



Safe emergency evacuation of a Tertiary Care Hospital during the “once in a century” floods in Chennai, India

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Abstract

The coastal city of Chennai, India, was inundated by unprecedented heavy rains during the last week of November 2015, in what was billed as a “once in a century” floods. Over 350 people lost their lives in the floods. Global Hospital, a 250-bedded tertiary care hospital in Chennai, was heavily flooded leaving more than 100 patients and their relatives stranded inside with access totally cutoff from the rest of the world. This article describes how these patients, many in the Intensive Care Unit on ventilators, were safely managed within the hospital for over 48 h on very limited power supply and resources and then safely evacuated by fishing boats to three other city hospitals. Careful planning, anticipating hazards, identifying critical areas, effective communication and team work contributed to the successful management of this situation.

Keywords: Emergency, evacuation, flood

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The Setting

The coastal city of Chennai is the largest city in South India with a population of nearly 5 million. It is densely populated and industrialized. While lakes and marshlands formed an important part of the Chennai landscape in the past, these have been depleted by rampant and unregulated construction activity and the number of wetlands in the city has decreased from 150 to only 27 currently.^[1] The Northeast (NE) monsoon (from October to December) is the major source of precipitation for the city and provides drinking water for the rest of the year. Monsoons are unpredictable and can develop into cyclones, which regularly affect large parts of the Eastern coastline of the Indian subcontinent including Bangladesh and Myanmar.

Chennai has had private tertiary care facilities much earlier than other Indian cities and is known as the health

care capital of India. These hospitals cater to patients from both within and outside India. Global Hospital is a tertiary care hospital in the South of Chennai. The area surrounding the hospital was predominantly a marshland. This has gradually been encroached in the last 10–15 years. The hospital campus is spread over 24 acres of land and all buildings are only 2–3 stories high. The original structure was 25-year-old and had been extensively refurbished 6 years ago. The hospital is located 2 km away from the main arterial road. There have not been any previous episodes of flooding of the hospital despite heavy rainfall in 2005 and 2011.

Global health city is a 250-bedded hospital with predominant specialties of liver surgery and liver

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transplantation (LT), neurosciences, cardiology and cardiothoracic surgery, urology and kidney transplantation. The liver transplant program performs 150 LT annually, predominantly living donor LT (LDLT) (80%), a third of which are pediatric patients.

Winter Monsoon of 2015 [Figure 1]

The NE monsoon of 2015 was intensified by the El Nino effect, bringing heavy rainfall during November. This developed as two distinct weather systems over Chennai, producing torrential rainfall. Average rainfall between October 1 and December 15 in Chennai and adjacent Kanchipuram district has been 744 mm and 611 mm, respectively, over several years. During this same period in 2015, the two districts received 1609 mm and 1815 mm of rainfall, respectively.^[2] The impact of these rains was further increased by the fact that most of this rainfall occurred over 4–5 days, in two bursts a week apart. In fact, recorded rainfall of 1197 mm in November 2015 had broken a century old record of 1088 mm (recorded in the year 1918).^[3]

The first round of heavy rains occurred around 15th of November. There was significant flooding of low-lying areas. Lakes around Chennai that are natural reservoirs for the monsoon rain had quickly filled up. Normal life was affected and the hospital was briefly cut off from the main arterial road. Elective procedures were stopped, but care of the inpatients was not affected. The number of patients admitted at that point was under 100 because of the rains with reduction in elective admissions. The interval from 19th November to 28th November was reasonably dry and elective work had resumed in the hospital.

A second depression in the Bay of Bengal developed leading to torrential rains starting on the 30th November. LDLT for a child with acute-on-chronic liver failure was planned for the next day. In view of forecast of further rains, the need for postponing the transplant for a week until the storm had blown over was considered. However, in view of the deteriorating condition of the child who was already in Intensive Care Unit (ICU), it was felt that the child is unlikely to survive the delay. Hence, a decision was made to proceed with the operation.

The Flooding [Figures 2 and 3]

On December 1, 2015, as the donor procedure was underway, news regarding torrential rains in the outskirts of Chennai with breaching of a major lake was reported. The transplant procedure continued and

was completed at around 7 pm. By then, it was clear that the impact of the second round of rainfall was very significant with breaching of multiple lakes and rivers in the city.

The access road to the hospital started flooding by around 7 pm and water started entering the main hospital building by 8 pm. The rate of water entry into the hospital raised a major concern and a major untoward incident was anticipated. There were enough senior doctors and administrators in the hospital at that time because of the LT surgery. Most other specialty doctors and staff had left the hospital in anticipation of the storm by around 2–3 pm. There was also enough nursing staff in the hospital at that time because the daytime staff were not able to complete their handover and leave before the flooding started.

