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The University Hospital NICU in the Midst of Hurricane Katrina: Caring for Children Without Power or Water

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AUGUST 26: 3 DAYS BEFORE LANDFALL: Like most Friday afternoons, our 12-person neonatology group went through the weekend sign-out process of patients divided among the 9 area hospitals for which we provide NICU coverage. I was assigned to University Hospital for the weekend. University Hospital is a state-run public hospital in downtown New Orleans, Louisiana, that serves primarily indigent patients as part of the campus of the old Charity Hospital. It has a level 3 NICU and is a full-service teaching hospital for the medical schools at Louisiana State University and Tulane University. I was aware of Hurricane Katrina, then a category 1 storm in south Florida, and all indications were that the storm was targeting the coast of the Florida panhandle.

By evening, as the storm's predicted path had dramatically changed westward, I began to review our available on-call neonatologists and plan for hospital coverage in the event that this new prediction held true. I also began to make plans for the evacuation of my wife and 5 children but hoped, as had been the case in recent years with other hurricanes, that Katrina would steer clear of New Orleans.

AUGUST 27: 2 DAYS BEFORE LANDFALL

As the predictions for the storm passing over or near New Orleans remained consistent, plans for covering each of our hospitals with an in-house neonatologist for the duration of the hurricane threat were finalized. Dating back to at least Hurricane Andrew in 1992, our division had gone through this process multiple times. Although several hurricanes during this time threatened to hit New Orleans, our city had managed to avoid any direct hit. Despite many doomsday scenarios, New Orleans had not experienced a direct hit since Hurricane

Betsy in September 1965. In recent years, there were increasing efforts to evacuate the city with such threats. Hospital evacuation had been discussed, but a plan to carry out an evacuation of such magnitude had never been fully developed. The risks and costs of such an evacuation would be significant. Instead, each hospital and the local civil authorities developed plans to allow for the hospitals and patients to weather the storm by using stockpiles of food and supplies, generator-supplied electricity, and staffing patterns for key personnel. This plan had worked well in recent years with several hurricanes striking glancing blows to our city. Hurricanes' effects on the hospitals, patients, and personnel had been more of an inconvenience than a problem.

The University Hospital NICU had a census of more than 20 infants, including 2 infants on conventional ventilators and 2 infants on high-frequency ventilators. Hospital administrators finalized details for implementing the "code gray" hurricane plan.

By nightfall, thousands of people had left the New Orleans area, including my own family. Evacuation continued through the night and into the next day as Katrina slowly moved closer to our region.

Key Words: Hurricane Katrina, neonatal intensive care unit, NICU

Abbreviations: CHNO, Children's Hospital of New Orleans; IV, intravenous

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AUGUST 28: 1 DAY BEFORE LANDFALL

With Katrina increasing in intensity and still targeting New Orleans, several hospitals closest to the projected path evacuated their small number of neonates from their level 2 NICUs. This began a flurry of activity with available local neonatal transport resources. Because of the concern for street flooding around University Hospital with heavy rains and its potential impact on electric power, a decision was made to transfer the 2 stable premature infants on conventional ventilators to other local hospitals that were less prone to such problems. The 2 unstable infants on high-frequency ventilators remained at University Hospital, because the risks to transfer these sicker infants at this time were thought to be greater than the risks of staying in place.

By early afternoon, light rains began and I assumed my role in-house at University Hospital along with my neonatologist colleague from Tulane University School of Medicine, Dr Betty Martinez. Together with a team of residents from both medical schools, we would be providing medical coverage for the NICU patients and any infants born during or after the storm. Although we hoped for the best, we each brought food, clothes, flashlights, extra batteries, portable radios, and other supplies to last several days. Along with many other in-house physicians, we jockeyed for a convenient place to lay our air mattresses down and call our own.

Throughout the evening, as the winds gradually increased and the rain fell in intermittent heavy bands, we monitored the hurricane on local television and the Internet. Shortly before midnight, I decided to go to sleep while I could, knowing that the worst was still to come.

AUGUST 29: LANDFALL

After a few hours of intermittent sleep, Katrina's fury woke me for good around 4 AM. Heavy rains and howling winds made sleep difficult. Outside electric power was lost, and the hospital's generator power came to the rescue. All of the infants were tightly cramped into an interior portion of our third-floor NICU away from windows, which rattled in their frames (Fig 1). As the sun tried to rise somewhere behind the darkened sky, the residents began their daily work. By midmorning, patient rounds took us away from concerns about the storm for a short while. Parts of the hospital roof, signage, and awnings were torn apart by the wind.

