water treatment supplies helped when water service returned, with initially high levels of sediment and chlorine Informal "buddy" system dialysis units and patients Bleaching after each dialysis for evacuees when hepatitis and HIV infection status was unknown Reducing dialysate flow rates to 300 ml/min to reduce water consumption CMS guidance on emergency dialysis treatment when patient data were limited	Multiple threats to dialysis unit function: Municipal water contamination, sewer systems malfunction, no power generator, fuel in short supply, security concerns Water contamination, including high levels of chlorine, salts, and sediment, damaged reverse osmosis filters and increased consumption of carbon filters and sediment filters Power surges from generators damaged sensitive electronic medical and communications equipment Severe dialysis unit staffing shortages in perimeter areas and insufficient reserve staff available Limited patient transportation options Difficulty with ordering supplies as a result of transportation problems, including medications, dialysis filters, and especially refrigerated goods Need for medical oxygen Difficulties experienced by dialysis units in rapidly verifying volunteer staff credentials in the absence of a precertified volunteer database
Supplies	Medical supplies provided gratis by LDO and vendors to supply depots to assist dialysis units with restocking Generator fuel and water provided by farmers' cooperatives	Hospitals needed peritoneal dialysis support but lacked contracts with suppliers
Communication and data management	Communication facilitated by daily conference call involving dialysis units, ESRD network staff, and FEMA and by NKF Listserv E-mails and text messages from patients and dialysis staff to the ESRD networks, which acted as clearinghouses to identify needs and solutions Support from amateur radio operators Support from print and broadcast media in disseminating information	Communication early in the disaster response was poor as a result of limited phone service and insufficient planning Impaired communication led to poor use of existing resources Dialysis facility status (open/closed) not quickly and widely disseminated No tracking system for kidney patients Medical response teams arriving in the disaster theater were not provided with a plan for nephrology referrals Failure to back up patient record database Shortage of staff led to inability to complete required paperwork
Transportation	Volunteers from communities, faith-based organizations, and service organizations assisted with dialysis patient transport	No prearranged transportation plan and lack of community-wide coordination of available volunteers to provide for regular transport of dialysis patients to dialysis facilities Transportation contracts not always honored when needs outstripped resources Lack of authority to allow patients and dialysis facility staff to pass easily through check points
Recovery	AKF provided funds to support patient needs, including food, clothing, lodging, and transportation ASN assistance with relocating displaced nephrology trainees RPA assistance with displaced physicians Vendors made grants for supplies	Early repopulation of dialysis units returning to function was delayed by inadequate transportation, housing, medical, and utilities infrastructure and security No system to develop consensus as to when neighborhoods are ready for repopulation, creating uncertainty for patients and staff Hurricane Rita added challenges as recovery commenced

^aAKF, American Kidney Fund; ASN, American Society of Nephrology; CMS, Centers for Medicare and Medicaid Services; DIPP, Disaster Information Public Post; FEMA, Federal Emergency Management Agency; LDO, large dialysis organization; NKF, National Kidney Foundation; RPA, Renal Physicians Association; UNOS, United Network for Organ Sharing.

treatments. Dialysis units extended their hours to accommodate the influx of patients, and treatment times for local patients were in some cases shortened to accommodate the additional patients. The federal government increased the availability of dialysis services by providing emergency certification of facilities with pending applications.

Barriers to Timely Evacuation of Kidney Patients

The 2005 hurricanes demonstrated the existence of important barriers to early and complete evacuation of kidney patients to safe areas (Table 3). As dialysis facilities and emergency response planners prepare disaster plans, a review of these barriers may suggest ways to facilitate evacuation. Dialysis patients and renal transplant patients should be encouraged to evacuate early, ahead of the general population. Encouragement from health care providers whom they know and trust will likely be more effective than announcements in the mass media. Health care providers should help patients develop individualized evacuation plans that address particular issues, including lack of transportation, limited social support, and physical and psychological factors.

Displaced Physician Assistance

Hurricane Katrina displaced an estimated 6000 physicians in Louisiana and Mississippi. As noted, even before the hurricane, these states had medical infrastructure that was considerably underresourced compared with other regions of the United States. Therefore, it is essential to the future health delivery in this region for these physicians to be able to reestablish their practices promptly. This will allow these physicians to continue to serve their patients, who in many cases have developed long-term medical relationships with their providers that are of great psychological and clinical value.