Day 1: Taking Stock and Setting Priorities

Immediate step was to form a disaster management task force (DMTF) with representatives from medical team, nursing staff and administrators present inside the hospital at that point of time. The DMTF comprised of a senior anesthetic/critical care specialist, senior transplant surgeon, senior physician, medical director, nursing director and the chief operating officer.

The DMTF first identified four focus areas – patient safety, power supply and backup, oxygen, water and medical supplies, and maintaining a communication line with senior hospital authorities outside the hospital and the state health authorities. One designated member of the DMTF took responsibility for each of these tasks.

Patient safety

Patients and their relatives were quickly briefed about the current situation, concerns and expected timeline of major events. They were reassured that all steps would be taken to ensure the safety of the patients and relatives. Inpatient list was quickly reviewed. All patients and relatives from the ground level wards were moved to the first floor where there are ward beds, ICU, and operating rooms. Essential equipment that could be moved was also shifted to the first floor. The intensive care team evaluated patients in different specialty ICUs. Sick patients and patients on ventilator from different ICUs were all moved into one large ICU space for efficient staffing and resource management. Stable ICU patients not on any organ support were transferred to a second ICU space. Nursing staff were assigned to each of the two ICU spaces ensuring at least 1:1 and 1:2 nurse–patient ratios for these two areas.

Power supply review

It is usual for the State Electricity Board to stop power supply in the event of heavy rains to avoid power line accidents. By late evening, power supply was cut off to major parts of the city including our hospital, to avoid overhead power line accidents. The hospital had started using two diesel power generators with 1500 KV capacities each. There was enough diesel supply to last for 3 days. Battery backup was also present in the hospital, which could provide power supply for 9–12 hours. These generators were located at the ground floor level in an annex building. Meanwhile, as water level in the ground floor reached one foot high within an hour, we estimated that in spite of all attempts, water would enter the generator rooms within 3 h and cause generators' failure. Attempts were made to procure two large 100 KV generators as backup. The generators were brought till the main arterial road by around 11 pm. But by then, the access road to the hospital was completely cut off by 7 ft deep flood water. Attempts were then made to procure small

portable generators that could be quickly brought by small boats.

A high alert was passed on to all staff and measures to be taken when power supply goes off were quickly discussed and circulated. DMTF had several meetings with patients, patient's relatives and staff to update the situation at each point of time. Emergency resuscitation kits, oxygen cylinders and Bain's circuits were checked and placed with each ventilated patient in case of complete power failure.

Water, food, medical gases and pharmacy review

Reserve supply of liquid oxygen and oxygen cylinders was available which was adequate for 7 days. There were adequate reserves of water, food, and medicines that could last for 48 h. A temporary kitchen was setup in the first floor to prepare simple hot meals for patients, relatives, and staff. The drug charts of all inpatients were reviewed and medications for the next 24 h were manually indented and stored in the ICU. The operating theater pharmacy was activated and staffed

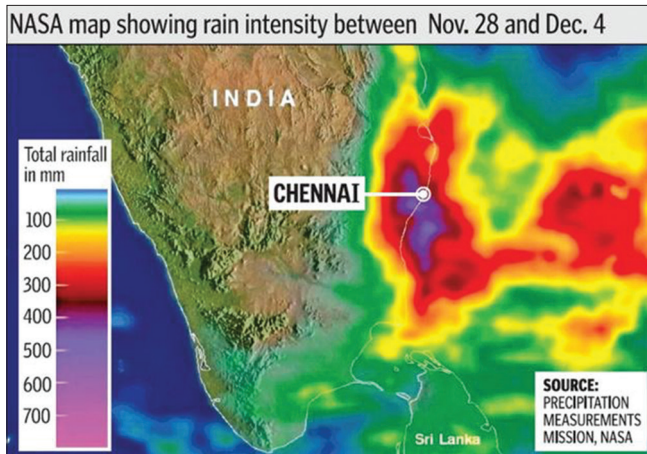


Figure 1: Map released by NASA detailing the intensity of rainfall over Southern India between November 28 and December 4, 2015

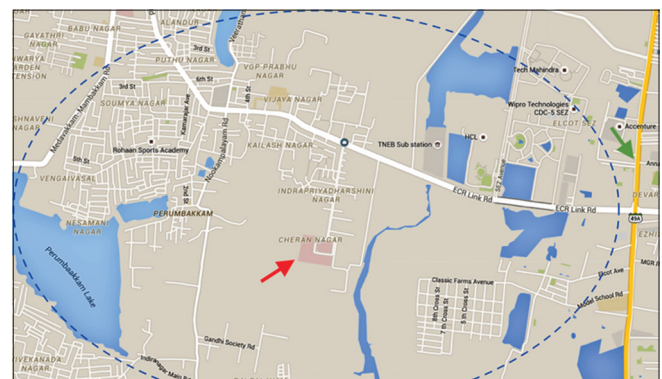


Figure 2: Google map showing the location of hospital and the extent of flooding of surrounding areas. Red arrow: Hospital campus, Green arrow: Closest arterial road, Broken blue circle: Area of flooding



Figure 3: Picture of areas surrounding the hospital during the flooding



Figure 4: Picture taken inside the main hospital building at the time of evacuation

round-the-clock to provide immediate access to essential medications as the main pharmacy on the ground level was flooded.