By early afternoon, the rain and wind began to subside. There was residual street flooding, but there was a sense of relief in everyone. The worst of the hurricane had passed, our hospital had survived, our infants had survived, and we had survived. We began to wonder out loud how soon we would be able to leave the hospital.

As the local television news came on later in the afternoon, we got our first glimpses of the extensive flooding in other parts of the city. Although we initially



FIGURE 1
The NICU's location away from windows when it still had power.

thought that we had weathered the storm reasonably well, the pictures we saw revealed that many parts of our city had not. We were surprised to see entire neighborhoods underwater. Flood victims were being rescued from the rooftops of their houses. As images of various parts of the city were shown on the screen, we tried to determine if our own houses were affected by the floodwaters. Outside, the skies were clearing, but water in the streets around the hospital continued to rise, reaching around 4 feet deep by sunset (Fig 2). Although several levees had been breached by this time and were responsible for the flooding, this information had not yet made it into news reports and certainly not to our unit.

AUGUST 30: 1 DAY AFTER LANDFALL

In the early-morning hours, generator power became erratic—the progressive street flooding had spilled over into the hospital basement and damaged the switching mechanisms. Without reliable power, the high-frequency ventilators supporting our 2 sickest patients would not function and the mechanisms usually used to monitor and care for these infants would be lost. Several portable generators were put into place on an adjacent



FIGURE 2
The view from the emergency department in the afternoon after landfall earlier in the day.

patio with extension cords running to the few pieces of equipment they could support. We quickly had to triage what equipment was absolutely needed and what equipment was not needed. As the sun rose, we could see that the water had risen further overnight, with 6 to 7 feet of water in the streets around University Hospital. In the air, the sounds of rescue helicopters blended with the hum of the high-frequency ventilators. On the radio, we heard that various levees around town had been breached and that additional flooding around the city was expected.

Realizing that the 2 extremely low birth weight infants on high-frequency ventilation could not be maintained for long under these circumstances, I began to make arrangements for transfer of these infants to Children's Hospital of New Orleans (CHNO), which had not flooded and had adequate generator power. Telephone contact was difficult at this time, with most landlines completely inoperable and cell phone service becoming progressively more erratic. A fire truck was available at CHNO with enough ground clearance to pass through flooded streets en route. The final 3 blocks of the journey, however, could not be negotiated by any available land vehicle, so arrangements for transport by boat or helicopter were necessary.

Attempts to reach outside rescue personnel by telephone and 2-way radio were unsuccessful. A ham radio operator volunteering at the hospital was able to relay a message to the state Department of Wildlife and Fisheries to request that a boat be made available to help transport these infants to the waiting fire truck and NICU transport team. After waiting almost 2 hours without any signs of such a boat, 3 orthopedic residents were seen canoeing in the streets across the hospital campus and up to our emergency department entrance, the level to which the water had risen. After they reported seeing the waiting fire truck, I explained the need for transport of the 2 infants and they agreed to help. Because they declined my offers to travel with the infants, I gave the nonpaddling chief resident brief but pertinent instruction: keep the endotracheal tube in place, squeeze the bag enough to make the chest rise, and keep the infant pink. The infants were transported 1 at a time wrapped in blankets, ventilated with 100% oxygen via bag to endotracheal tube, and placed into open acrylic infant cribs (Fig 3). At the end of the canoe trip, as the orthopedic resident handed the infant to my partner waiting with the transport team, he gave her the same instructions, word for word, that I had passed on to him minutes earlier. Both infants arrived at CHNO in good condition.

None of the remaining infants required mechanical ventilation, several were on supplemental oxygen, and several were on intravenous (IV) fluids. By typical standards, none were critical. Patient care issues were fairly simple at this time, and the thoughts of most everyone



FIGURE 3

The view from the emergency department 1 day after landfall. The canoe has an intubated neonate being bagged en route to a waiting fire truck.

centered on what was happening to our city and when we would be able to be evacuated.

As their batteries lost power, the hospital's strobe fire alarm lights dimmed after a day and a half of annoying pulses of light. By the end of the day, the water had neither risen nor fallen from where it was at sunrise.

AUGUST 31: 2 DAYS AFTER LANDFALL

Without communication outside the hospital, we could not get word on when we might be rescued, and we could not get in touch with our families. Rumors and wishful thinking for an imminent rescue provided some hope at a time when the uncomfortable conditions were continuing to take their toll on patients, families, and hospital personnel. Food and water were available but not plentiful. The air was hot, still, and muggy as nurses and doctors sought shady areas adjacent to the open windows. Because running water and sewerage were not available, personal hygiene was limited. Alcohol-based hand sanitizers were used in abundance. The various smells—floodwaters, generator exhaust, body odors, and wastes—were persistent. Thankfully, the NICU area smelled considerably better than the parts of the hospital in which adult patients were cared for.