Most physicians who were affected by Hurricane Katrina were faced with the following questions: Where are my patients and staff? What has happened to my office, equipment, and records? Will my patients eventually return to my practice? How will I be able to pay my staff and bills? Should I go back and rebuild my practice? The challenges that these physicians faced were daunting. A major issue was obtaining financial resources for rebuilding practices. Business interruption insurance policies in general do not cover losses from backup of water. Federal flood insurance coverage is often woefully inadequate to rebuild from the severity of damage such as occurred with Katrina. Private businesses do not qualify for help from the Federal Emergency Management Agency, and potential loans from the Small Business Administration are usually just that—small.

After Katrina, the Louisiana State Medical Society established a relief fund as a result of donations, which poured in from other state medical societies, large physician groups and hospitals, and the American Medical Association, among other sources. Displaced physician applicants who met the established criteria each received approximately \$3500 in a first round of disbursements, because the number of potential applicants and the total amount of available funds were yet un-

known. In a subsequent round of awards, another \$3500 per applicant was disbursed. Although these monies were not large, in dire circumstances they were most welcome. The total amount donated to this relief fund was approximately \$800,000 (Dr. David L. Tarver, Louisiana State Medical Society, personal communication to R.J.K.). The American Medical Association established a similar relief fund for its members who were displaced by the hurricanes of 2005.

In response to efforts by KCERC, the Renal Physicians Association agreed to host a web site listing physicians who were displaced by disasters. In the future, when a regional disaster is declared, the web site will be activated. The web site will have links to web sites of other participating organizations. A physician will have the ability to enter his or her name, location, contact information, and areas of subspecialization, such as renal transplantation. The list has the potential to document the number of displaced physicians. Furthermore, this listing will facilitate contacts by nephrology professionals who are seeking information about specific patients and may also assist the displaced physicians in identifying employment opportunities. The KCERC has been less successful in developing an ongoing relief program to provide financial assistance to displaced physicians. Disaster insurance for physicians is one approach, but it is unclear whether such a program would be economically feasible.

Lessons from Abroad: The Kashmir Earthquake

Earthquakes, explosions, and other causes of building collapse have the potential to produce many cases of crush injury and attendant acute renal failure (ARF). In these events, direct trauma as a result of falling debris is associated with a high early fatality rate, whereas ARF as a result of rhabdomyolysis causes delayed morbidity and mortality (Figure 5). Planning for disasters that are associated with crush injury should include input from the kidney community (7).

In the event of widespread building collapse, the role of nephrology providers is two-fold. First, they should remind first responders and other health providers that there is a significant risk for ARF and that the symptoms and signs of ARF include anorexia, nausea, vomiting, and diminished urine output. At minimum, laboratory tests such as hemoglobin, serum potassium, urea nitrogen, creatinine, and creatine phosphokinase should be measured on every victim in the field, emergency room, or hospital. In a massive event, however, casualties may run in the tens or hundreds of thousands, and there will likely be widespread infrastructure damage. Laboratory testing may not be easily accomplished in all patients, and resources may have to be focused on those with obvious crush injuries. Second, nephrology caregivers should ensure that patients with incipient ARF receive aggressive fluid management with saline, bicarbonate, and mannitol to prevent further renal damage as a result of hypoperfusion and receive dialysis when needed.

In the event of a major earthquake or other cause of building collapse, the demands on the nephrology community will be quite different from that seen after the recent hurricanes, for



Figure 4. Hurricanes Katrina and Rita: The evacuation experience. (A) In Baton Rouge, LA, a 250-bed acute triage and short-term special-needs shelter was set up in the Louisiana State University (LSU) Pete Maravich Assembly Center basketball arena by LSU physicians and residents and a 37-member PHS team from Washington, DC, and Atlanta, later complemented by the New Mexico-1 Disaster Medical Assistance Team and the Illinois Medical Emergency Response Team. (B) These federal teams provided the administrative and logistical structure for an operation that over 9 d triaged 20,000 evacuees from New Orleans and surrounding areas by helicopter, school bus, ambulance, and private vehicle. Behind the US Air National Guard Blackhawk helicopter landing on the LSU track is a field house that was used as special-needs shelter, accommodating up to 400 evacuees. The majority of direct medical care was delivered by civilian volunteer physicians, nurses, pharmacists, pharmacy technicians, respiratory therapists, psychologists, and social workers. In addition, countless college students and lay people of all backgrounds volunteered their time. (C) A PHS nurse and a civilian nurse and physician work with an intensive care patient, possibly from one of the shuttered New Orleans hospitals, an image emblematic of the close professional cooperation that characterized the operation. (D) The dialysis section was visited daily by local nephrologists, nephrology nurses, and nephrology social workers who met newly arrived evacuees and arranged for resumption of regular dialysis treatment and for transportation to special-needs shelters or other housing. (E) Dialysis patients outside a destroyed hospital in Bay St. Louis, MS, waiting “for death or salvation” in the words of one. They waved down a Coast Guard helicopter, which took this patient to Mobile, AL, where he resumed regular