Communication and seeking help

The situation and impending disaster were quickly communicated to the senior hospital staff outside the hospital and external help was sought from local government agencies, National Disaster Response Force (NDRF) and military forces. The priorities identified at that point of time were to provide small generators to run ventilators and monitors and to transfer sick patients and patients on life support to unaffected nearby hospitals safely as early as possible.

The decision to evacuate the hospital was discussed and initiated by the DMTF and communicated to the senior hospital members outside. Plan of action for safe transfer was quickly laid down and the hospital team outside initiated necessary arrangements. Three unaffected city hospitals were identified and contacted and they agreed to take up the patients on an emergent basis. Allotment of patients to each of the hospitals was based on the available facilities at each site.

Day 2: A Holding Game [Figure 4]

By midnight, water level rose up to 4 ft inside the main hospital building. As expected, both generators stopped working in 5 h and backup battery started to function. It was then decided that only ventilators, basic monitors, and few lights should be used to conserve power. Emergency strategies were planned and kept on standby to put in action when power completely fails. The nursing and medical staff rehearsed the steps and were well prepared to handle the inevitable. Battery backup also ran out in 12 h. For the next 4 h, ventilated patients were manually ventilated using Bain's circuit and Ambu bag. Inotropes and other essential medicines, which are normally infused using infusion pumps, had to be given through drip sets. Only old-fashioned noninvasive blood pressure monitor and small battery powered pulse oximeters were available to monitor patients. Two small babies who had recent liver transplants were held by nurses in their laps throughout this period to provide warm environment and ensure continuous monitoring of heart rate and respiration.

Chennai airport was closed due to flooding and malfunctioning of equipment, and as a result, military forces and NDRF had difficulty in reaching Chennai. As the 2 km long access road to hospital was more than 8 ft under water, no vehicles could reach hospital by road.

The hospital did not have helipad facilities, so air transfer of patients was not an option. As large parts of the city were affected, rescue services were thinned out across the city and it was impossible to get the desired prompt response from any of the agencies.

Help finally arrived 21 h from the start of flooding in the form of four small generators with a total capacity of 20 KV on two fishing boats. These were immediately used to power up the ventilators and essential monitors. The same boats were used to transfer two patients to nearby hospitals. One needed an urgent computed tomography of brain for new onset neurological deficit and another was a full-term pregnant lady who needed an urgent cesarean section. After these two boat trips, boat service had to be stopped due to poor visibility and torrential rain. Overnight, patients were managed safely, despite the constraints. A DMTF meeting was convened for strategic planning to safely transfer all patients, relatives and staff, the following day.

Day 3: Evacuation

Overnight, the clinical and nursing staff made a transfer list of patients based on their condition. A hand written clinical summary and a photocopy of the current medication chart accompanied each transferred inpatient. The only means of safely transferring these patients was with the help of small fishing boats that could be maneuvered around the flooded areas. Message was sent detailing the evacuation plan and the number of boats needed to complete evacuation before dark.

Local fishermen with their boats were enrolled into the rescue operations the next day morning. The hospital was evacuated completely using 12 boats and the assistance of fire services. We needed 65 boat trips to transfer everyone to a safe point from where ambulances were used to transfer the patients to three different hospitals. In all, 108 in-patients including 12 ventilated patients, 150 relatives, and 250 hospital staff were safely evacuated. Hospital medical staff were stationed at each of the receiving hospitals, to ensure continuity of care for the patients. In addition to the written transfer notes, Whatsapp messenger was also used to send these documents to the receiving teams as a backup.

Epilogue

The floods cost Chennai over 350 lives and millions of dollars worth of infrastructure damage. There were unconfirmed reports of hospital deaths^[4] due to flood-related power failure in another city hospital. Fortunately, all of our patients were safely transferred

without any loss of life. GH was reopened after extensive repairs in 3 weeks' time. By this time, most of the patients had recovered and been discharged from the receiving hospitals. The few remaining patients were transferred back to GH and are being discharged from here.

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Conflicts of interest

There are no conflicts of interest.

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