Patient rounds went quickly; nursing shifts began to blend together as sleeping space and clinical care areas were often separated by a few feet because everyone sought the coolest areas. Available portable-generator power was used to power a single incubator that was used to warm 2 very low birth weight infants who required thermal support despite the high ambient temperatures. With the absence of reliable pumps, they were weaned off of IV fluids and feedings advanced at a faster-than-normal pace.

The tattered roof of the Louisiana Superdome was visible a quarter mile away, with the adjacent raised interstate filled with increasing numbers of survivors who made their way out of the water and to higher

ground. Each day brought the sound of more and more helicopters, taking off and landing continuously from the Superdome heliport. Convoys of trucks pulling boats to launch sites along interstate down ramps became a common site.

Coping mechanisms varied among the NICU personnel. A group prayer service provided comfort to most for a while. People worried about their families, their homes, their cars, and, most obviously, about when help would arrive. In the absence of any really sick infants, patient care efforts shifted to helping to manage 2 non-medical NICU workers who experienced panic attacks.

SEPTEMBER 1: 3 DAYS AFTER LANDFALL

We were called to attend the possible cesarean-section delivery of an infant whose mother had been in labor for more than 24 hours. Under normal circumstances, this delivery would likely have happened much earlier in the course, but these were not normal circumstances. The extension cord from our NICU's portable generator was transferred to the windowless delivery room to provide power for 2 spotlights. Those not directly caring for the patient fanned those who were, providing some air circulation in a surreal setting. A healthy boy was born with forceps assistance more than 1 hour after our being called to attend the delivery (Fig 4).

Later that afternoon, this mom and infant were carried down from the third to the first floor along with the rest of our NICU patients. We were led to believe that our patients and a few necessary caretakers would be evacuated by boat to another nearby hospital where helicopter transport was available. Several critically ill adult patients were evacuated in this manner. Deciding which nurses and respiratory therapists would leave with which infants required some diplomacy given the progressive anxiety.

As the first 6 infants, along with 6 nurses and a respiratory therapist, left on a flatboat accompanied by the driver and a rifle-bearing policeman, a sense of relief was felt. This feeling was short-lived, though, because before a second boat could arrive, the first boat returned carrying everyone who had left. After traveling the half mile to the nearby hospital, they were turned away because there was miscommunication over who was actually being evacuated at that time. Without a doubt, morale reached its low point at this time.

Violence in our city, both real and perceived, along with poor communications were affecting rescue efforts. Later that evening, a rare telephone call came through on one of our cell phones. I was able to speak to Dr Steve Spedale of Woman's Hospital in Baton Rouge, Louisiana, who was coordinating the care of evacuated neonates. It was unbelievable to us, but there was uncertainty in the outside world as to whether NICU patients were still present at University Hospital! I assured him that we still had more than 20 neonates who needed evacuation, and



FIGURE 4
A high-risk delivery with lights powered by a portable generator.

as sunset approached, he assured me that he was working on getting this done (see "Caring for Displaced Neonates: Intrastate," pp S389–S395).

Around this time, we received word that a mother who had been hospitalized for preterm labor since before the storm was in more advanced labor and unlikely to be stopped. At this time, she was at 25 weeks' gestation. I spoke to her about the risks involved in such a severely preterm delivery. Beyond the typical risks, I told her of the primitive circumstances in which we were working and the need for evacuation of her infant whenever it could be accomplished. She asked that we do all we could to help her infant survive.

SEPTEMBER 2: 4 DAYS AFTER LANDFALL

Shortly after midnight, we were called to the delivery of this 25-week-gestation infant. In preparation, we rearranged extension cords to provide power for a ventilator, warmer, monitor, and IV pump. We decided to take the infant back to the NICU for resuscitation, given the lack of equipment and support in the delivery-room setting at this time. The sight of young intern Dr Brandy Beauchamp running through darkened halls while cra-

dling this tiny infant girl as her upper-level resident Dr Regina Robbins provided flashlight guidance will be etched in my mind forever.

The infant was intubated, given artificial surfactant, and provided with umbilical catheters in short order. Orders, an admit history, and physical were written. The entire process was done in less than an hour—there were no radiographs or laboratory results to wait for, because none were available. The infant did very well, with oxygen being weaned by pulse oximetry and IV fluids and antibiotics provided based on an estimated weight.

With daylight, the water level remained at the same level it had been for over 3 days. Although everyone was hopeful that this would be the day for evacuation, we also were cautious in our expectations given what had happened previously.