Table 3. Barriers to early evacuation of kidney patients

Barrier	Comment
No mandatory evacuation order	Patients may feel a false sense of security in the absence of a mandatory evacuation order Evacuation order intended for general population may not provide enough time for patients with transportation or other issues
Evacuation order and instructions not perceived as credible	Lack of trust in local, state, and federal government "Crying-wolf phenomenon": Past evacuations may have proved unnecessary or chaotic
No contact from dialysis staff urging early evacuation	Dialysis unit plan should include prompting patients to evacuate early, ahead of the general population Patients may lack telephone service and may have language, comprehension, and literacy barriers
No prearranged personal evacuation plan, with alternative contingency, or inadequate training in that plan	Plan should be simple, easy to follow, and with step-by-step check-off instructions Involve family or other social support members in the plan
No preselected destination, such as safe zone, staging area, or evacuation shelter	Special-needs shelters outside the (predicted) affected area need to open in advance of storms (at least 48 h and ideally 72 h)
No private vehicle or access to evacuation transportation	Dialysis unit disaster plan should address patient transportation; ideally, reimbursement would be available
Financial limitations and concerns	Patient may not be aware of community resources to support evacuation; despite these resources, evacuation remains a personal responsibility
Early evacuation of dialysis patients may complicate evacuating family, neighbors, or pets	
Physical factors: Dementia, impaired mobility, advanced age, comorbidities	
Psychological factors: Noncompliance, substance abuse, personality style	
Fear of leaving behind everything that is familiar: Home, social support, dialysis staff, physician	

which the major task was caring for patients with chronic renal failure. Patients with ARF as a result of rhabdomyolysis will generally have major trauma and require hospitalization, either in a conventional hospital or in a field hospital. Temporary vascular access may be necessary, and the patient may require daily dialysis as a result of tissue catabolism. Crush injury–associated ARF tends to occur in younger individuals because the muscle mass at risk and the likelihood of surviving the initial trauma are both greater. These people have usually enjoyed excellent health in the past, and if they survive the

trauma with appropriate medical care, then they may recover completely.

Earthquakes pose issues that are particularly problematic for the nephrology emergency response. Utilities including water and power supplies and other critical infrastructure may be disrupted over a wide area. Hospitals in the immediate area may be nonfunctional. Furthermore, aftershocks may cause additional damage. It is best to select tertiary-care hospitals that are outside the disaster zone and transport patients. In the United States, such transportation would likely require airlift

dialysis. Some evacuees from New Orleans traveled to the Astrodome (F) and the George R. Brown Convention Center (G) in Houston, TX, which served as special-needs shelters. (G) The Convention Center had a sign at the entrance encouraging dialysis patients to identify themselves, to expedite the swift resumption of dialysis treatments. A USPHS Commissioned Corps officer and nephrologist, CAPT Ken Lempert, assisted dialysis patients. (H) USPHS nurses CDR Debra Price and CAPT Debra Goldstein help evacuees make themselves comfortable in the shelter. Images courtesy of Louisiana State University, Baton Rouge, LA (A); the Acadian Ambulance Company, Lafayette, LA (B); Department of Health and Human Services (C); Dr. Jeffrey Kopp (D); Father James Pawlicki (E); Dr. Steven Fadem (Copyright 2005, Steven Fadem, MD; F); and Dr. Ken Lempert (F and G). Image C reproduced from reference (20), with permission.