Then, at midmorning, helicopters suddenly hovered unannounced over University Hospital. The sound of clanging metal and splashing water caused some alarm until we realized that roof debris was being cleared for the helicopters to land. In short order, we were called to carry the infants and their supplies up 6 flights of stairs to the roof, which had become a makeshift heliport.

Similar to what had been done 1 day earlier, the infants were carried in open cribs that also housed their medical chart and short-term supplies. The youngest infant, now less than 12 hours old and weighing about 700 g, was layered in plastic wrap and blankets, and brought to the roof being hand-bagged by Dr Robbins. The infant's mom gingerly walked behind. Several other postpartum moms made the same journey along with one dad and a new big brother.

Military helicopters hovered in proximity to the hospital like a car-pool line, waiting their turn to be filled with patients, families, and caretakers. Within minutes, 28 infants were airborne and headed for higher, drier, and safer ground. Pediatric and adult patients were likewise evacuated by air over the next few hours. The patient evacuation we had waited 4 days for was completed in less than 4 hours.

For any mother who had been discharged before the hurricane, we had no way of providing updates on her infant's condition, no way to ask for consent for transport, no way to let her know where her child was going. Many of these mothers were in the midst of their own rescue and evacuation. In the days and weeks after the evacuation, it would take the combined efforts of health care workers, the news media, and volunteer organizations to reunite these infants with their mothers (see "Reuniting Fractured Families After a Disaster: The Role of the National Center for Missing & Exploited Children," pp S442–S445).

Along with several hundred remaining physicians, nurses, and other health care workers, I left the hospital by airboat. Leaving behind most of our belongings, we

floated along high above the streets on which we usually drove. Turning a street corner by old Charity Hospital, I was startled by the sound of the airboat scraping the roof of a parked car below us. The excitement of leaving was tempered by the devastation and desperation seen along the journey to dry land, where ground transportation was available for the ride out. There was a sense of accomplishment in that all of our infants and all of us had made it out alive but also a sense of sadness for what we had been through, for what all of our city had been through.

NOVEMBER

Two months have passed since I left University Hospital to be reunited with my own family. Our house was flooded with up to 5 feet of water, which took almost 3 weeks to drain. All of the infants who left University Hospital after the flood have done well. The 2 "canoe" infants remain hospitalized, one reunited with her evacuated family in Fort Worth, Texas, and the other in Baton Rouge. Each has been to 4 hospitals with the hope that their next move will be to home. Although much media attention has focused on things that were done wrong in the days surrounding hurricane Katrina, 28 infants survived, in the midst of the worst natural disaster our country has ever faced, thanks to the efforts of many dedicated nurses, therapists, and physicians at a time when most faced great personal losses. Similar heroic efforts can be told about several other local hospitals.

University Hospital remains closed, having been extensively damaged by the hurricane and resulting floodwaters. Its future, like that of many other area businesses and families, remains uncertain, to be determined by a willingness and need to rebuild and the financial resources available to do so.

LESSONS LEARNED

There are many lessons to be learned from these events in the midst of Hurricane Katrina, some large and some small. Health care workers who may be involved in these situations need to be aware of what they may endure. Each person should bring necessary food and supplies for several days in addition to what may be available from the hospital. Having one's personal needs taken care of allows the health care worker to devote more effort to patient care. Hospital personnel have varying degrees of coping mechanisms in difficult circumstances. All need support both physically and emotionally. Team leaders should be prepared to provide such support.

Medical decision-making in such extreme circumstances is quite different from what is done in more normal times. Diagnostic modalities such as radiograph and laboratory testing may not be available. Standard therapies may be unavailable or difficult to implement. With limitations on resources, atypical triage decisions on

patient care may become necessary. Calmness, open-mindedness, tolerance, and improvisation are useful traits.

Large-scale patient evacuations were delayed and difficult after the flooding. The relative risks and benefits of large-scale patient evacuations in advance of such a storm threat need additional evaluation. Hospital evacuation of a large metropolitan area is difficult and risky without time constraints; such an evacuation in the short period before an impending hurricane is more difficult and more risky. Any such evacuation is beyond the capability of local and regional resources.

COMMENTS

Despite extensive media coverage, the devastation of Hurricane Katrina is difficult to comprehend unless you have been in the midst of it. For 4 days after this storm, interruption in everyday services such as electricity, water, sewerage, communication, and transportation presented great challenges in patient care. As we were evacuated from University Hospital that morning, most of us did not fully realize the more enduring challenges that were ahead of us as we started to rebuild our lives in the post-Katrina world.

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