Figure 5. International nephrology response to the Pakistan/Kashmir earthquake, October 8, 2005. The epicenter of this magnitude 7.6 earthquake was located in Pakistan. (A) A resident of Bakalot, Pakistan, surveys the damage; nearly all of the buildings in the city were damaged or destroyed. (B and C) Rescue workers stand on a partially collapsed building in Islamabad, located 138 km from the epicenter, and have just found two men who have been trapped inside a building (the head of a first responder is visible on the right side of the image). (D) American nephrologist Dr. Nauman Qureshi provides hemodialysis in a tertiary care hospital in Islamabad. The patient has sustained crush injury (note the right-arm amputation) and developed acute renal failure as a result of rhabdomyolysis. The patient is receiving hemodialysis 15 d after the earthquake, using one of several dialysis machines donated by DaVita and transported from the United States. The patient received hemodialysis for 18 d and ultimately survived. Images courtesy of Corbis (A and B), Associated Press (C), and Dr. Nauman Qureshi (D).

by military personnel. The course of ARF in rhabdomyolysis, although often associated with rapidly worsening azotemia, generally allows 3 to 5 d before dialysis is necessary. Hemodynamic monitoring and close laboratory support are essential. During this interval, the focus should be on surgical care and fluid management. The grace period can be exploited to secure the infrastructure that is needed for dialysis, including personnel, equipment, and laboratory backup. For each patient who needs hemodialysis, the plan should anticipate 10 or more sessions of dialytic therapy (7). Portable dialysis machines that require minimal infrastructure are suitable for austere conditions, such as those that follow disasters in third-world settings but also perhaps in domestic disasters. Two Food and Drug Administration–approved devices that might have a role in these settings are the NxStage System One (NxStage Medical, Lawrence, MA), which supports intermittent and continuous procedures, and the Allient Sorbent Hemodialysis System (Renal Systems, Warrendale, PA), which requires only 6 L of water per dialysis treatment.

Most of the major earthquakes in the past few decades have occurred in seemingly remote parts of third-world countries, including northern Iran (8); Bam, Iran (9); Marmara, Turkey (10); Kashmir, South Asia; Spitak, Armenia (11); and Tangshan, China (12). The earthquakes that affected Mexico City in 1985 and Kobe, Japan, in 1995 were exceptions, occurring in indus-

trialized regions (13–15). Although the experience gained from these countries is not entirely relevant to planning for a similar disaster in the United States, we can still learn valuable lessons. The catastrophic images of the latest major earthquake in Kashmir, South Asia, from October 2005 are still fresh in the minds of many people. This massive earthquake, with magnitude of 7.6 on the Richter scale, was the largest ever recorded in Pakistan and killed 97,000 people and left more than 3 million people homeless, many still without shelter 1 yr later. There was a substantial international effort to aid victims, including providing acute dialysis therapy.

The centennial of the “Big One” in San Francisco occurred in 2006. That historic earthquake occurred along the San Andreas fault, stretching for 700 miles along the California coast. The earthquake had a magnitude of 7.8 on the Richter scale and produced a death toll of 3000. There is a >60% probability that the San Andreas fault will experience a 6.7 or greater earthquake in the next three decades (16). Other faults in the United States with the potential for devastating earthquakes are located in the Pacific Northwest and western Tennessee.

A collaboration between the European Renal Disaster Response Task Force (ERDTF), Physicians without Borders, the Belgian military, and the European Union mounted a successful response to the Marmara, Turkey, earthquake of 1999 (17). A review from Blake and Parker (18), prepared in 2003, ad-

dressed whether the North American nephrology community might develop a dialysis response team analogous to the ER-DTF, assembled under the auspices of the International Society of Nephrology. These authors concluded that there was no military organization prepared to support the logistical needs that are required for such an international response team in the Americas in general or in North America in particular; this observation continues to be true. As an alternative, it was proposed that a list of nephrology professionals and an inventory of dialysis machines and related equipment be assembled for the Americas. Recently, a roster of nephrology professionals has been developed by the US National Disaster Medical System; this would provide assistance to dialysis facilities within the United States that are affected by an earthquake or other disasters. The KCERC has not yet addressed the issue of providing assistance to patients with dialysis needs associated with disasters in other countries. This remains an important issue to be addressed in the future.

Conclusion

The Gulf Coast hurricanes and the Kashmir earthquake of 2005 have reminded the kidney patient care community of the need for improved disaster planning. The KCERC has recently disseminated tools and materials to assist in disaster planning for patients, dialysis facilities, providers, and emergency response planners (19). Patients and their families, clinical staff, dialysis facility administrators, and emergency response personnel are encouraged to review these materials and to incorporate these ideas and suggestions into their disaster plans. Developing, refining, and maintaining emergency preparedness tools will be a continuing and challenging process for the KCERC. Many issues remain to be addressed; one example is the pressing need for a kidney community plan for pandemic influenza. We must continue to identify potential problems, develop approaches to preparing for disasters using the best available evidence and a detailed study of local conditions, and implement these plans.

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None.

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